# URETHRAL

в

EDITED BY: Gerald Jordan, Christopher Chapple and Chris Heyns

An International Consultation on Urethral Strictures

Marrakech, Morocco, October 13-16, 2010

### Co-sponsored by

SIU (Société Internationale d'Urologie) ICUD (International Consultation on Urological Diseases)



CENDING

**STRICTURES** 



# Contraction of the second seco

An International Consultation on Urethral Strictures

Marrakech, Morocco, October 13-16, 2010

**Co-sponsored by** SIU (Société Internationale d'Urologie) ICUD (International Consultation on Urological Diseases)





### **Urethral Strictures**

An International Consultation on Urethral Strictures Marrakech, Morocco, October 13-16, 2010

Editors Gerald Jordan, Christopher Chapple and Chris Heyns

Published by the Société Internationale d'Urologie (SIU)

For information and orders: SIU Central Office 1155 University Street Suite 1155 Montréal (QC) Canada H3B 3A7 T: +1 514 875-5665 F: +1 514 875-0205 E-mail: communications@siu-urology.org Website: www.siu-urology.org

©2012 Société Internationale d'Urologie

Coordination: SIU Communications Office Medical Editing: Jessica Cox, Corbeil, Canada Medical Proofreaders: Christine Albino, Namita Kumar and Areti Malapetsas Montréal, Canada Layout and Design: SAM Design, Montréal, Canada Printing: Felix Yang, Yinshantang Communication Services, Shanghai, China

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior permission from the publisher.

Accurate indications, adverse reactions, and dosage schedules for drugs are provided in this book, but it is possible that these may change after publication. The reader is urged to review the product information (i.e., product monograph, package insert or leaflet, prescribing information) published by the manufacturers of the medications mentioned.

The publishers have made every effort to trace the copyright holders for borrowed material. If they have inadvertently overlooked any, they will be pleased to make the necessary arrangements at the first opportunity.

Printed and bound in Shanghai, China

ISBN: 978-0-9877465-2-8



www.siu-urology.org

# Table of Contents

	Abbr	eviations	Used in the Text	IX
	Fore	word		XIII
	Evid Deve	ence-Bas eloping a	sed Medicine: Overview of the Main Steps for nd Grading for Guideline Recommendations	XV
COMMITTEE 1	Epid	emiology	r, Anatomy and Nomenclature	1
	1.1	Background		
	1.2	Introdu	iction and Statement of the Problem	5
	1.3	Metho	ds/Identification of References	5
		1.3.1	Quality of the References	6
	1.4	Recom	imendations	6
	1.5	Scienti	fic Foundations	6
		1.5.1	Nomenclature pertinent to urethral stenoses, strictures, and pelvic fracture urethral injuries	6
		1.5.2	Epidemiology and etiology of urethral stenoses, strictures, and pelvic fracture urethral injuries	8
		1.5.3	Mechanism of injury to the urethra	8
		1.5.4	Epidemiology and incidence of urethral stricture disease	8
		1.5.5	Etiology of urethral stricture disease	9
		1.5.6	Economic impact of urethral stricture disease	15
		1.5.7	Anatomy of urethral stenoses, strictures, and pelvic fracture urethral disruption injuries	15
		1.5.8	Anatomy and nomenclature of the male urethra	15
		1.5.9	Histology and pathology of urethral strictures	20
		1.5.10	Spongiofibrosis and classification of urethral strictures	22
	1.6	Refere	nces	23
COMMITTEE 2	Eval	uation an	d Follow-Up	27
	2.1	Introdu	iction	31
	2.2	Patient History		31
	2.3	Physica	al Examination	32
		2.3.1	General	32
		2.3.2	Abdomen	32
		2.3.3	Genitalia	32
		2.3.4	Musculoskeletal and neurological	33
	2.4	Labora	tory	33

	2.5	Urethrography, Cystography, and Cystoscopy	33
		2.5.1 Urethrography	33
		2.5.2 Cystography	40
		2.5.3 Cystoscopy	41
		2.5.4 Recommendations	43
	2.6	Ultrasound	44
		2.6.1 Recommendations	45
	2.7	Magnetic Resonance Imaging and Computed Tomography	46
		2.7.1 Recommendation	47
	2.8	The American Urological Association Symptom Index and Uroflowmetry	47
		2.8.1 Recommendations	50
	2.9	Sexual and Ejaculatory Function	50
		2.9.1 Recommendations	53
	2.10	Evaluation of Outcome Following Surgical Intervention for Urethral Stricture	53
	2.11	References	56
COMMITTEE 3	Dilati Male	on, Internal Urethrotomy and Stenting of Anterior Urethral Strictures	61
	3.1	Introduction	65
	3.2	Methods	65
	3.3	Incision/Dilation of Male Anterior Urethral Strictures	66
	3.4	Review of the Literature on Incision and Dilation Outcomes	66
	3.5	Repeat Direct Vision Internal Urethrotomy/Dilation	68
	3.6	Side Effects of Direct Vision Internal Urethrotomy	68
	3.7	Cost Effectiveness	69
	3.8	Laser Urethrotomy	69
	3.9	Direct Vision Internal Urethrotomy Plus Self-Dilation	70
	3.10	Catheter Urinary Drainage	71
	3.11	Direct Vision Internal Urethrotomy with Adjunctive Agents	71
	3.12	Effect on Future Urethral Reconstruction	71
	3.13	Anterior Urethral Stenting	72
	3.14	Recommendations	74
		3.14.1 Primary direct vision internal urethrotomy and dilation	74
		3.14.2 Repeat direct vision internal urethrotomy/dilation	74
		3.14.3 Direct vision internal urethrotomy/dilation and intermittent catheterization	75
		3.14.4 Laser urethrotomy	75
		3.14.5 Anterior urethral stenting	75
	3.15	References	76

COMMITTEE 4	Ante	rior Uret	thra – Primary Anastomosis	81
	4.1	Backg	round	85
	4.2	Introd	uction	85
	4.3	Metho	ods	85
	4.4	Discus	ssion	86
		4.4.1	Composite success rate of excision and primary anastomosis	86
		4.4.2	Cost effectiveness of excision and primary anastomosis for short bulbar urethral strictures	87
		4.4.3	Complications of excision and primary anastomosis	87
		4.4.4	Applications and limitations of excision and primary anastomosis	88
	4.5	Conclu	usion	88
	4.6	Recor	nmendations	89
		4.6.1	Composite success rate of excision and primary anastomosis	89
		4.6.2	Cost effectiveness of excision and primary anastomosis versus endoscopic treatment	89
		4.6.3	Excision and primary anastomosis complications	90
		4.6.4	Excision and primary anastomosis indications and Limitations	90
	4.7	Refere	ences	91
COMMITTEE 5	Ante	rior Ure	thra – Lichen Sclerosus	93
	5.1	5.1 Introduction		97
	5.2	Etiolo	ЗÀ	97
	5.3	Epider	niology	98
	5.4	Clinica	Il Features	98
	5.5	Diagn	osis	98
		5.5.1	Histological Diagnosis	98
	5.6	Progn	osis	99
	5.7	Maligr	nant Potential of Lichen Sclerosus	99
	5.8	Medic	al management of lichen sclerosus	100
		5.8.1	Non-surgical management	101
		5.8.2	Surgical management	101
	5.9	Conclu	usion	103
	5.10	Recor	nmendations	103
	5.11	Refere	ences	104

COMMITTEE 6	The I	Managem	nent of Anterior Urethral Stricture Disease	
	Using	g Substitu	ution Urethroplasty	107
	6.1	Backgro	bund	111
	6.2	Introduc	ction	111
	6.3	Method	s	111
	6.4	Pre-Ope	erative Assessment	112
	6.5	Pre-Ope	erative Counselling	113
	6.6	Choice	of Urethral Reconstruction Technique	113
	6.7	Augmer	ntation Urethral Reconstruction	115
	6.8	Grafts V	/ersus Flaps	116
	6.9	Oral Mu	ucosal Grafts	118
	6.10	Acellula	r Matrices and Tissue Engineering	119
	6.11	Graft Po	ositioning	120
	6.12	Patient	Follow-Up	122
	6.13	Recomr	nendations	122
	6.14	Referen	Ces	124
	6.15	Append	ix	129
COMMITTEE 7	Pelvi	c Fracture	e Urethral Injuries (PEUI)	145
	7.1	Introduc	stion	149
	7.2	Method	S	149
	7.3	Anatom	y of the Male Urethra	150
		7.3.1	Anatomy of the posterior urethra	151
		7.3.2	Urinary continence and sphincteric mechanism	152
	7.4	Mechar	nism of Posterior Urethral Injury	154
		7.4.1	Pelvic fracture pattern	154
		7.4.2	Mechanism of urethral injury	155
	7.5	Classific	cation	157
		7.5.1	Anatomical radiological classification	157
		7.5.2	Extended anatomical classification	157
		7.5.3	American Association for the Surgery of Trauma Classification	158
		7.5.4	Anatomical and functional classification	159
	7.6	Clinical	Presentation, Diagnosis, and Imaging: Associated Injuries	162
	7.7	Acute N	lanagement	164
		7.7.1	Early catheter realignment	164
		7.7.2	Suprapubic catheter cystostomy and delayed reconstruction	172

7.8	Urethra Their C	al Stenosis/Obliteration: Reconstructive Options and Outcomes	173
	7.8.1	Operative procedure: bulbomembranous anastomotic urethroplasty	173
	7.8.2	Staging investigations to predict the type of surgery required	174
	7.8.3	Inferior pubectomy	175
	7.8.4	The role of supracrural rerouting in bulbomembranous anastomotic urethroplasty	175
	7.8.5	Outcomes of primary bulbomembranous anastomotic urethroplasty for pelvic fracture urethral injury	175
	7.8.6	Reconstructive options for failed bulbomembranous anastomotic urethroplasty	176
	7.8.7	Outcomes of re-do urethroplasty for pelvic fracture urethral injury	176
7.9	Compl Urethra	ex Scenarios and Complications of Pelvic Fracture al Injury: Erectile Dysfunction, Incontinence, and Fistula	176
	7.9.1	Erectile dysfunction	177
	7.9.2	Incontinence	180
	7.9.3	Fistula	184
7.10	Recom	Imendations	186
	7.10.1	Anatomy, mechanisms of injury, and classification	186
	7.10.2	Clinical presentation, diagnosis, imaging: associated injuries	186
	7.10.3	Acute management	187
	7.10.4	Urethral stenosis/obliteration: reconstructive options and their outcomes	188
	7.10.5	Complex scenarios and complications	189
	7.10.6	Future research	189
7.11	Refere	nces	190
Poste 8.1	erior Ure Introdu	thral Stenosis After Treatment for Prostate Cancer action	<mark>197</mark> 201
8.2	Materi	als and Methods	204
8.3	Epiden	niology and Risk Factors	204
	8.3.1	Radical prostatectomy	204
	8.3.2	Radiation	207
	8.3.3	Cryotherapy	218
	8.3.4	High-intensity focused ultrasound	219
	8.3.5	Post-trans-urethral prostatectomy (trans-urethral resection of the prostate)	220

8.4	Evalua	ition and Pre-Operative Management	221
8.5	Treatm	nent	223
	8.5.1	Treatment approach after radiotherapy	223
	8.5.2	Treatment after trans-urethral resection of the prostate	225
	8.5.3	Management of post-radical prostatectomy	
		vesico-urethral anastomotic strictures	226
8.6	Recon	nmendations	231
	8.6.1	Future research	232
8.7	Refere	ences	233
Uretl	nral Stric	ctures in Children	241
9.1	Backg	round	243
9.2	Introdu	uction	243
9.3	Metho	ods	243
9.4	Meata	I Strictures	244
9.5	Anterio	or Urethra	245
9.6	Poster	rior Urethra	246
9.7	Discus	ssion	246
	9.7.1	Meatal strictures	246
	9.7.2	Anterior urethra	247
	9.7.3	Posterior urethra	247
9.8	Recon	nmendations	248
	9.8.1	Meatal stenosis	248
	9.8.2	Anterior (penile and bulbar) urethral strictures	249
	9.8.3	Posterior urethral stenoses/pelvic fracture	
		urethral injuries	249
9.9	Refere	ences	250

# Abbreviations Used in the Text

3DCRT	three-dimensional conformal radiotherapy
AAST	American Association for the Surgery of Trauma
AHCPR	Agency for Health Care Policy and Research
AIS	Abbreviated Injury Scale
ALA	5-aminolevulinic acid
ARGH	Acronym Resolving General Heuristics
AS	active surveillance
AUA	American Urological Association
AUA-SI	American Urological Association Symptom Index
AUS	artificial urinary sphincter
BM	bulbomembranous
BMA	bulbomembranous anastomotic urethroplasty
BN	bladder neck
BNC	bladder neck contracture
BPA	bulboprostatic anastomotic urethroplasty
BPH	benign prostatic hyperplasia
BT	brachytherapy
ВХО	balanitis xerotica obliterans
CaPSURE	Cancer of the Prostate Strategic Urologic Research Endeavor
CI	confidence interval
CIS	carcinoma in situ
CISC	clean intermittent self-catheterization
cm	centimetres
CO2	carbon dioxide
СТ	computed tomography
CTCUG	computed tomography cystourethrography
DNA	deoxyribonucleic acid
DR	delayed repair

DRE	digital rectal examination
DVIU	direct vision internal urethrotomy
EBRT	external beam radiotherapy
ECM1	extracellular matrix protein 1
ED	erectile dysfunction
EjF	ejaculatory function
ELISA	enzyme-linked immunosorbent assay
EMLA	A trade name - Eutectic Mixture of Local Anesthetics
EPA	excision and primary anastomosis
F	French (unit of measure)
GAG	glycosaminoglycan
GU	genito-urinary
GUI	gapometry/urethrometry index
Gy	Gray; the SI unit of absorbed dose, equal to 1 Joule/kg
HDRBB	high-dose-rate brachytherapy boost
HDR-BT	high-dose-rate brachytherapy
HIFU	high-intensity focused ultrasound
HPV	human papillomavirus
HR	hazard ratio
ICUD	International Consultation on Urological Diseases
IIEF	International Index of Erectile Function
IMRT	intensity-modulated radiotherapy
IPSS	International Prostate Symptom Score
ISC	intermittent self-catheterization
IU	internal urethrotomy
IVP	intravenous pyelogram
LDR-BT	low dose rate brachytherapy
LS	lichen sclerosus
LUTS	lower urinary tract symptoms
MeSH	Medical Subject Headings
MMC	mitomycin C
mo	months

MRI	magnetic resonance imaging
MSHQ	Male Sexual Health Questionnaire
NGU	non-gonococcal urethritis
NPT	nocturnal penile tumescence
OIU	optical internal urethrotomy
Oxford	Oxford Centre for Evidence-Based Medicine
р	p-value
PDE5	phosphodiesterase type-5 enzyme
PDS	polydioxanone
PFUDD	pelvic fracture urethral distraction defect
PFUI	pelvic fracture urethral injury
PgA	polyglycolic acid
PLLA	poly-L-lactic acid
PR	primary realignment
PROM	patient-reported outcome measure
PSA	prostate-specific antigen
PubMed	US National Library of Medicine and the National Institutes of Health
PubMed PUS	US National Library of Medicine and the National Institutes of Health posterior urethral stenosis
PubMed PUS PVR	US National Library of Medicine and the National Institutes of Health posterior urethral stenosis post-void residual
PubMed PUS PVR RCT	US National Library of Medicine and the National Institutes of Health posterior urethral stenosis post-void residual randomized controlled trial
PubMed PUS PVR RCT RP	US National Library of Medicine and the National Institutes of Health posterior urethral stenosis post-void residual randomized controlled trial radical prostatectomy
PubMed PUS PVR RCT RP RR	US National Library of Medicine and the National Institutes of Health posterior urethral stenosis post-void residual randomized controlled trial radical prostatectomy relative risk
PubMed PUS PVR RCT RP RR RRP	US National Library of Medicine and the National Institutes of Health posterior urethral stenosis post-void residual randomized controlled trial radical prostatectomy relative risk radical retropubic prostatectomy
PubMed PUS PVR RCT RP RR RR RRP RT	US National Library of Medicine and the National Institutes of Health posterior urethral stenosis post-void residual randomized controlled trial radical prostatectomy relative risk radical retropubic prostatectomy radiotherapy
PubMed PUS PVR RCT RP RR RRP RT RUG	US National Library of Medicine and the National Institutes of Health posterior urethral stenosis post-void residual randomized controlled trial radical prostatectomy relative risk radical retropubic prostatectomy radiotherapy retrograde urethrography
PubMed PUS PVR RCT RP RR RRP RT RUG SaRAD	US National Library of Medicine and the National Institutes of Health posterior urethral stenosis post-void residual randomized controlled trial radical prostatectomy relative risk radical retropubic prostatectomy radiotherapy retrograde urethrography Simple and Robust Abbreviation Dictionary
PubMed PUS PVR RCT RP RR RRP RT RUG SaRAD SEER	US National Library of Medicine and the National Institutes of Health posterior urethral stenosis post-void residual randomized controlled trial radical prostatectomy relative risk radical retropubic prostatectomy radiotherapy retrograde urethrography Simple and Robust Abbreviation Dictionary Surveillance Epidemiology and End Results
PubMed PUS PVR RCT RP RR RRP RT RUG SaRAD SEER SFR	US National Library of Medicine and the National Institutes of Health posterior urethral stenosis post-void residual randomized controlled trial radical prostatectomy relative risk radical retropubic prostatectomy radiotherapy retrograde urethrography Simple and Robust Abbreviation Dictionary Surveillance Epidemiology and End Results stricture-free rate
PubMed PUS PVR RCT RP RR RRP RT RUG SaRAD SEER SFR SHIM	US National Library of Medicine and the National Institutes of Health posterior urethral stenosis post-void residual randomized controlled trial radical prostatectomy relative risk radical retropubic prostatectomy radiotherapy retrograde urethrography Simple and Robust Abbreviation Dictionary Surveillance Epidemiology and End Results stricture-free rate Sexual Health Inventory for Men
PubMed PUS PVR RCT RP RR RRP RT RUG SaRAD SEER SFR SHIM SIS	US National Library of Medicine and the National Institutes of Health posterior urethral stenosis post-void residual randomized controlled trial radical prostatectomy relative risk radical retropubic prostatectomy radiotherapy retrograde urethrography Simple and Robust Abbreviation Dictionary Surveillance Epidemiology and End Results stricture-free rate Sexual Health Inventory for Men porcine small intestinal submucosa

SPC	suprapubic catheter cystostomy
SPT	suprapubic tube
SU	sonourethrography
TRUS	trans-rectal ultrasound
TUIP	trans-urethral incision of the prostate
TUMT	trans-urethral microwave thermotherapy
TURP	trans-urethral resection of the prostate
UK	United Kingdom
URF	urethrorectal fistula
US	United States
UTI	urinary tract infection
VCUG	voiding cystourethrography
VIU	visual internal urethrotomy
VS.	versus
VUAS	vesico-urethral anastomotic stricture
WHO	World Health Organization
wk	week

# Foreword



Christopher Chapple United Kingdom

Urethral damage resulting from spongiofibrosis (urethral strictures) or consequent upon traumatic disruption of the urethra (pelvic fractures or fall-astride injuries – so called urethral stenoses) have always been an important cause of presentation to the practicing urologist. Unless appropriately managed, they result in an important source of chronic morbidity in male patients. The prevalence and pathogenesis of urethral strictures and stenoses vary significantly between different countries in the world. It is clear that unless we have consensus on an accepted and consistent terminology for urethral stricture/stenosis, it will be difficult to advance our knowledge in this important field of reconstructive urology with regard to the pathophysiology, clinical evaluation and optimal surgical management of patients.

The International Consultations on Urological Disease (ICUD) organized an international consensus meeting under the auspices of the Société Internationale d'Urologie (SIU), which was held in Marrakech, Morocco, in 2010. This consultation was the first international forum where experts subspecializing in the management of urethral strictures and stenoses carefully and critically evaluated the entire peer-reviewed English-language literature on the subject.

This monograph summarizes the finalized consensus expert reports and recommendations from this consultation. This is an area of medicine where there is a limited evidence base and the consensus recommendations were formulated using the classification process recommended by the ICUD (see appendix 1). Each of the chapters provides an overview of the existing evidence base in this important area of reconstructive urology, and integrates the literature with contemporary views on best practice as defined by the experts participating in the consensus.

In dealing with any disease area, it is first essential to agree upon a standardized terminology. This is provided by the committee (Chapter 1) which reviewed the descriptive terms, etiology and management of urethral strictures and stenoses. The subsequent chapters (2-9) in this monograph provide a succinct expert overview of all aspects of urethral strictures and stenoses with recommendations for clinical practice, which we hope will prove helpful to practicing clinicians.

**Christopher Chapple** on behalf of the steering committee C. R. Chapple, G. H. Jordan, C. F. Heyns



# Evidence-Based Medicine Overview of the Main Steps for Developing and Grading Guideline Recommendations

### P. Abrams, S. Khoury, A. Grant

### Introduction

The International Consultation on Urological Diseases (ICUD) is a non-governmental organization registered with the World Health Organisation (WHO). In the last ten years, consultations have been organized on BPH, prostate cancer, urinary stone disease, nosocomial infections, erectile dysfunction and urinary incontinence. These consultations have looked at published evidence and produced recommendations at four levels: highly recommended, recommended, optional and not recommended. This method has been useful but the ICUD believes that there should be more explicit statements of the levels of evidence that generate the subsequent grades of recommendations.

The Agency for Health Care Policy and Research (AHCPR) have used specified evidence levels to justify recommendations for the investigation and treatment of a variety of conditions. The Oxford Centre for Evidence-Based Medicine have produced a widely accepted adaptation of the work of AHCPR. (June 5th 2001, www.cebm.net).

The ICUD has examined the Oxford guidelines and discussed with the Oxford group their applicability to the consultations organized by ICUD. It is highly desirable that the recommendations made by the consultations follow an accepted grading system supported by explicit levels of evidence.

The ICUD proposes that future consultations should use a modified version of the Oxford system which can be directly "mapped" onto the Oxford system.

### 1. First Step

Define the specific questions or statements that the recommendations are supposed to address.

### 2. Second Step

Analyze and rate (level of evidence) the relevant papers published in the literature.

The analysis of the literature is an important step in preparing recommendations and their guarantee of quality.

### 2.1 What papers should be included in the analysis?

- Papers published, or accepted for publication in the peer-reviewed issues of journals.
- The committee should do its best to search for papers accepted for publication by the peer-reviewed journals in the relevant field but not yet published.
- Abstracts published in peer-reviewed journals should be identified. If of sufficient interest, the author(s) should be asked for full details of methodology and results. The relevant committee members can then "peer review" the data, and if the data confirms the details in the abstract, then that abstract may be included, with an explanatory footnote. This is a complex issue – it may actually increase publication bias as "uninteresting" abstracts commonly do not progress to full publication.
- Papers published in non-peer-reviewed supplements will not be included. An exhaustive list should be obtained through:
  - The major databases covering the last ten years (e.g. Medline, Embase, Cochrane Library, Biosis, Science Citation Index).
  - II. The table of contents of the major journals of urology and other relevant journals, for the last three months, to take into account the possible delay in the indexation of the published papers in the databases.

It is expected that the highly experienced and expert committee members provide additional assurance that no important study would be missed using this review process.

### 2.2 How are papers analyzed?

Papers published in peer-reviewed journals have differing quality and level of evidence. Each committee will rate the included papers according to levels of evidence (see below).

The level (strength) of evidence provided by an individual study depends on the ability of the study design to minimize the possibility of bias and to maximize attribution.

### It is influenced by:

### The type of study, whose hierarchy is outlined below:

- Systematic reviews and meta-analysis of randomized controlled trials
- Randomized controlled trials
- Non-randomized cohort studies

### How well the study was designed and carried out

Failure to give due attention to key aspects of study methodology increases the risk of bias or confounding factors, and thus reduces the study's reliability.

The use of **standard checklists** is recommended to insure that all relevant aspects are considered and that a consistent approach is used in the methodological assessment of the evidence.

The objective of the checklist is to give a quality rating for individual studies.

### How well the study was reported

The ICUD has adopted the CONSORT statement and its widely accepted checklist. The CONSORT statement and the checklist are available at www.consort-statement.org.

- Case-control studies
- Case series
- Expert opinion

### 2.3 How are papers rated?

Papers are rated following a level of evidence scale.

ICUD has modified the Oxford Centre for Evidence-Based Medicine levels of evidence.

The levels of evidence scales vary between types of studies (i.e., therapy, diagnosis, differential diagnosis/ symptom prevalence study) the Oxford Centre for Evidence-Based Medicine Website: www.cebm.net.

### 3. Third Step: Synthesis of the Evidence

After the selection of the papers and the rating of the level of evidence of each study, the next step is to compile a summary of the individual studies and the overall direction of the evidence in an **Evidence Table**.

### 4. Fourth Step: Considered Judgment (Integration of Individual Clinical Expertise)

Having completed a rigorous and objective synthesis of the evidence base, the committee must then make a judgment as to the grade of the recommendation on the basis of this evidence. This requires the exercise of judgment based on clinical experience as well as knowledge of the evidence and the methods used to generate it. Evidence-based medicine requires the integration of individual clinical expertise with the best available external clinical evidence from systematic research. Without the former, practice quickly becomes tyrannized by evidence, for even excellent external evidence may be inapplicable to, or inappropriate for, an individual patient. On the other hand, without current best evidence, practice quickly becomes out of date. Although it is not practical to lay our "rules" for exercising judgment, guideline development groups are asked to consider the evidence in terms of quantity, quality, and consistency, as well as applicability, generalizability and clinical impact.

### 5. Fifth Step: Final Grading

The grading of the recommendation is intended to strike an appropriate balance between incorporating the complexity of type and quality of the evidence, and maintaining clarity for guideline users.

The recommendations for grading follow the Oxford Centre for Evidence-Based Medicine. The levels of evidence shown below have again been modified in the light of previous consultations. There are now four levels of evidence instead of five.

The grades of recommendation have not been reduced and a "no recommendation possible" grade has been added.

### 6. Levels of Evidence and Grades of Recommendation for Therapeutic Interventions

All interventions should be judged by the body of evidence for their efficacy, tolerability, safety, clinical effectiveness and cost-effectiveness. It is accepted that, at present, little data exists on cost-effectiveness for most interventions.

### 6.1 Levels of evidence

Firstly, it should be stated that any level of evidence may be positive (the therapy works) or negative (the therapy doesn't work). A level of evidence is given to each individual study.

Level of Evidence	Criteria
I	<ul> <li>Incorporates Oxford 1a, 1b</li> <li>Usually involves: <ul> <li>meta-analysis of trials (randomized controlled trials [RCTs]) or,</li> <li>a good-quality RCT or,</li> <li>"all or none" studies in which treatment is not an option (e.g. in vesicovaginal fistula)</li> </ul> </li> </ul>
II	<ul> <li>Incorporates Oxford 2a, 2b and 2c</li> <li>Includes: <ul> <li><i>Iow-quality RCT</i> (e.g. &lt; 80% follow-up),</li> <li><i>meta-analysis</i> (with homogeneity) of <i>good-quality prospective cohort studies</i></li> </ul> </li> <li>May include a single group when individuals who develop the condition are compared with others from within the original cohort group.</li> <li>There can be parallel cohorts, where those with the condition in the first group are compared with those in the second group</li> </ul>
III	<ul> <li>Incorporates Oxford 3a, 3b and 4</li> <li>Includes:         <ul> <li>good-quality retrospective case-control studies, where a group of patients who have a condition are matched appropriately (e.g. for age, sex, etc.) with control individuals who do not have the condition</li> <li>good-quality case series, where a complete group of patients, all with the same condition, disease or therapeutic intervention, are described without a comparison control group</li> </ul> </li> </ul>
IV	<ul> <li>Incorporates Oxford 4</li> <li>Includes <i>expert opinion</i>, where the opinion is based not on evidence but on "first principles" (e.g. physiological or anatomical) or bench research.</li> <li>The <i>Delphi process</i> can be used to give expert opinion greater authority: <ul> <li>involves a series of questions posed to a panel</li> <li>answers are collected into a series of "options"</li> <li>these "options" are serially ranked; if a 75% agreement is reached, then a Delphi consensus statement can be made</li> </ul> </li> </ul>

### 6.2 Grades of recommendation

The ICUD will use the four grades from the Oxford system. As with levels of evidence, the grades of evidence may apply either positively (procedure is recommended) or negatively (procedure is not recommended). Where there is disparity of evidence, for example if there were three well-conducted RCTs indicating that Drug A was superior to placebo, but one RCT whose results show no difference, then there has to be an individual judgment as to the grade of recommendation given and the rationale explained.

**Grade A** recommendation usually depends on consistent level I evidence and often means that the recommendation is effectively mandatory and placed within a clinical-care pathway. However, there will be occasions where excellent evidence (level I) does not lead to a Grade A recommendation, for example, if the therapy is prohibitively expensive, dangerous or unethical. Grade A recommendation can follow from Level II evidence. However, a Grade A recommendation needs a greater body of evidence if based on anything except Level I evidence.

Grade B recommendation usually depends on consistent level 2/3 studies, or "majority evidence" from RCTs.

- **Grade C** recommendation usually depends on level 4 studies or "majority evidence" from level 2/3 studies or Delphi processed expert opinion.
- **Grade D** "No recommendation possible" would be used where the evidence is inadequate or conflicting and when expert opinion is delivered without a formal analytical process, such as by Delphi.

### 7. Levels of Evidence and Grades of Recommendation for Methods of Assessment and Investigation

From initial discussions with the Oxford group, it is clear that application of levels of evidence/grades of recommendation for diagnostic techniques is much more complex than for interventions. The ICUD recommends that, as a minimum, any test should be subjected to three questions:

- Does the test have good technical performance? For example, do three aliquots of the same urine sample give the same result when subjected to dipstick testing?
- 2. Does the test have good diagnostic performance, ideally against a "gold standard" measure?
- 3. Does the test have good therapeutic performance, that is, does the use of the test alter clinical management? Does the use of the test improve outcome?

For the third component (therapeutic performance) the same approach can be used as for section 6.

# 8. Levels of Evidence and Grades of Recommendation for Basic Science and Epidemiology Studies

The proposed ICUD system does not easily fit into these areas of science. Further research needs to be carried out in order to develop explicit levels of evidence that can lead to recommendations as to the soundness of data in these important aspects of medicine.

### Conclusion

The ICUD believes that its consultations should follow the ICUD system of levels of evidence and grades of recommendation, where possible. This system can be mapped to the Oxford system.

There are aspects to the ICUD system that require further research and development, particularly diagnostic performance and cost-effectiveness, and also factors such as patient preference.

# Summary of the International Consultation on Urological Disease Modified Oxford Centre for Evidence-Based Medicine Grading System for Guideline Recommendations

Levels of Evidence	Description
Ι	Meta-analysis of RCTs or high-quality RCT
II	Low-quality RCT or good-quality prospective cohort study
	Good-quality retrospective case-control study or cohort study
IV	Expert opinion

Abbreviation: RCT= randomized controlled trial

# Summary of the International Consultation on Urological Disease Modified Oxford Centre for Evidence-Based Medicine Grading System for Guideline Recommendations

Grades of Recommendation	Description
А	Usually consistent with level I evidence
В	Consistent level II or III evidence or "majority evidence" from RCTs
C	Level IV evidence or "majority evidence" from level II or III studies
D	No recommendation possible because of inadequate or conflicting evidence

Abbreviation: RCT= randomized controlled trial

# Scientific Committees



### CONSULTATION CHAIR

**Gerald Jordan** United States



### CONSULTATION CO-CHAIR

Christopher Chapple United Kingdom



### CONSULTATION CO-CHAIR

**Chris Heyns** South Africa

### Epidemiology, Anatomy and Nomenclature

## CHAIRS

COMMITTEE 1



**Jerilyn Latini** United States

Jerilyn M. Latini, United States Jack W. McAninch, United States MEMBERS

Steven B. Brandes, United States

Jae Yong Chung, South Korea

Daniel Rosenstein, United States



Jack McAninch United States

### Evaluation and Follow-Up

### **CHAIRS**



Kenneth Angermeier United States

Kenneth W. Angermeier, United States

Keith F. Rourke, Canada

**MEMBERS** 

Deepak Dubey, India

Robert S. Forsyth, Australia

Christopher M. Gonzalez, United States



Keith Rourke Canada

# Dilation, Internal Urethrotomy and Stenting of Male Anterior Urethral Strictures

### **CHAIRS**

**Chris Heyns** South Africa

Jill Buckley, United States

Chris Heyns, South Africa

### **MEMBERS**

Peter Gilling, New Zealand

Jeff Carney, United States

# COMMITTEE 4

### Anterior Urethra – Primary Anastomosis

Allen Morey United States

Allen F. Morey, United States

Nick Watkin, United Kingdom

### **MEMBERS**

Ofer Shenfeld, Israel

Ehab Eltahawy, Egypt

Carlos Giudice, Argentina

### Anterior Urethra – Lichen Sclerosus

### COMMITTEE 5

### **CHAIRS**



Laurence Stewart United Kingdom

Kurt McCammon, United States

Laurence Stewart, United Kingdom

### **MEMBERS**

Michael Metro, United States

Ramon Virasoro, Argentina

### COMMITTEE 6

### CHAIRS



Christopher Chapple United Kingdom

# The Management of Anterior Urethral Stricture Disease Using Substitution Urethroplasty

Christopher Chapple, United Kingdom

Anthony Atala, United States

### **MEMBERS**

Daniela Andrich, United Kingdom

Guido Barbagli, Italy

André Cavalcanti, Brazil

Sanjay Kulkarni, India

Altaf Mangera, United Kingdom

Yosuke Nakajima, Japan

### Pelvic Fracture Urethral Injuries (PFUI)

### **CHAIRS**



**Reynaldo G. Gómez** Chile



**Tony Mundy** United Kingdom

Reynaldo G. Gómez, Chile Tony Mundy, United Kingdom <u>MEMBERS</u> Deepak Dubai, India Abdel Wahab El-Kassaby, Egypt Firdaoessaleh, Indonesia Ron Kodama, Canada Richard Santucci, United States

### Posterior Urethral Stenosis After Treatment for Prostate Cancer

### **CHAIRS**



Sender Herschorn Canada

Sender Herschorn, Canada

Sean Elliott, United States

**MEMBERS** 

Michael Coburn, United States

Hunter Wessells, United States

Leonard Zinman, United States



Sean Elliott United States

### Urethral Strictures in Children

### **CHAIRS**



**George W. Kaplan** United States



John W. Brock United States

George W. Kaplan, United States

John W. Brock, United States

### MEMBERS

Margit Fisch, Germany Mamdouh M. Koraitim, Egypt Howard M. Snyder, United States

Epidemiology, Etiology, Anatomy, and Nomenclature of Urethral Stenoses, Strictures, and Pelvic Fracture Urethral Disruption Injuries

### CHAIRS

Jerilyn M. Latini, United States Jack W. McAninch, United States

### MEMBERS

Steven B. Brandes, United States Jae Yong Chung, South Korea Daniel Rosenstein, United States

1

# Committee

# CONTENTS

Epidemiology, Etiology, Anatomy, and Nomenclature of Urethral Stenoses, Strictures, and Pelvic Fracture Urethral Disruption Injuries

1.1	Background	_4
1.2	Introduction and Statement of the Problem	_5
1.3	Methods/Identification of References	_5
	1.3.1 Quality of the references	_6
1.4	Recommendations	_6

# Committee

1.5	Scientific F	oundations	6
	1.5.1	Nomenclature pertinent to urethral stenoses, strictures, and pelvic fracture urethral injuries	6
	1.5.2	Epidemiology and etiology of urethral stenoses, strictures, and pelvic fracture urethral injuries	8
	1.5.3	Mechanism of injury to the urethra	8
	1.5.4	Epidemiology and incidence of urethral stricture disease_	8
	1.5.5	Etiology of urethral stricture disease	9
	1.5.6	Economic impact of urethral stricture disease	_15
	1.5.7	Anatomy of urethral stenoses, strictures, and pelvic fracture urethral disruption injuries	_15
	1.5.8	Anatomy and nomenclature of the male urethra	_15
	1.5.9	Histology and pathology of urethral strictures	_20
	1.5.10	Spongiofibrosis and classification of urethral strictures	_22
1.6	Reference	S	_23

# 1.1 Background

### Aims

This committee was charged with the responsibility of reviewing and evaluating published data, and standardizing terminology relating to the epidemiology, etiology, anatomy, and nomenclature of urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries, as well as their surgical management.

### Methods

A literature search using Medline, PubMed (US National Library of Medicine and the National Institutes of Health), Embase, online acronym databases, and abstracts from scientific meetings was performed for documents published from 1980–2010. Articles were evaluated using the Levels of Evidence adapted by the ICUD (International Consultation on Urological Diseases) from the Oxford Centre for Evidence-Based Medicine. Recommendations were based on the level of evidence and discussed among the committee members to reach a consensus.

### Results

The nomenclature pertinent to urethral stenoses, urethral strictures, and pelvic fracture urethral injuries, as well as their surgical management, is presented in this chapter. There is expert opinion to support standards regarding the epidemiology, anatomy, and nomenclature of urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries.

The etiology of anterior urethral stricture disease may be broadly subcategorized into *iatrogenic*, *traumatic*, *inflammatory*, and *idiopathic* causes. There is level 3 evidence regarding the epidemiology and etiology of urethral stenoses, urethral strictures, and pelvic fracture urethral injuries. The gross and histologic anatomy of these conditions is presented in this chapter.

### Conclusions

The literature regarding the epidemiology, anatomy, and nomenclature of urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries is sparse and generally of a low level of evidence. The proposed ICUD system does not readily apply to the areas of epidemiology, anatomy, and nomenclature.

Further research is needed so that stronger levels of evidence can be developed that can lead to recommendations regarding the accuracy of the data. To improve future research and promote effective scientific progress and communication, a standardized nomenclature and anatomy as to the urethra and urethral surgery was formulated and is detailed herein. Further research is also needed to elucidate the mechanisms and etiology of certain urethral strictures and stenoses.

# 1.2 Introduction and Statement of the Problem

This committee was charged with the responsibility of reviewing and evaluating published data, and standardizing terminology relating to the epidemiology, etiology, and anatomy of urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries, as well as their surgical management.

Relevant genitourinary anatomy related to the evaluation and management of these conditions is presented. A standardized nomenclature for urethral anatomy, urethral strictures, urethral stenoses, urethral injuries, and urethral surgery was formulated and is detailed herein.

Adoption of this standardized nomenclature from this point on should improve future research and promote effective scientific progress and communication among urologists and reconstructive specialists involved in the evaluation and management of men with urethral stenoses, urethral strictures, and pelvic fracture urethral injuries.

# 1.3 Methods/Identification of References

A literature search using Medline, PubMed, Embase, online acronym databases, and abstracts from scientific meetings from 1980–2010 was the basis of this review. The online electronic literature search involved unrestricted, fully exploded Medical Subject Headings (MeSH) using terms related to urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries in males. Four online acronym databases—the ARGH (Acronym Resolving General Heuristics) program, the Stanford Biomedical Abbreviation Server, AroMed, and SaRAD (the Simple and Robust Abbreviation Dictionary)—were identified and queried regarding urethral surgery.

Articles were evaluated using the Levels of Evidence adapted by the ICUD from the Oxford Centre for Evidence-Based Medicine. Recommendations were based on the level of evidence and discussed among the committee members to reach consensus. Recommendations for future research are also presented.

### 1.3.1 **Quality of the references**

**Level 1**: Meta-analyses of randomized controlled trials (RCTs) or good-quality prospective RCTs. (Oxford 1a,b) **[0 references]** 

**Level 2**: Clinical studies in which the data were collected prospectively and retrospective analyses based on clearly reliable data. Types of studies so classified include: observational studies, cohort studies, prevalence studies, low-quality RCTs, and case-control studies. (Oxford 2a,b,c) [**0 references**] **Level 3**: Studies based on retrospectively collected data. Evidence in this class includes case-control studies, clinical case series, and database or registry reviews. (Oxford 3a,b,c) [~90 references] **Level 4**: Expert opinion (Oxford 4)

# 1.4 **Recommendations**

There is insufficient Level 1 and 2 evidence/data to support any grade A or B recommendations, but there is Level 3 evidence to support grade C recommendations regarding the epidemiology, anatomy, and nomenclature of urethral stenoses, urethral strictures, and pelvic fracture urethral injuries.

# 1.5 Scientific Foundations

# 1.5.1 **Nomenclature pertinent to urethral stenoses, strictures, and pelvic fracture urethral injuries**

Urethral "stricture" is the preferred term to describe an abnormal narrowing of any segment of the urethra surrounded by corpus spongiosum, and specifically implies varying degrees of spongio-fibrosis. The term "spongiofibrosis" refers to scarring of the corpus spongiosum of varying degrees. Urethral "stricture disease" implies the underlying etiology. The Consultation Committee recommends that urethral terminology should be anatomical; therefore, the preferred term to describe urethral narrowing/obliteration is urethral "stricture." The term "stricture disease" should be reserved as a second-tier term. The term "stenosis" is reserved for narrowing of the membranous urethra not secondary to pelvic fracture urethral injury, the prostatic urethra, and the bladder neck, as they are not invested by corpus spongiosum. Importantly, the term "stenosis" does not imply spongiofibrosis.

Urethral "calibration" refers to the measurement of the calibre (diameter) of the urethral lumen by various techniques. Urethral "dilation" refers to the stretching or enlargement of the urethral lumen by various techniques. The Consultation recognizes that the term "dilatation" is used interchangeably. "Urethrotomy" is the general term to describe the incision of urethral epithelium and underlying spongiosum by either endoscopic or open techniques. "Internal urethrotomy" refers to an endoscopic urethrotomy performed with or without visual guidance. "Direct vision internal urethrotomy" (DVIU) refers to an endoscopic, visually guided incision of the scarred urethra using various techniques and is the preferred term. Second-tier terms are "optical internal urethrotomy" (OIU) and "visual internal urethrotomy" (VIU).

Regarding urethroplasty techniques, the term "onlay" refers to expanding the calibre of the urethra with a tissue graft or flap. The term "inlay" is not descriptive and not acceptable. "Excision and primary anastomosis (EPA) urethroplasty/urethral reconstruction" refers to when a narrowed urethral segment and its corresponding spongiofibrosis are excised with reapproximation of the two healthy ends of the urethra. This is the most descriptive, accurate, and appropriate term for this type of urethroplasty. The term "anastomotic urethroplasty/urethral reconstruction" should be reserved as a second-tier term, and "end-to-end urethroplasty" as a third-tier term. "Posterior" urethral reconstruction refers to reconstruction of the membranous urethra or prostatic urethra by various techniques and includes the subcategory of anastomotic repair for pelvic fracture urethral injuries.

The term "graft" refers to a tissue transfer technique where healthy tissue is harvested from one part of the body and transferred to another in order to replace diseased or injured tissue. A graft is without its own blood supply and relies on diffusion from its host bed for initial survival and subsequent re-establishment of the blood supply. "Flap" refers to a tissue transfer technique where healthy tissue is transferred on a vascular pedicle from one part of the body to another in order to replace/augment diseased or injured tissue. It is recognized that the continuity of the pedicle for microvascular free transfer flaps is surgically re-established at the time of surgery. Specific further description of tissue grafts and flaps is based on their anatomic donor site of origin and structure and will not be described herein. The term "augmented urethroplasty/urethral reconstruction" describes urethral reconstruction with a tissue graft or flap, whereas the term "substitution urethroplasty/urethral reconstruction" describes urethral reconstruction with a tubularized tissue graft or flap. "Augmented anastomotic urethroplasty/urethral reconstruction" is a procedure in which the stricture is excised, a portion of the urethra is anastomosed (either ventrally or dorsally), and a graft or flap is placed on the contralateral side to complete the urethroplasty/urethral reconstruction.

### Level of Evidence: 4

Recommendation: C
# 1.5.2 **Epidemiology and etiology of urethral stenoses, strictures, and pelvic fracture urethral injuries**

Urethral stricture disease results from a number of different etiologies. An understanding of the underlying cause of a particular stricture is helpful in determining the most appropriate type of repair. It may also impact the outcome and sequelae of the treatment options. Whereas inflammatory causes once accounted for the majority of urethral strictures, these have now become infrequent in the developed world. Iatrogenic injury to the urethra now accounts for most strictures, largely as a result of urethral catheterization or traumatic instrumentation. Further causes include external violence, which may result in blunt or penetrating trauma, ischemic urethral injury, and congenital strictures—the rarest type. This section classifies the most common etiologies of urethral strictures.

### 1.5.3 Mechanism of injury to the urethra

Injury to the anterior urethra results in scarring of the spongy tissue of the corpus spongiosum, or spongiofibrosis. This injury occurs outside the spongiosum as a result of blunt or penetrating injury, or results from internal disruption of the fragile urethral epithelium via instrumentation or inflammatory disease. The partial loss of the epithelial lining is the initiating factor in anterior urethral stricture disease. This typically results in a narrowing of the urethral calibre because the remaining epithelium is re-approximated by natural urethral closure pressure. The underlying de-epithelialized regions expose the underlying vascular spongy tissue, which heals by cross-adhesion and subsequent spongiofibrosis (1). The degree of spongiofibrosis underlying a stricture depends on both the degree of injury and the underlying etiology. These factors have important implications regarding treatment choice and expected outcome.

Devine *et al.* proposed a standardized classification system for urethral strictures based on degree of spongiofibrosis in 1983 (2). Based on this classification, Jordan has proposed an anatomic approach to the management of strictures, with patients being offered only those procedures that have resulted in high success rates in strictures of similar anatomic type (3). Adherence to this approach has resulted in success rates of 90%–93% in nearly all stages of anterior urethral strictures (4).

### 1.5.4 **Epidemiology and incidence of urethral stricture disease**

There are no direct measures of the true incidence of urethral stricture disease. A recent publication by Santucci *et al.* reviewed the available data from 10 public and private databases in the US in order to estimate the incidence and cost of this condition to the health care system (5). The incidence was estimated to be approximately 0.6% in susceptible populations, with 1.5 million office visits recorded between 1992 and 2000. In a follow-up publication, Anger *et al.* found that the incidence of urethral stricture diagnoses among Medicare beneficiaries dropped from 1.4% in 1992 to 0.9% in 2001 (6).

Level of Evidence: 3

Recommendation: N/A

### 1.5.5 **Etiology of urethral stricture disease**

### Overview

The etiology of anterior urethral stricture disease may be broadly subcategorized into *iatrogenic*, *traumatic*, *inflammatory*, and *idiopathic* causes. A recent meta-analysis of etiology in 732 stricture patients found that idiopathic and iatrogenic subtypes were by far the most common (7), accounting for 33% and 33% of all cases, respectively. Inflammatory and post-traumatic etiologies were found in only 15% and 19% of patients, respectively.

In another recent review, 268 Belgian urethral stricture patients were found to have predominantly idiopathic causes in men younger than 45 years, with iatrogenic causes (specifically, previous transurethral resection of the prostate—TURP) found mostly in men older than 45 years (8). A major weakness of this paper was that the study group was a cohort of highly selected patients who underwent urethroplasty at a referral centre rather than all Belgian men with urethral strictures.

Stricture etiology also varies significantly according to the location within the anterior urethra. In the recent review of 194 strictures by Fenton *et al.* (7), inflammatory etiologies were more common underlying causes of strictures of the fossa navicularis and penile urethra than of bulbar strictures (27% vs. 13%). Conversely, iatrogenic strictures were predominant in the bulbar urethra (52%), with trans-urethral surgery accounting for most of this subgroup.

### latrogenic: urethral instrumentation

Urethral strictures can manifest following various trans-urethral procedures. Diagnostic cystoscopy and urethral dilation are frequent causes of distal anterior urethral strictures. The frequency of post-TURP urethral stricture ranges from 1.9%–9%. The Agency for Health Care Policy and Research (AHCPR) found a stricture rate of 3.1% in their review for the benign prostatic hyperplasia (BPH) guideline report (9).

The etiology of post-TURP strictures remains controversial. In a retrospective analysis of etiologic factors in post-TURP stricture disease, Jorgensen *et al.* found a correlation between pre-operative indwelling catheters and post-operative stricture formation, possibly as a result of mechanical trauma to an acutely inflamed urethra (10). This group observed no significant correlation between stricture and urinary tract infection or prostatic carcinoma, or mechanical disproportion between urethral and resectoscope sheath diameter. Zheng *et al.* used an *in vitro* model to demonstrate that stricture may result from urethral electrical burn as a result of poorly insulated resecting loops (11).

Prostatic urethral stenoses have been reported following minimally invasive procedures for benign prostatic enlargement/hyperplasia. Sall and Bruskewitz reported on three patients who developed clinically significant mid-prostatic urethral stenoses following trans-urethral microwave thermotherapy (TUMT) (12). They postulated that the stenoses resulted from direct ischemic damage to the prostatic urethra secondary to heat delivery, despite continuous urethral cooling.

Long-term indwelling catheters are closely associated with urethral stricture development. The mechanism of injury is pressure necrosis of the fragile epithelium, as well as chronic inflammation from infection perpetuated by the catheter. Changes in catheter design, e.g., substitution of silicone for latex, have helped to reduce stricture incidence. Clean intermittent catheterization is a widely applied technique for facilitation of bladder emptying in various conditions. Hydrophilic catheters may be used for intermittent catheterization without catheter jelly (13). Urethral strictures arise following prolonged periods of intermittent catheterization. In a series of 75 patients with a mean follow-up of 7 years, Wyndaele and Maes found urethral structures to be the most common complication, mostly occurring after 5 years of intermittent catheterization (14).

Visual internal urethrotomy has been widely used as first-line therapy for short segment strictures. Stricture recurrence following internal urethrotomy is a common finding, particularly in series with longer follow-up. In a large retrospective analysis, Albers *et al.* found an approximately 37% recurrence rate with a mean follow-up period of 4 years (15). Risk factors for recurrence included strictures longer than 1 cm and post-operative catheter drainage for longer than 3 days. They suggested that urethroplasty/urethral reconstruction be considered in patients at high risk for stricture recurrence and in those with one treatment failure following internal urethrotomy.

Others have confirmed the law of diminishing returns with repeated dilation or internal urethrotomy for recurrent strictures. Heyns *et al.* prospectively followed 210 men for 48 months following dilation or internal urethrotomy, and found that a second dilation for early stricture recurrence was of no value at the 2–year follow-up point (16). Many believe that repeated dilations or internal urethrotomies establish a chronic inflammatory process within the corpus spongiosum, which may be perpetuated by urine extravasation within the corpus spongiosum. Barbagli *et al.* showed diffuse inflammation in excised post-urethrotomy spongiosum at the time of eventual urethroplasty, and suggested that post-urethrotomy recurrences are secondary to diffuse disease of the corpus spongiosum (17). Conversely, Kjaergaard *et al.* found that weekly clean intermittent catheterization significantly reduced the frequency of stricture recurrence at the original site after internal urethrotomy (18).

The UroLume<sup>®</sup> endoprosthesis has been used successfully in treating short bulbar strictures in appropriately selected patients (19). In addition to the complications of stent migration and encrustation, recurrent stricture may complicate use of the endoprosthesis. This may result from incorrect stent deployment, with part of the original stricture lying outside the end of the stent (20). An additional overlapping stent may be added to treat the recurrence. Similarly, if overlapping stents become separated, fibrosis and obstruction between the stents may occur. Post-operative intrastent hyperplasia may also cause obstruction, typically in the first 3 months following stent insertion (19). In symptomatic cases, this may be dealt with using careful resection. Histologic evaluation of resected hyperplastic tissue reveals polypoid hyperplasia with variable inflammatory cell infiltrates (21). Complications arising from the use of the UroLume stent have been seen secondary to its use outside of its current applications, and thus careful patient selection is critical to the successful use of this device (22).

Iatrogenic urethral strictures arise secondary to various ablative and reconstructive surgeries of the genitourinary tract. In the pediatric population, urethral stricture following posterior urethral valve ablation has been reported. Lal *et al.* found a 3.6% incidence in this setting, and suggested that these strictures are best avoided by employing meticulous surgical technique and avoiding oversized instruments (23). Children undergoing surgical correction of anorectal malformations are also at high risk of iatrogenic urethral stricture development. In the series of Misra *et al.*, infants with high anorectal malformation and those who underwent abdominoperineal pull-through (vs. posterior sagittal anorectoplasty) were at the greatest risk (24).

Urethral strictures are also a recognized complication of hypospadias repair, occurring in up to 10% of cases. In the series of Duel *et al.*, 29 such patients were treated with initial internal urethrotomy, but ultimately, 79% of those patients required urethroplasty/urethral reconstruction to achieve asymptomatic voiding without fistula or residual stricture (25). This was due to delayed failure of the initial operative procedure. These authors highlight the fact that internal urethrotomy may be warranted for a short post-hypospadias simple anastomotic stricture, but in cases of long stenoses (e.g., free graft failure), repeat urethroplasty/urethral reconstruction should be considered as a first-line treatment.

Meatal stenosis is a common complication following circumcision, although the exact incidence is unclear. The etiology in this setting may result from non-specific meatitis secondary to friction/ trauma or from meatal ischemia due to circumcision-induced injury to the frenular artery (26). Some authors highlight the under-reporting of post-circumcision meatal stenosis because symptomatic presentation may not occur until years later (27).

In the adult population, urethral strictures have been reported in association with extracorporeal circulation during cardiac revascularization surgery. Peri-operative urethral catheterization has been implicated, and a recent retrospective analysis showed a 6.6% stricture rate in patients with urethral catheter drainage compared to 0% in a comparable group treated with suprapubic urinary drainage (28). Some have suggested that urethral ischemia during extracorporeal circulation is causative (29). Bamshad *et al.* recently demonstrated a significant decrease in intra-operative urethral blood flow using laser Doppler flowmetry during cardiopulmonary bypass (30).

An uncommon group of patients with urethral strictures are those who have undergone total phallic construction—typically as a result of gender dysphoria, severe congenital deformity, or penile loss later in life. In this subset of patients, strictures typically develop at the native-neourethral anastomosis. These may develop secondary to relative ischemia at the anastomotic site or by kinking of the base of the phallus. Levine *et al.* reviewed their series of urethroplasties following phalloplasty, and highlight the superior results obtained using buccal mucosa grafts compared to other techniques in this population (31). Jordan *et al.* have stressed the value of incorporation of a gracilis muscle flap transferred to the perineum for adequate coverage of the neo-urethra to native urethra anastomosis (32).

Posterior urethral stenosis may arise from treatment for prostate cancer. A recent review found the incidence of stenosis treatment to be 5.2%, while the actual incidence of stenosis occurrence may be somewhat higher (33). Stenosis rates were highest with radical prostatectomy, followed by combination external beam plus brachytherapy.

### Trauma

Anterior urethral injury as a result of external trauma may be either blunt or penetrating in nature. Blunt urethral trauma results from straddle- or deceleration-type injuries, in which the relatively immobile bulbar urethra is compressed against the pubic bone. These injuries are rarely associated with pelvic fractures (unlike posterior urethral disruptions), and may present after a prolonged period if the initial injury went unrecognized. Rarely, the anterior urethra may be injured secondary to the buckling trauma related to a penile fracture. The frequency of urethral injury associated with penile fracture ranges from 3%–20%, depending on the study cited.

Traumatic anterior urethral disruptions may also be related to penile fracture in approximately 10%–20% of cases. The mechanism of injury is usually a direct blow or buckling force applied to the erect penis, resulting in a tear of the tunica albuginea of the corpus cavernosum with sudden detumescence (34). If the tear extends into the corpus spongiosum, a urethral injury may result. Because of the association of penile fracture with urethral injury, a retrograde urethrogram should be performed prior to surgical exploration and tunical repair. In a recent case report of penile fracture with complete urethral disruption at the level of the pendulous urethra, Gottenger and Wagner reported performing primary anastomotic repair with a good long-term outcome (35). A similar approach has also been described for penile fracture with partial urethral disruption (36).

Penetrating injuries of the anterior urethra usually result from gunshot wounds, which rarely involve the urethra in isolation. Patients may sustain gunshot wounds to the penis and/or anterior urethra (37–43). In cases of extensive urethral destruction (shotgun, high-velocity bullets) temporary suprapubic diversion followed by definitive urethroplasty is appropriate. Less common causes of penetrating injury include stab wounds and penile amputation injuries. Anterior urethral injuries may be classified according to their radiographic appearance as *contusions, incomplete disruptions*, or *complete disruptions* (44). In the unified blunt urethral trauma classification of Goldman *et al.*, all partial or complete blunt anterior urethral injuries are classified as type 5 (45).

As with anterior urethral injuries leading to stricture, posterior urethral injuries can be associated with significant traumatic mechanisms. Posterior urethral injuries commonly occur in association with pelvic fractures. Shear mechanisms resulting in pelvic fracture may tear through the urethra at the bulbomembranous junction. The incidence of this injury ranges from 3%–25%, depending on the study and the specific type of pelvic fracture. The recent SIU (Société Internationale d'Urologie) consensus statement makes the important distinction between *strictures* of the anterior urethra and *disruptions* of the posterior urethra, usually following pelvic fracture injuries (46). Pelvic fracture urethral disruption (distraction) injuries are addressed in great detail in another section of this Consultation. By consensus of the Consultation, Pelvic Fracture Urethral Distraction Defects represent a subset of the larger Pelvic Fracture Urethral Injuries subcategory.

### Inflammatory

Lichen sclerosus (LS) is a progressive sclerosing process, which can involve the penile shaft skin, glans, meatus, or anterior urethra. It is currently the most common inflammatory cause of glanular urethral strictures and acquired meatal strictures. Lichen sclerosus is commonly found at the time of circumcision performed for phimosis beyond the neonatal period (47), and has also been found to occur several years after hypospadias repair (48).

The exact cause of LS remains elusive, but trauma, autoimmune disorders, and infectious agents (most recently the spirochete *Borrelia burgdorferi*) have been implicated as causative (49). Histologically, LS is characterized by hyperkeratosis of the epidermal layer with collagenization of the underlying dermis. Clinically, LS may present as phimosis in an uncircumcised male, or it may appear as typically whitish sclerotic plaques on the glans. Lichen sclerosus may also present with obstructive voiding symptoms, as the disease progressively involves the meatus and fossa navicularis. The damaging effects of high-pressure voiding against an obstructed meatus compound this process and the injury caused by repeated instrumentation in many cases (37). The clinician must maintain a high index of suspicion for urethral involvement in the setting of LS and meatal stenosis. Lichen sclerosus is most common in Caucasian subjects, with a female-to-male prevalence of between 6:1 and 10:1 (50). Notably, the first-tier term for this process should be "lichen sclerosus" or "lichen sclerosis" (LS). The term "balanitis xerotica obliterans" (BXO) is antiquated and not acceptable.

Reiter's syndrome is an unusual cause of inflammatory urethral stricture disease. It is a form of reactive arthritis occurring after enteric or urogenital infections, usually occurring in patients possessing the histocompatibility antigen HLA-B27 (51). Urogenital infections come from *Chlamydia trachomatis* and possibly *Ureaplasma urealyticum* (52). The classic triad of urethritis, arthritis, and conjunctivitis may present to varying degrees. A specific agent in a susceptible host may trigger these symptoms. Mucocutaneous lesions of the glans are uncommonly found, superficial, painless ulcers, referred to as balanitis circinata (53). Although urethral involvement is usually mild and self-limiting, Jordan *et al.* have found rare cases of severe mucosal inflammation and necrosis (44). They have approached this devastating manifestation with urethral excision and perineal urethrostomy construction.

Vitiligo is an uncommon disorder of localized hypopigmentation, which may involve the genital skin (54). Histologically, vitiligo typically reveals the absence of melanocytes. Theories of pathogenesis include autoimmunity or neurohumoral factors leading to destruction of melanocytes (55). Urethral involvement arising from vitiligo is rare, but an inflammatory variant of the disease localized to the glans results in meatal stricture (56).

Bulbar urethritis is a common urologic problem in pre-pubertal and adolescent boys that may be associated with dysuria, meatal blood spotting, and microscopic hematuria. This has also been called idiopathic urethrorrhagia. In severe cases, bulbar urethral strictures may be associated with this condition. The exact etiology for this condition remains elusive, but Docimo *et al.* attribute it to the frequent histologic finding of squamous metaplasia of the urethra (57). They suggest that stricture formation may result from inflammation rather than instrumentation. Similarly, Dewan and Wilson reviewed seven cases of bulbar urethritis, and were in agreement as to the inflammatory nature of the strictures found. They postulate either an immunoreactive or infective agent as possible etiologic agents (58).

### Post-infectious

Recurrent gonococcal urethritis once accounted for the majority of anterior urethral strictures. *Neisseria gonorrhoeae* possesses particular types of pili that mediate attachment to urethral mucosa. This prevents clearance by urine flow. Gonococci are then internalized by urethral epithelial cells, and subsequently multiply within phagocytic vacuoles. These vacuoles are then discharged into the subepithelial connective tissue, where the multiplied organisms typically evoke a brisk inflammatory response. Clinically, this manifests as dysuria and purulent urethral discharge. Inflammatory infiltrates in the submucosa ultimately lead to spongiofibrosis and stricture, particularly if the infection is prolonged, recurrent, or untreated. The advent of effective antibiotic treatment has made such progression to stricture uncommon in North America, but post-gonococcal strictures still account for the majority of strictures in the developing world. In a review of stricture etiology in 556 men in Nigeria, Ahmed and Kalayi found that 66.5% were post-infectious in nature (59). Similarly, Sharfi and Elarabi's series of urethrocutaneous fistulas from Sudan revealed that 82% of patients had a past history of gonococcal infection (60).

In contrast, a large retrospective study of the incidence of urethral stricture in Scotland found that post-infectious stricture was an uncommon cause of stricture from 1982–1991 (61). The role of non-gonococcal urethritis (NGU) in stricture development remains unclear. It has been postulated that chronic post-chlamydial urethral inflammation may be mediated by delayed hypersensitivity mechanisms (55). *Ureaplasma urealyticum* and *Mycoplasma genitalium* were recently shown to be unlikely to be causative of clinically significant epithelial disease (62). More uncommon infectious diseases may also result in urethral stricture disease. These include tuberculosis, schistosomiasis, and others (63). In endemic areas, consideration should be given to these etiologies.

### Congenital

Congenital urethral strictures are the least common subcategory. It is a diagnosis that can be reasonably made only in the absence of inflammation, trauma, infection, and urethral manipulation. A review of pediatric stricture etiology in 36 children revealed that in only 2/36 children could the cause of stricture be deemed congenital (64). Cobb originally described a congenital narrowing of the bulbar urethra believed to be embryologically related to the rupture of the cloacal membrane or urogenital diaphragm (65). There is some dispute regarding whether this narrowing represents a variant of Young's Type 3 posterior urethral valve.

Nonomura *et al.* reviewed 74 boys who were found to have symptomatic congenital bulbar urethral narrowing, with a 93% improvement rate following trans-urethral incision (66). This group strongly advises meticulous cystourethroscopy in order to ascertain the presence of a significant Cobb's collar. Another rare form of congenital stricture disease may manifest in the form of amniotic band syndrome. This unusual syndrome results in compression deformities caused by amniotic bands *in utero*. Chen *et al.* recently reported a case of distal obstructive uropathy and prune-belly syndrome secondary to a fibrous band attached to the proximal urethra (67).

### Summary

Urethral stricture disease represents the final common pathway of a variety of different insults to the urethra. In the developed world, iatrogenic and traumatic injuries now account for the majority of urethral strictures, while post-infectious and congenital etiologies are less frequently encountered.

Inflammatory disease related strictures (e.g., LS) often present a particular reconstructive challenge and seem to be becoming more common. Thus, an understanding of each of the basic etiologies outlined here will help the reconstructive surgeon to determine the most appropriate treatment course.

Level of Evidence: 2b

Recommendation: N/A

### 1.5.6 **Economic impact of urethral stricture disease**

In the US national databases reviewed by Santucci *et al.*, the estimated annual expenditure for urethral stricture disease was \$191 million, or \$6000 per year for each patient treated (5). While this estimate applies only to the US, the amount is significant by US standards for a single diagnosis, and is relevant internationally as a considerable expenditure for a commonly encountered problem. Various authors have addressed the most cost-effective approach to treating urethral stricture disease. Rourke and Jordan used a cost minimization decision analysis model that suggested that treatment with internal urethrotomy for a 2 cm bulbar stricture was more costly than early urethroplasty (68).

In contrast, the decision analysis model of Wright *et al.* suggested that urethroplasty as primary therapy for bulbar strictures measuring 1–2 cm is cost effective only if the predicted success of an initial DVIU is less than 35% (69). In terms of cost effectiveness, they recommended urethroplasty for strictures that recur after a single DVIU or in cases where urethrotomy has a predicted success rate below 35%. In a series reviewing cost analysis from the United Kingdom, Greenwell *et al.* also concluded that the most cost-effective strategy in patients with recurrent strictures was initial urethrotomy followed by urethroplasty/urethral reconstruction (70).

# 1.5.7 **Anatomy of urethral stenoses, strictures, and pelvic fracture urethral disruption injuries**

A thorough understanding of the pertinent anatomy and its nomenclature is crucially important to improve future research and promote effective scientific progress and communication among urologists and reconstructive specialists involved in the evaluation and management of men with urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries. An extensive review of the anatomy of the penis, urethra, and male pelvis is beyond the scope of this manuscript but we refer the reader to various comprehensive reviews (71–73).

### 1.5.8 Anatomy and nomenclature of the male urethra

The penis is composed of three erectile bodies (two corpora cavernosa and the corpus spongiosum), fascial layers, arteries, veins, and nerves. The corpora cavernosa contain erectile tissue within the tunica albuginea, a dense elastic sheath of connective tissue.

The corpus spongiosum lies in the ventral groove beneath the two corpora cavernosa and contains the urethra. The tunica albuginea surrounds the majority of the three corporal bodies as an inner circular layer and outer longitudinal layer; however, there are no outer longitudinal fibres between 5- and 7-o'clock on the corpus spongiosum. The tunica albuginea of the corpora cavernosa is thicker than that of the corpus spongiosum. The distal end of the corpus spongiosum expands to form the glans penis, a broad cap of erectile tissue covering the distal ends of the corpora cavernosa. The penis is supported at its base by two ligaments continuous with the fascia of the penis. Posterior to this, the two corpora cavernosa diverge, and the corpus spongiosum broadens between the two crura to form the bulbospongiosus (bulb of the urethra).

The three erectile bodies of the penis are surrounded by Buck's fascia, the dartos fascia, and the skin. The dartos fascia is a layer of areolar tissue remarkable for its lack of fat that extends from the foreskin (prepuce) into the perineum, where it fuses with the superficial perineal (Colles') fascia. In the penis, the dartos fascia is loosely attached to the skin and the deeper layer of Buck's fascia, and contains the superficial arteries, veins, and nerves of the penis. Buck's fascia is the tough, elastic layer immediately adjacent to the tunica albuginea. On the superior aspect of the corpora cavernosa, the deep dorsal vein, paired dorsal arteries, and multiple branches of the dorsal nerves are enclosed within Buck's fascia. Buck's fascia splits in the midline groove on the underside of the corpora cavernosa to surround the corpus spongiosum. The fascial layers merge lateral to the corpus spongiosum and join the tunica albuginea of the corpora cavernosa. Buck's fascia extends from the undersurface of the glans penis at the corona into the perineum, enclosing each crus of the corpora cavernosa and the bulb of the corpus spongiosum, firmly fixing these structures to the pubis, ischium, and inferior fascia of the perineal membrane (urogenital diaphragm).

The urethra is the lumen of an epithelialized tube for the passage of urine and semen that extends from the distal bladder neck to the meatus. The "anterior" urethra extends from the meatus to the proximal bulbar urethra (or distal membranous urethra) and is entirely surrounded by the corpus spongiosum. The "posterior" urethra extends from the distal bladder neck to the distal membranous urethra (or proximal bulbar urethra). The consensus opinion of a World Health Organization (WHO) conference convened in Stockholm in 2002 is that the terms "anterior" and "posterior" urethra should be discarded. This International Consultation agrees and the recommended nomenclature reflects the fact that the urethra is subdivided into the following segments:

- 1. The urethral meatus is a slit-like opening located at the tip of the glans penis slightly ventrally, with its long axis oriented vertically. It is the termination of the urethra at the distal end of the penis. The term "external meatus" is redundant and thus it is recommended that the accepted term be "meatus" only.
- 2. The fossa navicularis is the distal portion of the penile urethra located within the erectile tissue of the glans penis proximal to the meatus. It ends at the junction of the urethral epithelium with the skin of the glans. The fossa navicularis is lined with stratified squamous epithelium. The term "glanular urethra" is confusing, as the fossa navicularis is part of the penile urethra. It is therefore recommended that the term "glanular urethra" is no longer acceptable.

- 3. The penile urethra extends from the meatus to the distal edge of the bulbocavernosus muscle. It is completely surrounded by the corpus spongiosum and maintains a constant lumen size, generally centred in the corpus spongiosum. The penile urethra is lined with simple squamous epithelium. The term "pendulous urethra" is confusing and not descriptive, so it is recommended that the correct term be "penile urethra."
- 4. The bulbar urethra extends from the proximal penile urethra to the distal membranous urethra. It is surrounded by the bulbospongiosus of the corpus spongiosum and covered by the midline fusion of the ischiobulbocavernosus muscle. It becomes larger and lies closer to the dorsal aspect of the corpus spongiosum as it extends proximally. The bulbar urethra is lined with squamous epithelium distally that progressively changes to transitional epithelium in the membranous urethra.
- 5. The membranous urethra extends from the proximal bulbar urethra to the distal verumontanum. It is surrounded by the voluntary external sphincter mechanism, both the smooth muscle external sphincter and the striated/rhabdosphincter. The membranous urethra is unattached to any fixed structure and is the only segment of the male urethra not surrounded by any other structure. It is lined with transitional epithelium.

- 6. The prostatic urethra extends from the proximal edge of the membranous urethra or the proximal verumontanum to the distal bladder neck. It is surrounded by the prostate. The transitional epithelium of the prostatic urethra is continuous with the trigone and bladder.
- 7. The bladder neck is surrounded by the fibres of the detrusor muscle and variably by any intravesical extension of the prostate. The transitional epithelium of the bladder neck is continuous with the trigone and bladder. When the bladder neck is affected by scarring, the term "bladder neck stricture" is not descriptive or correct because there is no corpus spongiosum located at the bladder neck, and by definition a "stricture" involves scarring of the corpus spongiosum or spongiofibrosis. The term "bladder neck contracture" is also not descriptive and is confusing. It is recommended that the preferred term be "bladder neck stenosis" when the prostate is in situ or "vesico-urethral anastomotic stenosis" after radical/total prostatectomy. Therefore, the terms "bladder neck stricture" and "bladder neck contracture" are no longer acceptable.

The normal anatomic description of the urethra is with the penis in the erect state. Therefore, the dorsal urethra is that aspect of the urethra closest to the corpora cavernosa. The ventral urethra is the contralateral aspect of the urethra, farthest from the corpora cavernosa.

Urinary continence in men results from sphincter mechanisms located along the urethra from the bladder neck to the distal membranous urethra. Multiple muscular "sphincters" are described in the male urethra (71). Beginning proximally, there is the bladder neck. The prostate contains a muscular stroma that continues into the membranous urethra as the external smooth muscle sphincter. The external rhabdosphincter, often referred to simply as the external sphincter, is composed of slow-twitch striated muscle for voluntary urinary control. In the region of the membranous urethra there are peri-urethral striated muscles of recruitment, which are not true sphincters but provide support for volitional continence. They allow for momentary interruption of the urine stream but

are incapable of maintaining continence in the absence of a functional intrinsic mechanism. Brooks *et al.* (74) created computer-generated three-dimensional reconstructions of the male pelvis and provided unique insights into the anatomy. The striated urethral sphincter appears circular with abundant tissue posteriorly. This sphincter muscle has greater length anteriorly than posteriorly.

Yucel and Baskin (75) dissected 12 male normal human pelvises ranging from 17.5 to 38 weeks of gestation. Three-dimensional reconstructions were created to demonstrate the lower urogenital tract and urethral sphincter anatomy. They determined that the urinary continence mechanism is formed by a combination of detrusor, trigone, and urethral sphincter muscles with distinctive histological characteristics in both sexes. In males, the external urethral sphincter covers the ventral surface of the prostate in a crescent shape above the verumontanum, a horseshoe shape below the verumontanum, and a crescent shape along the proximal bulbar urethra. The levator ani muscles form an open circle around the external sphincter with a hiatus at the ventral aspect. As the levator ani does not surround the ventral aspect of the urethra, it may not have an active role in continence in males.

Dalpiaz *et al.* (76) carefully dissected 15 male human cadavers to investigate the anatomy of the male rhabdosphincter, neurovascular bundles, and membranous urethra, as well as their relationship. The membranous urethra (about 1.5 cm long) contains smooth muscle fibres. In histological cross-sections, the rhabdosphincter forms an omega-shaped loop around the ventral and lateral aspects of the membranous urethra. It is separated from the membranous urethra by a delicate sheath of connective tissue. Based on precise anatomical knowledge, the ventral wall of the membranous and prostatic urethra can be dissected and exposed without injuring the rhabdosphincter's external smooth muscle and the neurovascular bundles. This anatomical approach helps preserve the muscular structures involved in the continence mechanism (77). Continence after anastomotic urethroplasty/urethral reconstruction for post-traumatic posterior urethral stenoses is maintained solely by the proximal urethral mechanism.

In terms of urethral injury that occurs with a pelvic fracture, it is recommended that "pelvic fracture urethral injury" (PFUI) be the preferred term. This terminology reflects the fact that various injury mechanisms may be involved, each resulting in fibrosis. This includes entities such as injury to the proximal bulbar urethra that may result in spongiofibrosis and proximal bulbar urethral stricture. This also includes entities such as complete urethral disruption with loss of urethral continuity, which, by definition, is not a urethral "stricture" because it does not involve spongiofibrosis. In these cases of urethral disruption with loss of urethral continuity, "pelvic fracture urethral distraction defect" (PFUDD), as discussed previously, is the preferred term, and "posterior urethral stricture" is not acceptable. It is recognized that "urethral disruption defect" is an alternative, second-tier term.

Mouraviev and Santucci (78) reported that posterior urethral disruption injuries (in their cadaveric anatomy models) appear to most commonly occur distal to the urogenital diaphragm, contrary to classic teaching. These injuries are on average between 3 and 4 cm and are more significant dorsally than ventrally. They appear to occur as simple or complex injuries, mirroring the clinical findings seen in clinically simple and complex urethral strictures. Andrich and Mundy (79) suggested that the urethral injury associated with pelvic fracture is an avulsion of the membranous urethra from the bulbar urethra rather than a shearing through the membranous urethra, and that some degree of urethral sphincter function is preserved in a significant percentage of patients.

Andrich *et al.* (80) proposed mechanisms of lower urinary tract injury in fractures of the pelvic ring. They found that the pattern of pelvic fracture did not help to predict the presence of lower urinary tract injury, but the type of injury was related to the fracture mechanism. The pattern of injury to the soft tissue envelope and specifically to the ligaments supporting the lower urinary tract offers the best correlation with the observed injury.

A detailed description of the venous, arterial, lymphatic, and nervous anatomy of the penis is beyond the scope of this manuscript. Briefly, the penis is drained by three venous systems: superficial, intermediate, and deep. The superficial veins in the dartos fascia on the dorsolateral penis unite at its base to form a single superficial dorsal vein, which generally drains into the left saphenous vein, rarely into the right, and occasionally as two veins that drain into both. More superficial veins may drain into the external superficial pudendal veins. The intermediate system contains the deep dorsal and circumflex veins within and beneath Buck's fascia, with emissary veins in the corpora cavernosa passing through the tunica albuginea from the lateral and dorsal surfaces of the corpora cavernosa to empty into the circumflex veins or the deep dorsal vein. The circumflex veins arising from the corpus spongiosum (usually in the distal two thirds of the ventral penis) receive the emissary veins from the corpora cavernosa to empty into the deep dorsal vein. They communicate with one another and those of the opposite side to form common venous channels, usually accompanied by dorsal nerve and artery branches, and can also become confluent ventrally, forming bilateral peri-urethral veins. The deep dorsal vein is formed by veins emerging from the glans penis to form the retrocoronal plexus, which drains into the deep dorsal vein in the midline groove between the corpora. The superficial and deep dorsal veins may connect. The deep dorsal vein gathers blood from the emissary and circumflex veins, and drains into the periprostatic plexus. The deep venous system involves the crural and cavernosal veins, and emissary veins, that join to drain into the internal pudendal veins. The internal pudendal veins course with the internal pudendal artery and nerve in Alcock's canal to empty into the internal iliac vein.

The arterial supply to the corpus spongiosum and urethra arises from the internal pudendal artery. After the internal pudendal artery gives off its perineal branch, the artery is termed the common penile artery. The common penile artery travels along the medial margin of the inferior pubic ramus and as it nears the urethral bulb, divides into three terminal branches: 1) the bulbourethral artery, which penetrates Buck's fascia to enter the bulbospongiosus, oriented almost parallel to the path of the membranous urethra; 2) the dorsal artery, which travels dorsally along the penis giving off circumflex branches (the circumflex cavernosal arteries) to the corpus spongiosum with its terminal branches in the glans penis; and 3) the cavernosal artery as the terminal branch of the penile artery, which enters the corpus cavernosum and runs the length of the penile shaft, giving off the many helicine arteries that constitute the arterial portion of the erectile apparatus. A dual blood supply to the proximal corpus spongiosum comes from the circumflex arteries. The dual blood supply is maintained distally by the dorsal artery's terminal union with the tissue of the glans. Two cavernosal arteries run near the centre of the corpus spongiosum via numerous anastomotic channels.

The nerves of the penis arise from the pudendal and cavernosal nerves. The pudendal nerves supply somatic motor and sensory innervation to the penis. The cavernosal nerves are a combination of parasympathetic and visceral afferents that constitute the autonomic innervation to the penis from the pelvic plexus. Pre-ganglionic parasympathetic visceral efferents and afferents arise from S2–4 and sympathetic pre-ganglionic afferents and visceral afferents arise from T11–L2. Beyond the prostate, the cavernosal nerves run next to and through the membranous urethra. As they penetrate the perineal membrane, the nerves pass near and supply Cowper's gland before entering the corpora cavernosa dorsomedial to the cavernosal arteries.

### 1.5.9 **Histology and pathology of urethral strictures**

The normal urethra is primarily lined by pseudostratified columnar epithelium. Beneath the basement membrane there is connective tissue composed of fibroblasts and an extracellular matrix with collagen, proteoglycans, elastic fibres, and glycoproteins, and the spongiosum composed of vascular sinusoids and smooth muscle. The most remarkable histologic changes of urethral strictures arise in the connective tissue. Strictures are the consequence of epithelial damage and spongiofibrosis. Scott and Foote (81) examined early events in stricture formation in the guinea pig urethra using light and electron microscopy. After trauma, the urethral surface initially ulcerated and was subsequently covered by simple, then stratified, squamous epithelium.

The stricture tissue is rich in myofibroblasts and multi-nucleated giant cells. These cells were thought to be related to stricture formation and collagen synthesis, respectively. An increase in collagen is associated with the loss of vascular characteristics of the normal urethra. Singh and Blandy (82) did an experimental study in the rat to determine the role of extravasation of urine in the pathogenesis of urethral stricture. They observed that the ultrastructure of urethral stricture tissue has features that suggest why some strictures are fibrous and others resilient, and the total amount of collagen increases in urethral stricture, resulting in dense fibrotic tissue with decreased smooth muscle and elasticity.

In contrast, Baskin *et al.* (83) could not demonstrate an increase in total collagen amount in the stricture compared with normal urethra, but rather found that an alteration in the ratio of collagen type may explain the fibrotic, non-compliant nature of urethral stricture scar tissue. They found that the normal urethral spongiosum was composed of 75% type I collagen and 25% type III collagen. In contrast, the type III collagen in urethral stricture tissue was increased (84%) with a corresponding decrease in type I collagen (16%).

Cavalcanti *et al.* (84) reported a qualitative and quantitative histological analysis of the tissues of the corpus spongiosum in 15 bulbar urethral stricture patients managed by anastomotic urethroplasty/ urethral reconstruction. They noted that there was complete loss of the relationship between smooth muscle, the extracellular matrix, and sinusoids in the peri-luminal area of the strictured urethra, with collagen replacement. The extension of the fibrotic area was greater in those with a traumatic stricture than in those with an atraumatic stricture. There was a remarkably lower vascular density in the traumatic etiology group than in the non-traumatic etiology group. There was an increase in

type III collagen in the peri-luminal area and in type I in the peripheral spongiosum. Collagen type III in the peri-luminal area was greater in the group with no suprapubic cystostomy diversion before surgery, which suggests that the diversion can modify the structure of fibrotic urethral tissue.

By and large, urethral stricture formation is characterized by marked changes in the extracellular matrix components, with consequent changes in function. The different causes of urethral strictures must be considered when choosing the surgical technique, because they affect the spongiosum differently.

Little is known about the molecular environment in urethral strictures, and the majority of studies available focused on collagen analysis. Glycosaminoglycans (GAGs) and collagens are major components of the extracellular matrix and they have key roles in fibrotic diseases. Da Silva *et al.* (85) measured the GAG composition in the strictured urethral segment. They concluded that composition changes in GAGs in strictured urethras could contribute to the non-compliant nature of urethral scar tissue and cause functional changes, and that these results may be useful in defining new targets for therapy for urethral stricture disease.

Visual internal urethrotomy has been most widely used as a primary treatment for anterior urethral stricture, but the long-term results are disappointing, with high recurrence rates. The fact is that during urethrotomy, the fibrotic tissue with low vascularity is incised instead of healthy tissue. Lopes *et al.* (86) histologically analyzed urethral healing after dorsal incision and stenting of normal urethra in an animal model. The incision through a normal urethral plate was associated with epithelialization without excess collagen deposition or scar formation. In most cases, for patients with traumatic urethral strictures, urethroplasty/urethral reconstruction should be the primary treatment, rather than endoscopic incision.

Bastos *et al.* (87) noted that the concentration of elastic fibres in the corpus spongiosal tissues increased significantly with age during human fetal development. This high concentration of elastic fibres in those tissue may partly explain its high extensibility as a functional adaptation of the fetal male urethra. Cavalcanti *et al.* (84) reported that this feature was markedly changed, especially in traumatic urethral stricture, with dense and hypovascular scarring, when compared with urethral strictures of other causes.

### 1.5.10 **Spongiofibrosis and classification of urethral strictures**

Jordan and Devine (88) proposed a classification of anterior urethral strictures based on the extent of spongiofibrosis and outlined a treatment algorithm with urethrotomy or surgery based on the classification. The authors presented a logical approach to anterior urethral strictures based on the "anatomy" of the stricture.

Pansadoro and Emiliozzi (89) proposed a classification of iatrogenic prostatic (posterior) urethral stenoses according to location and etiology: type I, located exclusively at the bladder neck; type II, located in the midportion of the prostatic fossa; and type III, in which the whole prostatic fossa is replaced by stenosis. Klosterman *et al.* (90) proposed a staging system based on the degree of lumen occlusion using the sonographic appearance of the urethral stricture. They reported that ultrasonography of the anterior urethra offers a dynamic three-dimensional study that can easily be repeated. It holds the promise of defining accurately, not only the exact length and severity of the strictured urethral segment, but also the extent of urethral fibrosis and the anatomy of the periurethral structures. A significant reduction in the incidence of recurrent stricture may be obtained by selecting patients for treatment on the basis of the findings of ultrasonography.

Moreover, the potential exists for the use of this imaging method during internal urethrotomy to ensure a more accurate and appropriate incision of the stricture. A major limitation to ultrasonography is that it is operator dependent and that clinical stratification of strictures by ultrasonography may be very subjective and lack reproducibility.

Chiou *et al.* (91) categorized urethral strictures into five categories, combining the sonographic findings of spongiofibrosis with the length of the urethral stricture. They studied the role of urethral ultrasonography and colour Doppler imaging in the evaluation of patients with urethral strictures and associated abnormalities. They concluded that, with the advantages of avoiding radiation to the testes, providing real-time evaluation of the distensibility of the urethra, and having the capacity of assessing spongiofibrosis, periurethral tissue involvement, and urethral artery location, urethral ultrasonography appears to offer more than retrograde urethrography for the evaluation of anterior urethral strictures.

### 1.6 **References**

- Turner-Warwick R. Principles of urethral reconstruction. In: Webster GD, Kirby R, King L, et al., editors. Reconstructive urology. Oxford: Blackwell Scientific Publications; 1993. p. 609-642.
- Devine CJ, Devine PC, Felderman TP, et al. Classification and standardization of urethral strictures [abstract #325]. Presented at: The 78th American Urologic Association Annual Meeting; 1983 Apr 17-21; Las Vegas.
- 3. Jordan GH, Devine CJ, Devine PC. An anatomical approach to urethral stricture disease [abstract]. J Urol. 1986;135:210A.
- Jordan GH. Management of anterior urethral stricture disease. In: Webster GD, Kirby R, King L, et al., editors. Reconstructive urology. Oxford: Blackwell Scientific Publications; 1993. p. 703-723.
- 5. Santucci RA, Joyce GF, Wise M. Male urethral stricture disease. J Urol. 2007;177(5):1667-1674.
- Anger JT, Santucci RA, Grossberg AL, et al. The morbidity of urethral stricture disease among male Medicare beneficiaries. BMC Urol. 2010;10:3.
- 7. Fenton AS, Morey AF, Aviles R, et al. Anterior urethral strictures: Etiology and characteristics. Urology. 2005;65(6):1055-1058.
- 8. Lumen N, Hoebeke P, Willemsen P, et al. Etiology of urethral stricture disease in the 21st century. J Urol. 2009;182(3):983-987.
- McConnell JD, Barry MJ, Bruskewitz RC. Benign prostatic hyperplasia: Diagnosis and treatment (Quick reference guide for clinicians). Rockville (MD): Agency for Health Care Policy and Research, Public Health Service, US Department of Health and Human Services; 1994. Publication No.: AHCPR 94-0583. p. 1-17.
- Jorgensen PE, Weis N, Bruun E. Etiology of urethral stricture following transurethral prostatectomy. Scand J Urol Nephrol. 1986;20(4):253-255.
- 11. Zheng W, Vilos G, McCulloch S, *et al.* Electrical burn of urethra as a cause of stricture after transurethral resection. J Endourol. 2000;14(2):225-228.
- 12. Sall M, Bruskewitz RC. Prostatic urethral strictures after transurethral microwave thermal therapy for benign prostatic hyperplasia. Urology. 1997;50(6):983-985.
- 13. Biering-Sorensen F, Nielsen K, Vest Hansen H. Urethral epithelial cells on the surface of hydrophilic catheters after intermittent catheterization: Cross-over study with two catheters. Spinal Cord. 1999; 37(4): 299-300.
- 14. Wyndaele JJ, Maes D. Clean intermittent self-catheterization: A 12-year followup. J Urol. 1990;143(5):906-908.
- 15. Albers P, Fichtner J, Bruhl P, et al. Long-term results of internal urethrotomy. J Urol. 1996;156(5):1611-1614.
- Heyns CF, Steenkamp JW, DeKock MLS, et al. Treatment of male urethral strictures: Is repeated dilation or internal urethrotomy useful? J Urol. 1998;160(2):356-358.
- 17. Barbagli G, Azzaro F, Menchi I, et al. Bacteriologic, histologic and ultrasonographic findings in strictures recurring after urethrotomy. Scand J Urol Nephrol. 1995;29(2):193-195.
- Kjaergaard B, Walter S, Bartholin J, *et al.* Prevention of urethral stricture recurrence using clean intermittent self-catheterization. Br J Urol. 1994;73(6):692-695.
- Badlani GH, Press SM, Defalco A, et al. UroLume endourethral prosthesis for the treatment of urethral stricture disease: Longterm results of the North American multicenter UroLume trial. Urology. 1995;45(5):846-856.
- 20. Parikh AM, Milroy EJG. Precautions and complications in the use of the UroLume wallstent. Eur Urol. 1995;27(1):1-7.
- Bailey DM, Foley SJ, McFarlane JP, et al. Histological changes associated with long-term urethral stents. Br J Urol. 1998;81(5):745-749.
- 22. Jordan GH. UroLume endoprosthesis for the treatment of recurrent bulbous urethral stricture. AUA Update Series. 2000;19(3):18-23.
- 23. Lal R, Bhatnagar V, Mitra DK. Urethral strictures after fulguration of posterior urethral valves. J Pediatr Surg. 1998;33(3):518-519.
- 24. Misra D, Chana J, Drake DP, *et al.* Operative trauma to the genitourinary tract in the treatment of anorectal malformations: 15 years' experience. Urology. 1996;47(4):559-562.

- 25. Duel BP, Barthold JS, Gonzalez R. Management of urethral strictures after hypospadias repair. J Urol. 1998;160(1):170-171.
- 26. Persad R, Sharma S, McTavish J, *et al.* Clinical presentation and pathophysiology of meatal stenosis following circumcision. Br J Urol. 1995;75(1):91-93.
- 27. Upadhyay V, Hammodat HM, Pease PWB. Post circumcision meatal stenosis: 12 years' experience. N Z Med J. 1998;111(1060):57-58.
- 28. Buchholz NP, Riehmann M, Gasser TC. Absence of urethral strictures with suprapubic urinary drainage during extracorporeal circulation. J Urol. 1993;150(2 Pt 1):337-339.
- 29. Abdel-Hakim A, Bernstein J, Teijeira J *et al.* Urethral stricture after cardiovascular surgery: A retrospective and prospective study. J Urol. 1983;130(6):1100-1102.
- 30. Bamshad BR, Poon MW, Stewart SC. Effect of cardiopulmonary bypass on urethral blood flow as measured by laser Doppler flowmetry. J Urol. 1998;160(6 Pt 1):2030-2032.
- 31. Levine LA, Elterman L. Urethroplasty following total phallic reconstruction. J Urol. 1998;160(2):378-382.
- 32. Jordan GH, Gilbert DA, Jensen PL. Phallic construction. In: McAninch JW, editor. Traumatic and reconstructive urology. Philadelphia: WB Saunders Co.; 1996. p. 683-691.
- 33. Elliott SP, Meng MV, Elkin EP, *et al.* Incidence of urethral stricture after primary treatment for prostate cancer: Data from CaPSURE. J Urol. 2007;178(2):529-534.
- 34. Uygur MC, Gulerkaya B, Altug U, et al. 13 years' experience of penile fracture. Scand J Urol Nephrol. 1997;31(3):265-266.
- 35. Gottenger EE, Wagner JR. Penile fracture with complete urethral disruption. J Trauma. 2000;49(2):339-341.
- 36. Kowalczyk J, Athens A, Grimaldi A. Penile fracture: An unusual presentation with lacerations of bilateral corpora cavernosa and partial disruption of the urethra. Urology. 1994;44(4):599-601.
- 37. Hall SJ, Wagner JR, Edelstein RA, *et al.* Management of gunshot injuries to the penis and anterior urethra. J Trauma. 1995;38(3):439-443.
- 38. Miles BJ, Poffenberger RJ, Farah RN, et al. Management of penile gunshot wounds. Urology. 1990;36(4):318-332.
- 39. Gomez RG, Castanheira AC, McAninch JW. Gunshot wounds to the male external genitalia. J Urol. 1993;150(4):1147-1149.
- 40. Brandes SB, Buckman RF, Chelsky MJ, *et al.* External genitalia gunshot wounds: A ten-year experience with fifty-six cases. J Trauma. 1995;39(2):266-271.
- 41. Cline KJ, Mata JA, Venable DD, et al. Penetrating trauma to the male external genitalia. J Trauma. 1998;44(3):492-494.
- 42. Kunkle DA, Lebed BD, Mydlo JH, *et al.* Evaluation and management of gunshot wounds of the penis: 20-year experience at an urban trauma center. J Trauma. 2008;64(4):1038-1042.
- 43. Najibi S, Tannast M, Latini JM. Civilian gunshot wounds to the genitourinary tract: Incidence, anatomic distribution, associated injuries and outcomes. Urology. 2010;76(4):977-982.
- 44. Armenakas N, McAninch JW. Acute anterior urethral injuries: Diagnosis and initial management. In: McAninch JW, editor. Traumatic and reconstructive urology. Philadelphia: WB Saunders Co.; 1996. p. 543-550.
- 45. Goldman SM, Sandler CM, Corriere JN, *et al.* Blunt urethral trauma: A unified, anatomical mechanical classification. J Urol. 1997;157(1):85-89.
- 46. Chapple C, Barbagli G, Jordan G, et al. Consensus statement on urethral trauma. BJU Int. 2004;93(9):1195-1202.
- 47. Meuli M, Briner J, Hanimann B, *et al.* Lichen sclerosis et atrophicus causing phimosis in boys: A prospective study with 5-year follow up after complete circumcision. J Urol. 1994;152(3):967-989.
- 48. Kumar MVK, Harris DL. Balanitis xerotica obliterans complicating hypospadias repair. Br J Plast Surg. 1999;52(1):69-71.
- 49. Akporiaye LE, Jordan GH, Devine CJ. Balanitis xerotica obliterans. AUA Update Series. 1997;16(21):162-165.
- 50. Pugliese J, Morey AF, Peterson AC. Lichen sclerosis: Review of the literature and current recommendations for management. J Urol. 2007;178(6):2268-2276.
- 51. Taurog JD, Lipsky PE. Ankylosing spondylitis and reactive arthritis. In: Harrison TR, Wilson JD, Isselbacher KJ, *et al.*, editors. Harrison's principles of internal medicine. 12th ed. New York: McGraw-Hill Professional; 1991. p. 1451-1453.

- 52. Horowitz S, Horowitz J, Taylor-Robinson D, et al. Ureaplasma urealyticum in Reiter's syndrome. J Rheumatol. 1994;21(5):877-882.
- 53. Wright V. Arthritis associated with spondylitis. In: Beers MH, Berkow R, editors. The Merck manual of diagnosis and therapy. 17th ed. Rahway, NJ: Merck Research Laboratories; 1999. p. 445-448.
- Bolognia J, Braverman I. Skin manifestations of internal disease. In: Harrison TR, Wilson JD, Isselbacher KJ, et al., editors. Harrison's principles of internal medicine. 12th ed. New York: McGraw-Hill Professional; 1991. p. 322-338.
- 55. Murphy GF, Mihm MC. The skin. In: Cotran RS, editor. Robbins' pathologic basis of disease. 4th ed. Philadelphia: WB Saunders; 1989. p. 1277-1313.
- 56. Armenakas NA, McAninch JW. Fossa navicularis and meatal stricture penile flap reconstruction. In: McAninch JW, editor. Traumatic and reconstructive urology. WB Saunders; 1996. p. 615-622.
- 57. Docimo SG, Silver RI, Gonzalez R, *et al.* Idiopathic anterior urethritis in prepubertal and pubertal boys: Pathology and clues to etiology. Urology. 1998;51(1):99-102.
- 58. Dewan PA, Wilson TM. Idiopathic urethritis in the adolescent male. Eur Urol. 1996;30(4):494-497.
- 59. Ahmed A, Kalayi GD. Urethral stricture at Ahmadu Bello University Teaching Hospital, Zaria. East Afr Med J. 1998;75(10):582-585.
- 60. Sharfi ARA, Elarabi YE. The "watering-can" perineum: Presentation and management. Br J Urol. 1997;80(6):933-936.
- 61. McMillan A, Pakianathan M, Mao JH, et al. Urethral stricture and urethritis in men in Scotland. Genitourin Med. 1994;70(6):403-405.
- 62. Martinelli F, Garrafa E, Turano A, *et al.* Increased frequency of detection of ureaplasma urealyticum and mycoplasma genitalium in AIDS patients without urethral symptoms. J Clin Microbiol. 1999;37(6):2042-2044.
- 63. Garcia-Rodriguez JA, Garcia Sanchez JE, Munoz Bellido JL, *et al.* Genitourinary tuberculosis in Spain: Review of 81 cases. Clin Infect Dis. 1994;18(4):557-561.
- 64. Frank JD, Pocock RD, Stower MJ. Urethral strictures in childhood. Br J Urol. 1988;62(6):590-592.
- 65. Cobb BG, Wolf JA, Ansell JS. Congenital stricture of the proximal urethral bulb. J Urol. 1968;99(5):629-631.
- Nonomura K, Kanno T, Kakizaki H, et al. Impact of congenital narrowing of the bulbar urethra (Cobb's collar) and its transurethral incision on children. Eur Urol. 1999;36(2):144-149.
- 67. Chen CP, Liu FF, Jan SW, *et al.* First report of distal obstructive uropathy and prune-belly syndrome in an infant with amniotic band syndrome. Am J Perinatol. 1997;14(1)31-33.
- Rourke KF, Jordan GH. Primary urethral reconstruction: The cost-minimized approach to the bulbous urethral stricture. J Urol. 2005;173(4):1206-1210.
- Wright JL, Wessells HB, Nathens AB, et al. What is the most cost-effective treatment for 1 to 2 cm bulbar urethral strictures? Societal approach using decision analysis. Urology. 2006;67(5):889-893.
- Greenwell TJ, Castle C, Andrich DE, et al. Repeat urethrotomy and dilation for the treatment of urethral stricture disease are neither clinically effective nor cost effective. J Urol. 2004;172(1):275-277.
- Jordan GH, Schossberg SM. Surgery of the penis and urethra. In: Wein AJ, Kavoussi LR, Novick AC, et al., editors. Wein: Campbell-Walsh urology. 9th ed. Philadelphia: Saunders Elsevier; 2007. p. 1025-1040.
- 72. Quartey JKM. Anatomy and blood supply of the urethra and penis. In: Schreiter F, Jordan GH, editors. Urethral reconstructive surgery. Heidelberg, Germany: Springer Medizin Verlag; 2006. p. 11-17.
- 73. Wood DN, Nethercliffe J, Andrich DE, et al. Peritoneal and perineal anatomy and surgical approaches. BJU Int. 2004;94(5):719-737.
- 74. Brooks JD, Chao WM, Kerr J. Male pelvic anatomy reconstructed from the visible human data set. J Urol. 1998;159(3):868-872.
- 75. Yucel S, Baskin LS. An anatomical description of the male and female urethral sphincter complex. J Urol. 2004;171(5):1890-1897.
- 76. Dalpiaz O, Mitterberger M, Kerschbaumer A, *et al.* Anatomical approach for surgery of the male posterior urethra. BJU Int. 2008;102(10):1448-1451.
- Koraitim MM, Atta MA, Fattah GA, et al. Mechanism of continence after repair of post-traumatic posterior urethral strictures. Urology. 2003;61(2):287-290.

- Mouraviev VB, Santucci RA. Cadaveric anatomy of pelvic fracture urethral distraction injury: Most injuries are distal to the external urinary sphincter. J Urol. 2005;173(3):869-872.
- 79. Andrich DE, Mundy AR. The nature of urethral injury in cases of pelvic fracture urethral trauma. J Urol. 2001;165(5):1492-1495.
- Andrich DE, Day AC, Mundy AR. Proposed mechanisms of lower urinary tract injury in fractures of the pelvic ring. BJU Int. 2007;100(3):567-573
- 81. Scott TM, Foote J. Early events in stricture formation in the guinea pig urethra. Urol Int. 1980;35(5):334-339.
- 82. Singh M, Blandy JP. The pathology of urethral stricture. J Urol. 1976;115(6):673-676.
- Baskin LS, Constantinescu SC, Howard PS, et al. Biochemical characterization and quantitation of the collagenous components of urethral stricture tissue. J Urol. 1993;150(2 Pt 2):642-647.
- 84. Cavalcanti AG, Costa WS, Baskin LS, et al. A morphometric analysis of bulbar urethral strictures. BJU Int. 2007;100(2):397-402.
- 85. Da-Silva EA, Sampaio FJ, Dornas MC, et al. Extracellular matrix changes in urethral stricture disease. J Urol. 2002;168(2):805-807.
- Lopes JF, Schned A, Ellsworth PI, et al. Histological analysis of urethral healing after tubularized incised plate urethroplasty. J Urol. 2001;166(3):1014-1017.
- 87. Bastos AL, Silva EA, Silva Costa W, *et al.* The concentration of elastic fibres in the male urethra during human fetal development. BJU Int. 2004;94(4):620-623.
- 88. Jordan GH, Devine PC. Management of urethral stricture disease. Clin Plast Surg. 1988;15(3):493-505.
- Pansadoro V, Emiliozzi P. latrogenic prostatic urethral strictures: Classification and endoscopic treatment. Urology. 1999;53(4):784-789.
- Klosterman PW, Laing FC, McAninch JW. Sonourethrography in the evaluation of urethral stricture disease. Urol Clin North Am. 1989;16(4):791-797.
- 91. Chiou RK, Anderson JC, Tran T, *et al.* Evaluation of urethral strictures and associated abnormalities using high-resolution and color Doppler ultrasound. Urology. 1996;47(1):102-107.

# Committee



# Evaluation and Follow-Up

### CHAIRS

Kenneth W. Angermeier, United States Keith F. Rourke, Canada

### MEMBERS

Deepak Dubey, India Robert J. Forsyth, Australia Christopher M. Gonzalez, United States

# Committee

# CONTENTS

2

### Evaluation and Follow-Up

2.1	Introducti	ion	31
2.2	Patient H	istory	31
2.3	Physical I	Examination	32
	2.3.1	General	32
	2.3.2	Abdomen	32
	2.3.3	Genitalia	32
	2.3.4	Musculoskeletal and neurological	33
2.4	Laborator	ΓΥ	33
2.5	Urethrography, Cystography, and Cystoscopy		33
	2.5.1	Urethrography	33
	2.5.2	Cystography	40
	2.5.3	Cystoscopy	41
	2.5.4	Recommendations	43

# Committee

2.6	Ultrasound	44
	2.6.1 Recommendations	45
2.7	Magnetic Resonance Imaging and Computed Tomography	46
2.8	The American Urological Association Symptom Index and Uroflowmetry 2.8.1 Becommendations	47
2.9	Sexual and Ejaculatory Function 2.9.1 Recommendations	50 53
2.10	Evaluation of Outcome Following Surgical Intervention for Urethral Stricture	53
2.11	References	56



# 2.1 Introduction

In all surgical disciplines, successful outcomes are dependent on patient selection and determination of the most appropriate surgical procedure for a given clinical situation. In patients with a urethral stricture, a thorough history and physical examination, endoscopy, and radiographic imaging are essential for proper evaluation.

In the field of urethral reconstruction, there are two defining events that have enhanced this process. In the mid-1970s, McCallum and Colapinto provided an elegant description of dynamic retrograde and voiding cystourethrography correlated with urethral anatomy (1), outlining techniques still used today by virtually every reconstructive urologist. The second event was the development of the flexible cystoscope in 1984, taking this procedure from the operating room to the office in most cases with much improved tolerability (2).

Although urethrography and endoscopy remain the primary forms of evaluation of the patient with a urethral stricture, additional means have been subsequently reported, including uroflowmetry, symptom scores, quality of life assessments, ultrasonography, computed tomography (CT), and magnetic resonance imaging (MRI). The goal of this chapter is to attempt to better define the role of each of these methods in the evaluation and follow-up of patients with urethral stricture.

## 2.2 Patient History

A thorough history is important in the evaluation of a patient with a known or suspected urethral stricture. The onset and severity of obstructive and storage-related voiding symptoms is documented. The presence of hematuria, dysuria, or urinary retention at any point in time is also recorded. Urinary tract infection may take the form of cystitis, prostatitis, or epididymitis, with or without associated abscess, and should be noted. The patient should also be asked about a history of sexually transmitted diseases, even though in most areas of the world this is currently less common as an etiology for urethral stricture than in the past, due to more effective antibiotic therapy.

The patient is also asked about the presence or absence of previous trauma to the penis or perineum, as well as a history of difficult urethral catheterization, hypospadias repair, or lichen sclerosus involving the genitalia. If there has been a pelvic fracture, the orthopedic injuries must be assessed to ensure that the healing is sufficient to allow placement of the patient into lithotomy position. Osteoarthritis or a history of joint replacement may also cause difficulties with proper patient positioning.

Previous urethral dilation and surgical procedures for urethral stricture or other urethral disorders, such as diverticulum or hypospadias, are carefully recorded. With regard to urethral dilation or internal urethrotomy, a progressively shorter interval between treatments may indicate increasing density of the stricture. It is also important to inquire about the use of intermittent self-catheterization currently or in the past, as this may have an impact on the timing of urethral reconstruction. In general, it is preferable for the urethra to be free of instrumentation for 2–3 months prior to surgery to aid with accurate identification of the true extent of a urethral stricture.

The current status of erectile and ejaculatory function and time course of any previous alterations is documented. The patient should be asked about the presence of chordee, particularly in the setting of previous hypospadias, as this may require repair at the time of urethral reconstruction. A thorough review of systems and medical history can reveal the presence of medical problems that may have an additional impact on voiding function, such as benign prostatic enlargement, diabetes mellitus, and neurological disorders.

Social history should include assessment of previous tobacco use. Smoking may contribute to a decreased success rate following urethroplasty (Level 3) (3), particularly penile island flap procedures (Level 3) (4). Chewing tobacco or betel leaves can lead to abnormal buccal mucosa, which can increase donor-site morbidity or make the tissue unsuitable for use in substitution urethroplasty (Level 2) (5).

### 2.3 Physical Examination

### 2.3.1 General

Overall body habitus is assessed for possible difficulties with positioning at the time of urethral surgery, particularly when considering a lengthy procedure in lithotomy position. The oral mucosa should be examined for suitability for harvest of a buccal or lingual mucosa graft.

### 2.3.2 Abdomen

Palpation of the abdomen may reveal a palpable bladder in a patient with chronic urinary retention related to urethral stricture. Location of the suprapubic tube (SPT), if present, is assessed for the possibility of using the tract for antegrade passage of a sound or a cystoscope at the time of posterior urethral reconstruction following pelvic-fracture–related urethral injury. If the SPT site is very proximal or off of the midline, open cystotomy may be required at the time of surgery to facilitate sound passage.

### 2.3.3 Genitalia

With every patient, it is important to document whether he has been circumcised, since the foreskin may be used in some cases for substitution urethroplasty in the form of a flap or a graft. If circumcised, the penis is inspected for the presence of redundant foreskin or sufficient hairless shaft skin. Patients may also have a relatively hairless area of skin near the midline of the scrotum that may serve as an island flap; however, this flap has been used much less frequently since the widespread adoption of oral mucosa grafts.

The penile skin should be carefully examined for lichen sclerosus, which has an impact on selection of the method of surgery for urethral reconstruction (Level 3) (6-8). The urethral meatus is assessed for stenosis and location, with the degree of hypospadias noted if present.

A urethral fistula may be detected in some cases, particularly in patients who have undergone previous urethral surgery. Palpation of the scrotum, perineum, and urethra is done to look for thickening or induration of the urethra and to rule out associated abscess or epididymitis. Urethral induration often indicates severe spongiofibrosis, and if there is a mass effect, the uncommon diagnosis of urethral carcinoma may be considered. Digital rectal examination (DRE) is performed, particularly in older males, to document the degree of clinical benign prostatic hyperplasia (BPH), since this may make it more difficult to assess voiding symptoms or to interpret a low flow rate following internal urethrotomy or urethroplasty.

### 2.3.4 Musculoskeletal and neurological

In patients with a posterior urethral injury following pelvic fracture, consideration should be given to placing the patient into lithotomy position in the office to assess flexibility of the lower extremities and overall tolerability. This manoeuvre may also be helpful in evaluating the significantly obese patient for urethral reconstruction. Lower extremity contractures in the neurologically impaired patient may necessitate alternative and creative positioning manoeuvres for adequate surgical exposure. It is a good idea to document sensory and motor deficits in these patients in order to establish a baseline for comparison with post-operative physical examination if necessary.

## 2.4 Laboratory

Urinary tract infection is not uncommon in the setting of urethral stricture, and every patient should have urinalysis, followed by urine culture if indicated. In certain clinical situations indicative of long-term untreated outlet obstruction or medical renal disease, assessment of serum creatinine should also be considered.

# 2.5 Urethrography, Cystography, and Cystoscopy

### 2.5.1 Urethrography

Urethrography has been used for over 100 years in the diagnosis and staging of urethral stricture disease (9). In many ways, it remains the gold standard for accurate assessment of urethral strictures.

Typically, urethrography is performed in a retrograde fashion using 10–20 mL of water-soluble radiocontrast agent. This is done after plain film imaging (scout film) to document proper positioning and to assess for any concurrent radio-opaque urethral pathology. This study is commonly known as retrograde urethrography (RUG). Contrast is injected slowly while serial fluoroscopic or radiographic images are obtained. This method is known as dynamic urethrography and allows for continuous assessment of the urethra while injecting contrast (10).

Dynamic urethrography, in theory, allows for more accurate assessment of the bladder neck, posterior landmarks, and areas of the urethra proximal to the stricture (11). Despite its widespread use and time-tested applicability, performing proper and accurate RUG does require a few key steps to ensure accuracy when diagnosing and staging a urethral stricture.

Retrograde urethrography should ideally be performed (or directly supervised) and interpreted by the treating urologist. Oblique positioning of the patient (45 degrees) is a critically important step, especially when assessing the bulbar urethra (12). The downward obturator fossa should be completely closed on the scout film to confirm appropriate positioning (**Figure 1**). This is important in order to position the urethra as parallel as possible to the film.

**FIGURE 1** 

Positioning of patient for RUG. Note the occlusion of the downward obturator fossa. An incidental urethral stone is also evident.



Without proper positioning, the bulbar urethra will not be visualized along its parallel axis and the presence or length of stricture can be underestimated (**Figure 2**).

### **FIGURE 2**

The importance of proper positioning during RUG. Without sufficient oblique positioning, the presence and length of stricture can be underestimated.



Plain film imaging done during positioning may also assist in the diagnosis of any concurrent urethral pathology, such as a radio-opaque calculus (**Figure 1**).

During RUG, the penis should be placed on stretch in order to allow for complete assessment of the entire penile urethra. Avoiding the introduction of air bubbles during injection of contrast prevents filling defects from being masked and other urethral pathology from being obscured. Many advocate avoiding the use of lubricating gel and anesthetic, as they may obscure the image and cause edema without any substantial benefit to patient comfort (Level 4) (10).

If possible, contrast should be seen passing proximal to the stricture segment and through the membranous urethra. Without this proximal imaging, the true extent of the stricture may not be determined. It should also be noted that multiple views might be required to accurately delineate urethral pathology (11).

Various techniques for the injection of contrast during RUG have been advocated. Typically, a catheter-tipped syringe or Brodny clamp has been used (**Figure 3**) (13).

**FIGURE 3** The use of a Brodny clamp to evaluate a penile urethral stricture.



Others have described the use of a small-bore Foley catheter (12 or 14 French) placed just inside the fossa navicularis (1–2 cm) with 2–3 mL placed in the balloon to facilitate luminal occlusion, or the use of a catheter-tipped syringe (1). Several modifications of the Brodny clamp and varying injection techniques have been used (Level 4) (14–16). Modifications of the technique have ranged from the use of a drip infusion system (to allow a more gradual distension of the urethra during urethrography) to the use of auto-urethrography (Level 4) (17,18).

Typically, well-performed RUG should seek to identify three key features of a urethral stricture:

- The location of the stricture
- The length of the stricture

• The presence of any associated urethral pathology (fistula, false passages, calculi, etc.)

When performing RUG, it is also important to be aware of several normal findings and key urethral anatomic landmarks.

The urethra is typically divided into two distinct parts: the anterior urethra and the posterior urethra. The anterior urethra is composed of the penile urethra and the bulbar urethra. Starting from the level of the urethral meatus, the urethra is typically smooth and uniform to the area of the penoscrotal junction, where it transitions to the bulbar urethra (**Figure 4**).

FIGURE 4 Normal RUG. p = penile urethra, b = bulbar urethra, m = membranous urethra, pr = prostatic urethra, B = bladder



This transition is usually evident as a slight S-shaped change in the course of the urethra. In some images, the soft tissue of the scrotum can be seen, which can facilitate the distinction between these two parts of the anterior urethra. Given the elastic nature of the penis and penile urethra, it is important to place the penis on moderate stretch during urethrography in order to accurately delineate stricture length in this segment.

Throughout the anterior urethra, several peri-urethral glands exist (Littre glands). These can sometimes be identified as small punctate areas of extra-luminal contrast on RUG (**Figure 5**). The filling of the glands can be normal, but is more common in the setting of obstructive urethral pathology.

FIGURE 5 Littre glands filling in association with a long bulbar urethral stricture.



The bulbar urethra is wider than the penile urethra, but tapers proximally into the posterior urethra at the level of the pelvic floor. The urethra forms a symmetrical cone at this level. There is sometimes intravasation of contrast into the corpus spongiosum (**Figure 6**) or into the penile venous drainage system (**Figure 7**). This may occur in the setting of urethral inflammation or due to overzealous injection of contrast during imaging.

FIGURE 6 Intravasation of contrast into the corpus spongiosum during RUG.



FIGURE 7 Intravasation of contrast into veins of the penile circulation during RUG.



In some patients, visualization and filling of one or both Cowper's ducts and glands may occur, but this is virtually only seen in the presence of obstruction distal to the insertion of the ducts into the proximal bulbar urethra. In some patients, contraction of the musculus compressor nuda (an anterior leaf of the bulbospongiosus muscle) may compress the very proximal bulbar urethra. It is important not to confuse this finding with a proximal bulbar urethral stricture.

The posterior urethra has two segments: the membranous urethra and the prostatic urethra. The membranous urethra appears on RUG as a 1–2 cm long wisp of contrast that extends to near the verumontanum of the prostate (**Figure 4**). The verumontanum in turn marks the beginning of the prostatic urethra and is often seen as a discrete filling defect on urethrography. It is important to note that the posterior urethra is not open physiologically during RUG and will not (in the normal urethra) be distended by contrast.

Since its introduction in 1910, RUG has evolved as the de facto gold standard for evaluating and diagnosing a urethral stricture. When properly performed, RUG provides visualization of strictures involving the penile and bulbar urethra and facilitates assessment of posterior urethral distraction defects and stenoses (**Figures 8–11**); however, there is a paucity of controlled trials documenting its accuracy.

**FIGURE 8** 

A long-segment penile urethral stricture due to lichen sclerosus.



**FIGURE 9** A short-segment bulbar stricture on RUG.



**FIGURE 10** A long-segment bulbar urethral stricture.



**FIGURE 11** 

RUG demonstrating a posterior urethral stricture related to pelvic fracture.



As a diagnostic modality, RUG has reported sensitivities between 75% and 100%, with specificities of 72%–97% when compared in cohort series to cystoscopy and intraoperative findings as definitive diagnostic entities (Level 3) (19–21). Positive and negative predictive values range from 50%–93% and 76%–100%, respectively (19,21). As a single modality, RUG offers a means of both diagnosing urethral stricture and concurrently staging the stricture with regard to length, location, and number of strictures (Level 3).

Retrograde urethrography does not allow for the direct assessment of peri-urethral tissue (spongiofibrosis), and instead depends on the experience of the examiner to infer its presence based on the intra-luminal findings (Level 4). Retrograde urethrography is typically sufficient to diagnose concurrent pathology such as fistula, false passage, and significant ductal reflux (**Figure 12**) (Level 3) (22).

FIGURE 12

False passages associated with a complex bulbar urethral stricture. Note the filling of Cowper's duct.



Retrograde urethrography also plays a vital role in staging complex urethral defects after trauma. In this setting, RUG allows assessment of the urethra distal to a distraction defect and also facilitates determination of bulbar urethral length (urethrometry). This information may help direct surgical management of a pelvic fracture related urethral distraction defect (Level 4) (23).

Several limitations to RUG do exist. Strictures of the very distal (urethral meatus and fossa navicularis) and proximal (bulbomembranous) urethra can be difficult to detect with RUG alone (24). In addition, RUG can be technically more difficult in patients with a very distal stricture, obesity, hypospadias, or a redundant prepuce. One should always be aware of the magnification artifact that occurs with conventional radiography, depending on patient size and distance from the radiation source.

Given the nature of RUG (injecting contrast) there is a risk of patient discomfort, urinary tract infection, and contrast agent reaction (should intravasation occur). In cases of severe or complete urethral occlusion, retrograde assessment of the urethra proximal to the obstruction is often impossible (**Figure 13**). In these instances, RUG can be combined with an antegrade urethrogram in order to accurately define the extent of the stenosis (**Figure 14**) (25). **FIGURE 13** Occlusion of the bulbar urethra following straddle injury.



Overall, RUG is a reliable, accessible, and versatile means to both diagnose and stage urethral strictures. Properly performed RUG typically provides accurate information about the number, location, and length of a urethral stricture. Though not a perfect single modality, RUG can readily be combined with other diagnostic tests to achieve a synergistic approach to the evaluation of urethral stricture.

### 2.5.2 Cystography

Cystography (as both a static radiograph and a voiding study) has been used to diagnose and stage urethral strictures. Voiding cystourethrography (VCUG) is typically most useful for visualizing the posterior urethra and the segment of urethra proximal to a urethral stricture. In contrast to RUG, during VCUG both the bladder neck and prostatic urethra are distended. Because of this, VCUG can complete the evaluation of an obliterated urethral stricture or urethral distraction defect that cannot be completely assessed with RUG alone (**Figures 13** and **14**).

In addition, VCUG allows for the assessment of the functional impairment caused by the stricture, by showing the hydrodynamic effect on the urethra proximal to the stricture (hydrodistention) (Level 3) (26). Voiding cystourethrography may be performed after retrograde instillation of contrast during RUG, or the bladder may be cannulated with a ureteral access catheter to facilitate filling without dilating or distorting the stricture. If a patient has a suprapubic catheter in place, this greatly facilitates access to the bladder for the purpose of performing VCUG. In some rare instances, patients may undergo VCUG after intravenous contrast administration and subsequent filling of the bladder with contrast. This technique is time consuming and carries an increased risk of contrast agent reaction. Like RUG, VCUG should be performed with the patient in the oblique position (upright or lying).

Typically, VCUG does not optimally visualize the anterior urethra, especially the segment distal to the site of obstruction. In one study, visualization of the anterior urethra was improved by the occlusion of the distal urethra with a penile clamp or manual compression (Level 3) (27), but this does not seem to be a commonly used technique, since this information can be readily obtained with RUG. Voiding cystourethrography is often used as a complementary investigation done in conjunction with RUG.

Cystography without the voiding component has little place in the staging and diagnosis of most anterior urethral strictures. However, static cystography can be useful in assessing urethral distraction defects due to a pelvic fracture-related urethral injury. In many instances, urethral distraction defects may be completely obliterated and associated with significant nerve injury. Typically, a patient has an indwelling suprapubic catheter, and in some cases may be unable to void for the purposes of outlining the posterior urethra during VCUG. In these instances a static cystogram may still provide insight into the integrity of the bladder neck.

Ultimately, the finding of an open bladder neck at rest on cystogram may indicate a higher risk of incontinence after establishing urethral patency (Level 3) (28–31). In one series, the risk of post-operative incontinence was estimated at 53% when the bladder neck was found to be open on cystography (29). Therefore, when assessing urethral distraction defects due to pelvic fracture, a cystogram is highly recommended.

FIGURE 14 The combined use of RUG and VCUG to stage an obliterative bulbar

urethral stricture.



### 2.5.3 **Cystoscopy**

Despite its widespread use, cystoscopy is a relatively under-reported modality for urethral stricture assessment in the current urological literature. As a diagnostic modality, cystoscopy has been considered the gold standard for determining the presence or absence of a urethral stricture (Level 3) (19–21).

Cystoscopy has been reported to allow detection of a urethral stricture prior to the occurrence of findings with other studies, such as uroflowmetry and symptom assessment (Level 3) (32). However, cystoscopy alone does not allow for complete visual staging in terms of stricture length and exact location, since most significant strictures are smaller in calibre than most cystoscopes (**Figure 15**). In some cases, the use of a pediatric cystoscope or ureteroscope can allow assessment of the urethra proximal to strictures of the distal (penile) urethra.

#### **FIGURE 15**

The cystoscopic appearance of an anterior urethral stricture.



Urethral distraction defects associated with pelvic fracture represent a different arena for the use of cystoscopy. In these instances, cystoscopy is frequently required to accurately assess the length of the distraction. Many patients have complete obliteration of the urethra and are unable to sufficiently relax the bladder neck to allow visualization of the posterior urethra during VCUG (**Figure 16**). This may result in overestimation of the length of the urethral distraction defect. In these instances, antegrade flexible cystoscopy can be performed via the suprapubic tract in conjunction with RUG to accurately delineate the urethral distraction length (**Figure 17**). Concurrent antegrade and retrograde cystoscopy may also be used to obtain this information (**Figure 18**).

#### **FIGURE 16**

Cystogram combined with RUG demonstrating an overestimation of urethral distraction defect length.



#### **FIGURE 17**

Combined flexible cystoscopy through suprapubic cystostomy tract and RUG to accurately assess urethral distraction length.



#### **FIGURE 18**

Combined use of flexible and rigid cystoscopy to stage a pelvic fracture urethral distraction defect.



This distraction length is useful in planning surgical intervention, and can also be combined with other studies to predict difficulty and outcomes during the reconstruction of these defects (Level 3) (33). Antegrade cystoscopy can also be combined with RUG to determine the gapometry/urethrometry index. This index assesses the ratio of the length of the distraction defect to the length of the bulbar urethra and has been proposed as a method to help predict the type and difficulty of operative repair required for a pelvic fracture-related urethral defect (Level 4) (23).

Cystoscopy via the suprapubic tract also allows for the assessment of bladder neck competence and can offer additional information that may not be provided by cystography alone. Cystoscopy can visualize post-traumatic bladder neck scarring or tethering due to fibrosis. When present, this finding can substantiate concern for incontinence following posterior urethral reconstruction and aid in pre-operative patient counseling or in some instances alter management (Level 3) (29,30).

### 2.5.4 **Recommendations**

### Urethrography

- 1. Retrograde urethrography is recommended as a reliable, accessible, and versatile means to both diagnose and stage urethral stricture (Level 3; A).
- Retrograde urethrography can readily be combined with VCUG to achieve a synergistic approach to the evaluation of the entire urethra, and this approach is currently recommended as the optimal method for pre-operative staging of urethral stricture (Level 3; B).
#### Cystography

- 1. Voiding cystourethrography is recommended for (and typically most useful in) assessment of the bladder neck and posterior urethra, as well as visualization of the segment of urethra proximal to an anterior urethral stricture (Level 3; B).
- 2. In the setting of a pelvic-fracture-related urethral distraction defect, a cystogram demonstrating an open bladder neck at rest may indicate a higher risk of incontinence once urethral patency is established (Level 3).

#### Cystoscopy

- 1. Cystoscopy is recommended as the most specific procedure for the diagnosis of urethral stricture (Level 4; A)
- 2. Cystoscopy is recommended as an adjunctive procedure in the staging of anterior urethral stricture, particularly to confirm abnormal or equivocal findings on imaging studies (Level 3; B).
- 3. In the setting of a pelvic-fracture-related urethral distraction defect, cystoscopy is a highly recommended staging modality for assessing the bladder neck and posterior urethra (Level 3; A).

## 2.6 Ultrasound

Urethral ultrasound or sonourethrography (SU) is an ancillary technique for the evaluation of urethral stricture. First described by McAninch in 1988, SU may be used to identify strictures with a reported sensitivity of 66%–100%, a specificity of 97%–98%, and positive and negative predictive values of 50%–80% and 96%–98%, respectively, for anterior strictures 3–5 cm in length (Level 4) (34).

The utility of SU is limited by stricture location, with this modality being more sensitive to identify strictures located in the penile urethra as compared to the bulbar portion (Level 4) (35). The benefits of SU include detailed three-dimensional anatomic information about stricture location and length, while the drawbacks include operator dependency and the semi-invasive nature of the procedure, which often requires local or general anesthesia for full urethral distension.

Only 8% of studies used SU to evaluate for stricture recurrence, with most employing it as a secondary procedure after a positive primary screen (Level 3) (36). In a prospective study involving 70 men with lower urinary tract symptoms, RUG was compared to high-resolution ultrasonography of the urethra (Level 2) (21). The ultrasonographer was blinded and all stricture lengths were eventually confirmed intra-operatively. Sonourethrography was found to be as effective as RUG for the detection of anterior urethral stricture. Greater sensitivity to characterize the length (73.3%–100%), diameter, and degree of spongiofibrosis (77.3%–83.3%) of the urethral stricture was seen with SU, and there was less pain and bleeding reported with this modality than with RUG. Furthermore, SU showed a high sensitivity in the detection of false urethral passages and calculi as compared to RUG alone.

Similarly, Gupta *et al.* found that SU was more sensitive than RUG in the estimation of mean anterior urethral stricture length at the time of surgery. The authors reported that the sensitivity to detect spongiofibrosis was 42%, 56%, and 83% in 52 men with mild, moderate, and severe fibrosis, respectively, and there were no complications associated with using ultrasound as compared to RUG (Level 2) (37).

Sonourethrography may provide better diagnostic accuracy in different portions of the urethra. Samaiyar *et al.* reported that the overall diagnostic accuracy of SU was 96.4%, as compared to 85.7% with RUG. The authors showed that the main difference between RUG and SU was related to the sensitivity advantage of ultrasound in the penobulbar region (90%) as compared to that of RUG (70%). Retrograde urethrography underestimated urethral stricture length by 37% as compared to intra-operative length determination, which was significantly less accurate than SU (Level 2) (38).

Finally, in a prospective study involving 51 men, Peskar and Perovic showed that SU and RUG were each effective in determining the diameter and length of stricture disease once the limitations of radiographic magnification during RUG were taken into account. The authors concluded that the use of both modalities was the best approach for staging and diagnosis of urethral stricture disease (Level 2) (22).

#### 2.6.1 **Recommendations**

- 1. Sonourethrography may be used as an adjunct to RUG in the pre-operative staging of anterior urethral stricture (Level 2; C).
- 2. Sonourethrography may be more sensitive than RUG in the assessment of stricture length and the degree of spongiofibrosis; however, the clinical relevance of these findings remains uncertain (Level 2).

## 2.7 Magnetic Resonance Imaging and Computed Tomography

Conventional radiographic evaluation of patients with an obliterative posterior urethral distraction defect due to pelvic fracture includes RUG and VCUG. However, these imaging studies have certain limitations. If there is failure of bladder neck opening on VCUG, the prostatic urethra is not demonstrated, and this prevents delineation of the length of the distraction defect. Prostatic displacement along the vertical or horizontal axis may not be accurately identified. In addition, associated pathology such as false passages, fistulas, and diverticula may not be well outlined with conventional imaging.

In an attempt to overcome these limitations, MRI has been used for evaluation of obliterative posterior urethral distraction defects, with the first published report in 1992 (Level 3) (39). A total of 18 patients with complete occlusion of the prostatomembranous urethra from pelvic crush injury underwent MRI of the pelvis just before open urethroplasty. All patients underwent conventional cystography and RUG, and operative findings were correlated with MRI. The severity and direction of prostato-urethral dislocation in all three planes, and the length of the urethral defect could be accurately determined using MRI. Fractures and avulsions of the cavernous erectile bodies were also demonstrated. Magnetic resonance imaging was felt to be a potentially useful adjunct in the evaluation of patients with urethral injury after pelvic fracture, providing information that conventional imaging may not. Similar findings have since been reported by others (Level 3) (40–42).

In addition to the use of MRI in evaluating urethral defects, Narumi *et al.* reported on the correlation of MRI findings with erectile dysfunction (ED) in patients with traumatic posterior urethral injury (Level 3) (43). Significant variables affecting permanent impotence were avulsion of the corpus cavernosum, separation of the corporal bodies, and superior and/or lateral prostatic displacement. When MRI findings of both cavernous body avulsion and superior and/or lateral prostatic displacement were present, the probability of permanent impotence was 95%. In the absence of these findings, the probability of normal potency was 83%. The authors concluded that MRI could aid in the assessment of permanent ED in this group of patients.

Three-dimensional spiral CT cystourethrography (CTCUG) was reported as a novel technique for evaluating post-traumatic posterior urethral defects in 2003 (Level 3) (44). Twenty-seven patients underwent RUG and VCUG followed by CTCUG using a technique in which high-density images (bony pelvic and contrast-filled structures) were visualized. The technique allowed images to be viewed in several planes, thereby precisely defining pelvic anatomy. Aspects that were more thoroughly evaluated with CTCUG included the location and length of the distraction defect, the degree and direction of alignment of the urethral ends, the relationship of bony fragments to the urethra, and the presence of associated pathology (fistulas, false passages, diverticula). The authors concluded that static and dynamic CTCUG images may allow improved staging of a pelvic-fracture–related urethral distraction defect, leading to better surgical planning.

Studies reporting on the use of MRI in the evaluation of anterior urethral strictures are fewer in number. Osman *et al.* compared RUG and MRI in the evaluation of 20 patients with urethral stricture, 18 of which were within the anterior urethra (Level 3) (45). The patients underwent subsequent endoscopic or open surgical intervention. Overall, the accuracy for diagnosis of urethral stricture was equal with both modalities (85%), and MRI provided additional useful information in seven patients (35%). This included improved assessment of urethral stricture length in three patients and diagnosis of a urethral tumor, a bladder mass, and a urethra-rectal fistula, in one patient each. Unlike RUG, MRI also provided information about the degree of spongiofibrosis in all patients. Therefore, MRI may provide extra guidance for treatment planning in selected patients with anterior urethral stricture.

#### 2.7.1 **Recommendation**

## 2.8 The American Urological Association Symptom Index and Uroflowmetry

Introduced in 1992 as a quantifiable measure for BPH assessment and treatment outcome (Level 2) (46), the American Urological Association Symptom Index (AUA-SI) or International Prostate Symptom Score (IPSS) has become internationally accepted as a validated, standardized, and reproducible technique for the quantification of lower urinary tract symptoms (LUTS) (Level 2) (47). As a tool for the assessment of LUTS related to BPH, the AUA-SI has been criticized for its lack of specificity, with a number of other conditions affecting the score, including prostatitis, bladder calculi, neurological disorders, prostate cancer, painful bladder syndrome, urethral stricture disease, and urinary incontinence (Level 2–3)(48–51).

The AUA-SI does quantify the severity of subjective voiding symptoms in both men and women (Level 2-3) (52–55) and can differentiate between patients with BPH/LUTS and controls (46). However, it is yet to be substantiated in patients with urethral stricture. Although the AUA-SI was originally designed for self-administration, physician administration has also been validated (Level 2) (56–58), as has its utility in various cultures (Level 3) (59,60). Despite this, ongoing concerns exist regarding its accuracy in those with reduced comprehension or literacy skills (Level 2) (58,61,62).

<sup>1.</sup> Magnetic resonance imaging and CT may be useful adjuncts in the evaluation of patients with urethral stricture, particularly in the setting of pelvic-fracture-related urethral defects or luminal obliteration, or when associated pathology is strongly suspected (Level 3; C).

Morey *et al.* were the first to examine the role of the AUA-SI in the assessment of urethroplasty outcomes (Level 3), enrolling 50 men between the ages of 16 and 73 with urethral stricture requiring operative intervention (63). The mean pre-operative AUA score of 26.9 excluded 12 men with posterior urethral disruptions in whom the AUA-SI was not assessed. Urethral reconstruction was accomplished in a variety of ways, and all men had post-operative evaluation that included the AUA-SI, administered between 3 and 111 months post-operatively (average: 38 months).

Forty-one patients were deemed successful on RUG, with a mean post-operative symptom score of 5.1. The nine failures with recurrent narrowing on urethrography and/or cystoscopy had a mean score of 22.5, decreasing to 3.4 after successful repeat urethroplasty. A significant inverse correlation was found with symptom scores and maximum urinary flow rates. The authors concluded that the AUA-SI was a useful tool in the outcome assessment of urethral stricture treatment, but did not advocate its use to select patients for urethral reconstruction surgery.

Lemma *et al.* administered the validated Amharic translation of the AUA-SI to 84 men with predominantly (70%) recurrent urethral stricture on two separate occasions pre-operatively (Level 3) (64,65). This was compared to 73 men with no symptoms or history of urethral stricture. There was high internal consistency and reliability of the AUA-SI in the pre-intervention stricture group, with an average score of 18.4 compared to 5.8 in the control group. Scores of < 8 were found in 25% of the stricture group versus 72% of the control group, and scores of > 19 were found in 54% of the stricture group but only 6% of the control group.

These studies indicate that symptom score assessment may be a useful adjunct in monitoring for stricture recurrence, and its use is specifically documented in 47% of series published between 2000 and 2008 (36). Its utility may be enhanced by the addition of other investigations, and uroflowmetry, with its simple, cost-effective, and non-invasive nature, is appealing. Though uroflowmetry has well documented limitations (Level 2–3) (26,66–69), it is now commonly used in stricture assessment, being cited as the primary screen for stricture recurrence in 56% of urethroplasty articles (36).

Aydos *et al.* combined the AUA-SI and uroflowmetry with RUG in the assessment of 33 men approximately 6 months after reconstruction for posterior urethral disruption (Level 3) (70). While only six men had recurrent stricture on RUG, these men had a mean AUA score of 30 and a mean maximum flow rate of 6 mL/sec. In contrast, those with no radiographic recurrence had a mean AUA score of 6 and a mean maximum flow rate of 25.7 mL/sec. Despite the limitations of small sample size, these findings support the ability of maximum flow rate and AUA score to identify stricture recurrence, particularly in younger men (mean age: 31), regardless of stricture location or treatment method.

Heyns and Marais attempted to define thresholds for symptom scores and maximum flow rates indicative of stricture presence or absence (Level 3) (71). They studied 49 patients undergoing RUG and urethral calibration for stricture assessment. The mean pre-treatment AUA-SI was 12 and the mean maximum flow rate was 9.45 mL/sec, with significant negative correlations between urethral diameter and symptom index, and between symptom index and maximum flow. A significant positive correlation between urethral diameter and maximum flow was noted. They advocate an AUA-SI greater than 10 or maximum flow less than 15 mL/sec as optimal in excluding stricture (urethral

diameter > 18 F) and identifying the presence of a significant stricture (14 F or less). This threshold provided 93% sensitivity, 68% specificity, and 82% overall accuracy, obviating the need for further invasive testing in 34% of their patients, while missing a stricture of 14 F or less in 4.6%.

Information other than maximum flow rate can be obtained from uroflowmetry, and flow curve character in particular may be of interest in patients with urethral stricture. Five flow-curve patterns have been defined (Level 3) (72), and are associated with various voiding disabilities (Level 3) (73); urethral stricture is associated with a plateau curve (Level 3). Interpretation of curves is subjective, although assessors demonstrate higher agreement rates for plateau than for other pathological curve patterns (Level 3) (74).

Erickson *et al.* reviewed data from 278 men with a mean age of 42.5 years undergoing urethral reconstruction, 63 of whom developed recurrent stricture during follow-up (Level 3) (75). The men underwent uroflowmetry, symptom assessment, and RUG/VCUG at 3 and 12 months post-operatively. The symptom assessment was not in the form of a validated score, and a single non-blinded assessor interpreted the flow curve as either obstructed or normal. A combination of symptoms or obstructed voiding curve gave the greatest sensitivity (99%) in predicting stricture recurrence, with curve characteristics proving more useful than maximum flow in their study population. They concluded that uroflowmetry alone is insufficient to diagnose recurrent stricture post-therapy, although if used in combination with flow curve characteristics, some men may be able to avoid invasive follow-up testing.

Current evidence supporting the use of the AUA-SI and uroflowmetry does not clearly establish their roles in patients with urethral stricture. No studies have assessed their place in initial diagnosis, nor their ability to predict complications of strictures such as urinary retention. However, uroflowmetry does have an established role in the follow-up of pediatric hypospadias surgery, where the absence of other urinary tract pathology makes it more reliable in assessing for stricture recurrence (Level 3) (76,77). The greater variability in adult voiding function secondary to coexisting pathologies compromises its accuracy in diagnosing urethral stricture.

Combining uroflowmetry with the AUA-SI improves the ability to identify the presence or absence of stricture, but to date, no other tests have been assessed in combination with these to see if further refinement is possible. Post-void residual (PVR) in particular is commonly used for evaluation of voiding symptoms, but has not been tested in a stricture population despite being used in 8% of urethroplasty studies as a primary screen for stricture recurrence (36). In the BPH population, PVR has been demonstrated to be highly variable, with poor inter-test reliability (Level 3) (78), and to be poorly predictive of the need for invasive therapy (Level 3) (79).

The role of pre-operative symptom assessment and uroflowmetry should not be dismissed, as these may represent reliable non-invasive methods of assessing treatment outcome, particularly from the patients' perspective (Level 3) (80). For some, it may allow for less invasive follow-up testing once baseline uroflow parameters and AUA-SI in the absence of stricture have been established. Deviations from this baseline may indicate recurrent pathology and trigger further evaluation, although such triggers are yet to be fully defined.

#### 2.8.1 **Recommendations**

- 1. Voiding symptom assessment and uroflowmetry may be used as adjuncts to imaging and/or cystourethroscopy in the initial diagnosis of urethral stricture, but cannot be used by themselves to diagnose or reliably exclude a stricture (Level 3; C).
- 2. When feasible, pre-operative voiding symptom and uroflowmetry determination may be considered as a baseline evaluation to facilitate objective assessment of intervention outcomes and monitoring over time (Level 3; B).
- 3. Post-operative assessment of uroflowmetry and voiding symptoms may allow identification of patients who are at low risk of stricture recurrence (Level 3).

## 2.9 Sexual and Ejaculatory Function

The topic of erectile function following anterior urethroplasty was first evaluated by Coursey *et al.* in 2001 (Level 2) (81). In this multicentre study, 250 men were retrospectively analyzed for posturethroplasty sexual dysfunction, of whom nearly 30% reported some degree of post-operative ED. A similar rate of sexual dysfunction was noted in the control group of patients, prompting the authors to conclude that urethral reconstructive surgery was associated with no greater risk of ED than was circumcision. Erickson *et al.* subsequently reported retrospective data using the Brief Male Sexual Function Inventory, and found that ED following anterior urethroplasty for stricture disease occurred in 25% of men. However, recovery of erectile function was seen in the vast majority of these men within 6–12 months (Level 2) (82,83).

The International Index of Sexual Function (IIEF) is a 15-question patient response survey first developed by Rosen *et al.* in 1997 (84). The questionnaire covers the five domains of male sexual function: erectile function, orgasmic function, sexual desire, intercourse satisfaction, and overall satisfaction; however, the domain of erectile function appears to be most useful. The instrument can be used to evaluate individual domains of sexual function or as an overall score. It has been validated in multiple languages and has been proven to have a high degree of test reliability, construct validity, and treatment responsiveness. Its limitations involve its lack of sexual partner response, its focus on current sexual function only, and its inability to delineate organic from psychogenic sexual dysfunction. An abbreviated version of the IIEF, known as the Sexual Health Inventory for Men (SHIM) or IIEF-5 may also be used to screen and assess for ED (85).

Anger *et al.* were the first to publish a prospective study using the IIEF patient-based questionnaire (Level 2) (86). At a mean follow-up time of 6.2 months, post-operative erectile function domain scores were not significantly different from pre-operative values in 25 men undergoing bulbar urethroplasty. The authors concluded that anterior urethroplasty performed by an experienced

surgeon should not affect erectile function post-operatively. However, one of the limitations of this study was the relatively small number of men, evaluated at separate institutions, which may have been too few to detect minor variations in erectile function (Level 2).

Erickson *et al.* prospectively evaluated 52 men undergoing anterior urethroplasty for stricture disease. They used the erectile function portion of the IIEF survey and distributed questionnaires to eligible patients pre-operatively and at 1 month, 3 months, 6 months, and annually post-operatively. The authors found that the post-operative ED rate may be as high as 38%; however, recovery was seen in nearly all of these men by 6 months after surgery (Level 2) (87). Bulbar urethroplasty appeared to affect erectile function to a greater extent than did penile urethroplasty (88% vs. 33%), which may be explained by the proximity of the bulbar urethra to the nerves responsible for erection. Within the bulbar urethra subgroup, excision and primary anastomosis led to slightly higher rates of ED than did augmented anastomotic repairs (50% vs. 26%). The primary limitation of this study was its inability to detect small differences between the many subgroups, due to the relatively small cohort.

The mechanism for ED following anterior urethroplasty is not clear. Because a significant proportion of men experience temporary ED following urethroplasty, extensive counseling on this topic and the use of standardized instruments to prospectively monitor these men is encouraged.

Men with urethral stricture have also been reported to complain of concomitant ejaculatory dysfunction (Level 2) (82,88). Normal ejaculation requires three coordinated steps: emission of the ejaculate into the urethra by alpha-adrenergic–induced contractions of the prostate, seminal vesicles, and vas deferens; bladder neck contraction to prevent retrograde ejaculation; and final expulsion of the semen from the urethra by the somatically coordinated contractions of the bulbocavernosus and ischocavernosus muscles. The urethra plays an important role in ejaculation in that it serves as the conduit for semen to be expelled from the body during normal ejaculation. Furthermore, proper coordination of the bulbocavernosus muscle, which has been shown to aid in semen expulsion, is also needed for normal ejaculatory function (EjF) (89).

Ejaculatory dysfunction after urethroplasty has been studied considerably less than erectile function. A retrospective study by Erickson *et al.* conducted in 2007 on anterior urethroplasty patients used three EjF questions from the Brief Male Sexual Function Inventory, and found an overall increase in post-operative ejaculatory scores (from 5.3 to 6.2, p = 0.04) (Level 2) (82). Although this improvement may have simply been due to the relief of urethral obstruction, the findings were interpreted with caution, due to known problems with sexual function recall (90).

A previous study that evaluated the use of scrotal flaps for urethroplasty noted post-operative ejaculatory dysfunction in three men, in all of whom the authors had been unable to re-approximate the bulbocavernosus muscle over the urethral repair. The affected men noted post-orgasm "dribbling" of semen from the urethra, and it was presumed that this was from the loss of the bulbocavernosus contraction and subsequent stasis of semen in the bulb. However, this study was limited by the small number of men and the lack of a validated instrument to quantify the level of ejaculatory dysfunction (Level 4) (91). In a retrospective study evaluating the effects of posterior urethral reconstruction on EjF, all 32 men in the study were reported to have post-operative antegrade ejaculation. Of these men, only five (16%) had decreased volume and only one (3%) experienced delayed ejaculation. However, recall bias was again a concern due to the retrospective study design (Level 4) (92).

Erickson *et al.* reported a prospective study of men undergoing anterior urethroplasty for stricture disease (Level 2) (88). The authors successfully used the Male Sexual Health Questionnaire (MSHQ), a self-administered questionnaire related to overall sexual function and patient satisfaction developed by Rosen and colleagues in 2004 (90). The questionnaire contains a seven-item ejaculatory domain that asks questions related to ejaculatory frequency, latency of ejaculation, volume of ejaculate, force of ejaculation, ejaculatory pain, ejaculatory pleasure, and the presence of dry ejaculation. Similar to the IIEF methodology, this questionnaire has a high degree of test reliability, construct validity, and treatment responsiveness. Each of the seven questions are scored from 1 (lowest/poorest function) to 5 (highest/best function) for a maximum score of 35 (no dysfunction). Good preoperative EjF on the MSHQ was defined as a score  $\geq$  28; average pre-operative EjF as a score of 22–28; and poor pre-operative EjF as a score of  $\leq$  21. Although not all ejaculatory dysfunction is captured with this questionnaire, the authors found it to be a useful tool to assess pre-operative EjF.

In the study by Erickson et al., 11 out of 43 men (25%) reported poor pre-operative EjF. Of these 11, six (20%) had bulbar urethral strictures and five (38%) had penile strictures. The most commonly reported problems in this group pre-operatively were low ejaculatory volume (100%), lack of vigor (91%), and pain with ejaculation (100%) (Level 2). A total of 43 men were studied and the authors found that the overall ejaculatory score did not change post-operatively (25.54 vs. 26.94, p = 0.17) at a mean follow-up time of 8.1  $\pm$  6.0 months. Few men complained of post-operative dysfunction at a median follow-up of 6.8 months, and a significant percentage (19%) of men reported improvement in their function after reconstructive surgery. The improvement in EjF was most striking for men who had decreased pre-operative EjF, with nearly 36% reporting improved ejaculation after urethroplasty. This was especially evident in the bulbar urethral stricture group. There were no individuals who started with normal pre-operative EjF who were later found to have a significant decrease in function. Interestingly, the authors reported that they routinely split the bulbocavernosus muscle during bulbar dissection. Previous reports have shown the importance of this muscle in the normal ejaculatory process, and that inhibition or damage of the bulbocavernosus muscle resulted in decreased ejaculatory function (93,94). However, these data did not involve a prospective study design in men undergoing urethroplasty. Limitations of the study by Erickson et al. include the single-institution, single-surgeon origin of the data; the subjective nature of the questionnaire; the inability of the EjF domain to capture all components of ejaculatory dysfunction; and the possibility of the domains not moving independently of each other.

Further testing is needed to fully define the pathophysiology of ejaculatory dysfunction as related to urethral stricture. These types of tests will also be critical in evaluating new minimally invasive urethroplasty techniques that aim to decrease post-operative complications and sexual dysfunction, in order to determine whether the proposed benefits are measurable (95,96). Despite these limitations, the use of the EjF domain of the MSHQ represents a non-invasive, cost-effective method of prospectively evaluating EjF before and after urethroplasty.

#### 2.9.1 **Recommendations**

1. Temporary ED following anterior urethroplasty may be experienced by a significant number of men. Recovery is seen in the majority within 1 year (Level 2).

2. A significant proportion of men with untreated anterior urethral stricture report poor ejaculatory function (Level 2).

3. The IIEF and MSHQ patient questionnaires are non-invasive instruments that may be used to assess peri-operative erectile and ejaculatory function in men with urethral stricture (Level 2; C).

## 2.10 Evaluation of Outcome Following Surgical Intervention for Urethral Stricture

Despite increasing awareness of urethroplasty as a reliable option for the management of recurrent urethral strictures, and the number of publications supporting its use, there is no consensus as to the best method of evaluating post-operative outcome. In fact, there is not even a standard definition of what constitutes post-operative success or a recurrent urethral stricture.

In order to determine what methods have been used for this purpose in the past, Meeks *et al.* performed a meta-analysis of urethroplasty articles published between 2000 and 2008 (Level 3) (36). Nearly half of the reviewed articles described a multi-tier approach to evaluating for stricture recurrence, employing a mean of 3.15 procedures or questionnaires (range: 1–8). A fairly common strategy was to perform primary screening with a non-invasive test, followed by more invasive evaluations when indicated.

The most commonly used methods for assessment of outcome following urethroplasty are AUA-SI, uroflowmetry, PVR, RUG, VCUG, urethral calibration, and cystoscopy (36). As would be expected, each has its proponents based on availability, ease of use, sensitivity, and invasiveness. However, before deciding on the best procedure, one must consider what constitutes post-operative stricture recurrence and post-operative success.

At its most basic level, a urethral stricture is a narrowing of the urethral lumen, and urethroplasty is designed to restore urethral calibre. It has been stated that a stricture may stenose to a calibre of 10–12 French or a diameter of 3 mm before it significantly impairs the voiding flow rate (Level 4) (32,97). These comments seem to be based on experimental and clinical studies performed more than 40 years ago (98,99). Therefore, it may be safe to infer that, allowing for a small additional margin, a urethral calibre of greater than 14 French is unlikely to cause changes in flow or symptoms.

Urethral calibration has been proposed as a useful tool for the assessment of prognosis following surgery for a urethral stricture (97), and flexible cystoscopy has been considered the most useful method to confirm the presence or absence of a stricture (Level 4) (100). In addition to stricture diagnosis, the flexible cystoscope can also be used to calibrate the urethral lumen. The diameter of the instrument should be measured to aid in this assessment, commonly 5 mm (15.7 French) or 5.5 mm (17.3 French). In many cases, the cystoscope need not be passed beyond the bulbomembranous junction to assess the surgical repair, significantly decreasing patient discomfort and risk of infection. Given these factors, flexible cystoscopy can be considered the optimal form of assessment for stricture recurrence after urethroplasty, with the ability to provide an accurate diagnosis and calibrate the urethral lumen. Proponents of RUG may disagree, but imaging may at times be confusing or uncertain, and when this is the case, the typical response is to pass the flexible cystoscope to better assess whether a particular area of narrowing is significant.

Post-operative success following urethroplasty differs from lack of stricture recurrence and is more difficult to define. In some studies, success has been equated with lack of stricture recurrence. Others have used definitions of success based on symptom assessment, voiding flow rate, a non-validated questionnaire (Level 3) (101), the need for post-operative intervention for stricture (Level 3) (102), or some combination thereof. It is clear that with these definitions, some recurrent strictures will be missed, and therefore post-operative success rates will tend to be higher than the rate free of stricture. From a clinical standpoint however, post-operative success may be just as (or more) important than true stricture-free status. When comparing results of future studies, the difference between these two endpoints will need to be recognized.

The ideal method of follow-up remains to be determined, and it is beyond the scope of this review to set the standard. It is likely that some combination of the above-noted techniques should be adopted. A validated patient-reported outcome measure for use following urethroplasty is in development (103) and could possibly be combined with an objective measure such as voiding flow rate for a completely non-invasive approach, or with flexible urethroscopy for the most accurate result.

The timing of follow-up is another issue that deserves mention. In the era of buccal mucosa, personal experience suggests that if the urethra is patent to the flexible cystoscope at 1–2 years following surgery, future stricture recurrence is unlikely. This seems to differ compared to a time when skin flaps and grafts predominated for substitution urethroplasty (104). Therefore, a final assessment approximately 18 months following surgery would seem to be reasonable, with ongoing scheduled evaluation limited to those with a possible impending stricture or other problem at that time. In many health care systems, it is difficult to continue to monitor this patient population beyond that point.

It should be realized that these comments are merely suggestions based on limited literature and personal opinion, and therefore we have elected not to make formal recommendations. The issue of standardizing patient evaluation after urethroplasty will most likely require a task force to coordinate a consensus opinion among the leading reconstructive urologists in the world, so that an accepted guideline can be created.

## 2.11 References

- 1. McCallum RW, Colapinto V. The role of urethrography in urethral disease. Part I. Accurate radiological localization of the membranous urethra and distal sphincters in normal male subjects. J Urol. 1979;122(5):607-611.
- 2. Kavoussi LR, Clayman RV. Office flexible cystoscopy. Urol Clin North Am. 1988;15(4):601-608.
- Breyer BN, McAninch JW, Whitson JM, et al. Multivariate analysis of risk factors for long-term urethroplasty outcome. J Urol. 2010;183(2):613-617.
- 4. Whitson JM, McAninch JW, Elliott SP, et al. Long-term efficacy of distal penile circular fasciocutaneous flaps for single stage reconstruction of complex anterior urethral stricture disease. J Urol. 2008;179(6):2259-2264.
- Sinha RJ, Singh V, Sankhwar SN. Does tobacco consumption influence outcome of oral mucosa graft urethroplasty? Urol J. 2010;7(1):45-50.
- 6. Depasquale I, Park AJ, Bracka A. The treatment of balanitis xerotica obliterans. BJU Int. 2000;86(4):459-465.
- 7. Peterson AC, Palminteri E, Lazzeri M, *et al.* Heroic measures may not always be justified in extensive urethral stricture due to lichen sclerosis (balanitis xerotica obliternas). Urology. 2004;64(3):565-568.
- Levine LA, Strom KH, Lux MM. Buccal mucosa graft urethroplasty for anterior urethral stricture repair: Evaluation of the impact of stricture location and lichen sclerosis on surgical outcome. J Urol. 2007;178(5):2011-2015.
- 9. Cunningham JH. The diagnosis of stricture of the urethra by Roentgen rays. Trans Am Assoc Genitourin Surg. 1910;5:369-371.
- 10. Colapinto V, McCallum RW. The role of urethrography in urethral disease. Part II. Indications for transphincter urethroplasty in patients with primary bulbous strictures. J Urol. 1979;122(5):612-618.
- 11. Jordan GH, Schlossberg SM. Surgery of the penis and urethra. In: Kavoussi LR, Novick AC, Partin AW, *et al.*, editors. Campbell-Walsh urology. 9th ed. Philadelphia: WB Saunders; 2007. p. 1023-1096.
- 12. Gallentine ML, Morey AF. Imaging of the male urethra for stricture disease. Urol Clin North Am. 2002;29(2):361-372.
- 13. Brodny ML. A new instrument for urethrography in the male. J Urol. 1941;46:350-354.
- 14. Knutsson F. On the technique of urethrography. Acta Radiol. 1929;10:437-441.
- Barange XS, Schorlemmer WC, Vijande RA, et al. Barcelona retrograde urethrography: A new device and technique. J Urol. 1999;161(6):1863-1864.
- 16. Berna JD, Berna JD Jr. A new device for retrograde urethrography in the male. Eur Radiol. 2003;13(6):1420-1422.
- 17. Berna JD, Berna JD Jr, Aparicio Meson M. Urethrography in the male: The clamp method. Acta Radiol. 2009;50(2):233-237.
- 18. Kirshy DM, Pollack AH, Becker JA, et al. Autourethrography. Radiology. 1991;180(2):443-445.
- Mahmud SM, El Khalid S, Rana AM, et al. Is ascending urethrogram mandatory for all urethral strictures? J Pak Med Assoc. 2008;58(8):429-431.
- 20. Andersen J, Aagaard J, Jaszczak P. Retrograde urethrography in the postoperative control of urethral strictures treated with visual internal urethrotomy. Urol Int. 1987;42(5):390-391.
- 21. Choudhary S, Singh P, Sundar E, *et al.* A comparison of sonourethrography and retrograde urethrography in evaluation of anterior urethral strictures. Clin Radiol. 2004;59(8):736-742.
- 22. Peskar DB, Perovic AV. Comparison of radiographic and sonographic urethrography for assessing urethral strictures. Eur Radiol. 2004;14(1):137-144.
- 23. Koraitim MM. Predictors of surgical approach to repair pelvic fracture urethral distraction defects. J Urol. 2009;182(4):1435-1439.
- 24. Bircan MK, Sahin H, Korkmaz K. Diagnosis of urethral strictures: Is retrograde urethrography still necessary? Int Urol Nephrol. 1996;28(6):801-804.

- Goel A, Gupta A, Dalela D. Antegrade urethrogram: A technique to visualize the proximal bulbous urethral segment in anterior urethral stricture. Indian J Urol. 2009;25(3):415-416.
- Asklin B, Nilsson A, Pettersson S. Functional evaluation of anterior urethral strictures with combined antegrade and retrograde urethrography. Scand J Urol Nephrol. 1984;18(1):1-7.
- 27. Pearman RO, Miller JB. Choke voiding cystourethrography. J Urol. 1963;90:481-488.
- 28. MacDiarmid S, Rosario D, Chapple CR. The importance of accurate assessment and conservative management of the open bladder neck in patients with post-pelvic fracture membranous urethral distraction defects. Brit J Urol. 1995;75(1):65-67.
- 29. Iselin CE, Webster GD. The significance of the open bladder neck associated with pelvic fracture urethral distraction defects. J Urol. 1999;162(2):347-351.
- Hosseini SJ, Kaviani A, Jabbari M, et al. Diagnostic application of flexible cystoscope in pelvic fracture urethral distraction defects. J Urol. 2006;3(4):204-207.
- 31. Koraitim MM. Assessment and management of an open bladder neck at posterior urethroplasty. Urology. 2010;76(2):476-479.
- 32. Chapple CR, Goonesinghe S, Nicholson T, *et al.* Flexible cystoscopy is the best way of following up patients with urethral stricture disease. Eur Urol. 2002;1(Suppl 1):90.
- 33. Koraitim MM. Gapometry and anterior urethrotomy in the repair of posterior urethral defects. J Urol. 2008;179(5):1879-1881.
- McAninch JW, Laing FC, Jeffrey RB Jr. Sonourethrography in the evaluation of urethral strictures: A preliminary report. J Urol. 1988;139(2):294-297.
- Nash PA, McAninch JW, Bruce JE, et al. Sono-urethrography in the evaluation of anterior urethral strictures. J Urol. 1995;154(1):72-76.
- Meeks JJ, Erickson BA, Granieri MA, et al. Stricture recurrence after urethroplasty: A systematic review. J Urol. 2009;182(4):1266-1270.
- 37. Gupta N, Dubey D, Mandhani A, *et al.* Urethral stricture assessment: A prospective study evaluating urethral ultrasonography and conventional radiological studies. BJU Int. 2006;98(1):149-153.
- Samaiyar SS, Shukla RC, Dwivedi US, et al. Role of sonourethrography in anterior urethral stricture. Indian J Urol. 1999;15(2):146-151.
- Dixon CM, Hricak H, McAninch JW. Magnetic resonance imaging of traumatic posterior urethral defects and pelvic crush injuries. J Urol. 1992;148(4):1162-1165.
- 40. Sung DJ, Kim YH, Cho SB, *et al.* Obliterative urethral stricture: MR urethrography versus conventional retrograde urethrography with voiding cystourethrography. Radiology. 2006;240(3):842-848.
- Koraitim MM, Reda IS. Role of magnetic resonance imaging in assessment of posterior urethral distraction defects. Urology. 2007;70(3):403-406.
- 42. Oh MM, Jin MH, Sung DJ, *et al.* Magnetic resonance urethrography to assess obliterative posterior urethral stricture: Comparison to conventional retrograde urethrography with voiding cystourethrography. J Urol. 2010;183(2):603-607.
- 43. Narumi Y, Hricak H, Armenakas NA, et al. MR imaging of traumatic posterior urethral injury. Radiology. 1993;188(2):439-443.
- 44. EI-Kassaby AW, Osman T, Abdel-Aal A, et al. Dynamic three-dimensional spiral computed tomographic cysto-urethrography: A novel technique for evaluating post-traumatic posterior urethral defects. BJU Int. 2003;92(9):993-996.
- 45. Osman Y, El-Ghar MA, Mansour O, *et al.* Magnetic resonance urethrography in comparison to retrograde urethrography in diagnosis of male urethral strictures: Is it clinically relevant? Eur Urol. 2006;50(3):587-593.
- Barry MJ, Fowler FJ, O'Leary MP, et al. The American Urological Association symptom index for benign prostatic hyperplasia. The Measurement Committee of the American Urological Association. J Urol. 1992;148(5):1549-1557.
- Barry MJ, Fowler FJ, O'Leary MP, et al. Correlation of the American Urological Association symptom index with self-administered versions of the Madsen-Iversen, Boyarsky and Maine Medical Assessment Program symptom indexes. Measurement Committee of the American Urological Association. J Urol. 1992;148(5):1558-1563.

- 48. Yalla SV, Sullivan MP, Lecamwasam HS, et al. Correlation of American Urological Association symptom index with obstructive and nonobstructive prostatism. J Urol. 1995;153(3 Pt 1):674-679.
- 49. Chancellor MB, Rivas DA, Keeley FX, et al. Similarity of the American Urological Association Symptom Index among men with benign prostate hyperplasia (BPH), urethral obstruction not due to BPH and detrusor hyperreflexia without outlet obstruction. Br J Urol. 1994;74(2):200-203.
- 50. Ko DS, Fenster HN, Chambers K, *et al.* The correlation of multichannel urodynamic pressure-flow studies and American Urological Association symptom index in the evaluation of benign prostatic hyperplasia. J Urol. 1995;154(2 Pt 1):396-398.
- 51. Roberts RO, Jacobsen SJ, Jacobsen DJ, *et al.* Natural history of prostatism: High American Urological Association Symptom scores among community-dwelling men and women with urinary incontinence. Urology. 1998;51(2):213-219.
- 52. Chai TC, Belville WD, McGuire EJ, *et al.* Specificity of the American Urological Association voiding symptom index: Comparison of unselected and selected samples of both sexes. J Urol. 1993;150(5 Pt 2):1710-1713.
- 53. Chancellor MB, Rivas DA. American Urological Association symptom index for women with voiding symptoms: Lack of index specificity for benign prostate hyperplasia. J Urol. 1993;150(5 Pt 2):1706-1708.
- 54. Groutz A, Blaivas JG, Fait G, *et al.* The significance of the American Urological Association symptom index score in the evaluation of women with bladder outlet obstruction. J Urol. 2000;163(1):207-211.
- 55. Scarpero HM, Fiske J, Xue X, *et al.* American Urological Association Symptom Index for lower urinary tract symptoms in women: Correlation with degree of bother and impact on quality of life. Urology. 2003;61(6):1118-1122.
- 56. Plante M, Corcos J, Gregoire I, *et al.* The international prostate symptom score: Physician versus self-administration in the quantification of symptomatology. Urology. 1996;47(3):326-328.
- Barry MJ, Fowler FJ, Chang Y, et al. The American Urological Association symptom index: Does mode of administration affect its psychometric properties? J Urol. 1995;154(3):1056-1059.
- Netto Júnior NR, de Lima ML. The influence of patient education level on the International Prostatic Symptom Score. J Urol. 1995;154(1):97-99.
- Sagnier PP, Richard F, Botto H, et al. Adaptation and validation in the French language of the International Score of Symptoms of Benign Prostatic Hypertrophy [Article in French]. Prog Urol. 1994;4(4):532-538.
- Arocho R, Kason NM, Colon B, et al. Translation and validation of the American Urological Association symptom index into Spanish. Clin Ther. 1995;17(4):777-785.
- MacDiarmid SA, Goodson TC, Holmes TM, et al. An assessment of the comprehension of the American Urological Association Symptom Index. J Urol. 1998;159(3):873-874.
- 62. Johnson TV, Abbasi A, Ehrlich SS, *et al.* Patient misunderstanding of the individual questions of the American Urological Association symptom score. J Urol. 2008;179(6):2291-2294.
- Morey AF, McAninch JW, Duckett CP, et al. American Urological Association symptom index in the assessment of urethroplasty outcomes. J Urol. 1998;159(4):1192-1194.
- 64. Lemma B, Taye M, Hawando T, *et al.* International prostate symptom score as a clinical outcome measure for Ethiopian patients with urethral stricture. Ethiop Med J. 2004;42(2):277-281.
- 65. Lemma B, Bakke A, Taye M, *et al.* Validation of the Amharic translation of international prostate symptom score in Ethiopian patients. Ethiop J Health Dev. 2001;15(3):203-208.
- Drach GW, Layton TN, Binard WJ. Male peak urinary flow rate: Relationships to volume voided and age. J Urol. 1979;122(2):210-214.
- 67. Bukurov NS, Stefanovic KB, Marinkovic JM. Uroflow via stenotic urethra. Int Urol Nephrol. 1992;24(2):55-63.
- Rosier P, de la Rosette JJ, Koldewijn EL, et al. Variability of pressure-flow analysis parameters in repeated cystometry in patients with benign prostatic hyperplasia. J Urol. 1995;153(5):1520-1525.
- Reynard JM, Yang Q, Donovan JL, et al. The ICS, 'BPH' Study: Uroflowmetry, lower urinary tract symptoms and bladder outlet obstruction. Br J Urol. 1998;82(5):619-623.

- Aydos MM, Memis A, Yakupoglu YK, et al. The use and efficacy of the American Urological Association Symptom Index in assessing the outcome of urethroplasty for post-traumatic complete posterior urethral strictures. BJU Int. 2001;88(4):382-384.
- 71. Heyns CF, Marais DC. Prospective evaluation of the American Urological Association symptom index and peak urinary flow rate for the followup of men with known urethral stricture disease. J Urol. 2002;168(5):2051-2054.
- 72. Jorgensen JB, Jensen KM-E, Klarskov P, *et al.* Intra- and inter- observer variations in classification of urinary flow curve patterns. Neurourol Urodyn. 1990;9(5):535-539.
- 73. Klarskov P. Urologic diagnosis by urinary flow measurements with the Glostrup flowmeter [Article in Danish]. Ugeskr Laeger. 1974;136(48):2684-2686.
- Shoukry I, Susset JG, Elhilali MM, et al. Role of uroflowmetry in the assessment of lower urinary tract obstruction in adult males. Br J Urol. 1975;47(5):599-566.
- 75. Gacci M, Del Popolo G, Artibani W, *et al.* Visual assessment of uroflowmetry curves: Description and interpretation by urodynamists. World J Urol. 2007;25(3):333-337.
- Frickson BA, Breyer BN, McAninch JW. The use of uroflowmetry to diagnose recurrent stricture after urethral reconstructive surgery. J Urol. 2010;184(4):1386-1390.
- 77. Garibay JT, Reid C, Gonzalez R. Functional evaluation of the results of hypospadias surgery with uroflowmetry. J Urol. 1995; 154(2 Pt 2):835-836.
- Kaya C, Kucuk E, Ilktac A, et al. Value of urinary flow patterns in the follow-up of children who underwent Snodgrass operation. Urol Int. 2007;78(3):245-248.
- Dunsmuir WD, Fenely M, Corry DA, et al. The day-to-day variation (test-retest reliability) of residual urine measurement. Br J Urol. 1996;77(2):192-193.
- Mochtar CA, Kiemeney LA, van Riemsdijk MM, et al. Post-void residual urine volume is not a good predictor of the need for invasive therapy among patients with benign prostatic hyperplasia. J Urol. 2006;175(1):213-216.
- Kessler TM, Fisch M, Heitz M, et al. Patient satisfaction with the outcome of surgery for urethral stricture. J Urol. 2002;167(6):2507-2511.
- 82. Coursey JW, Morey AF, McAninch JW, et al. Erectile function after anterior urethroplasty. J Urol. 2001;166(6): 2273-2276.
- 83. Erickson BA, Wysock JS, McVary KT, et al. Erectile function, sexual drive, and ejaculatory function after reconstructive surgery for anterior urethral stricture disease. BJU Int. 2007;99(3):607-611.
- 84. O'Leary MP, Fowler FJ, Lenderking WR, et al. A brief male sexual function inventory for urology. Urology. 1995;46(5):697-706.
- Rosen RC, Riley A, Wagner G, et al. The international index of erectile function (IIEF): A multidimensional scale for assessment of erectile dysfunction. Urology. 1997;49(6):822-830.
- Rosen RC, Cappelleri JC, Smith MD, et al. Development and evaluation of an abridged, 5-item version of the International Index of Erectile Function (IIEF-5) as a diagnostic tool for erectile dysfunction. Int J Impot Res. 1999;11(6):319-326.
- 87. Anger JT, Sherman ND, Webster GD. The effect of bulbar urethroplasty on erectile function. J Urol. 2007;178(1 Pt 1):1009-1011.
- Erickson BA, Granieri MA, Meeks JJ, et al. Prospective analysis of erectile dysfunction after anterior urethroplasty: Incidence and recovery of function. J Urol. 2010;183(2):657-661.
- 89. Erickson BA, Granieri MA, Meeks JJ, *et al.* Prospective analysis of ejaculatory function after anterior urethral reconstruction. J Urol. 2010;184(1):238-242.
- 90. Yang CC, Bradley WE. Reflex innervation of the bulbocavernosus muscle. BJU Int. 2000;85(7):857-863.
- Rosen RC, Catania J, Pollack L, et al. Male Sexual Health Questionnaire (MSHQ): Scale development and psychometric validation. Urology. 2004;64(4):777-782.
- 92. Vijayan P, Sundin T. Island patch urethroplasty: Effects on urinary flow and ejaculation. Br J Urol. 1983;55(1):69-72.
- Anger JT, Sherman ND, Webster GD. Ejaculatory profiles and fertility in men after posterior urethroplasty for pelvic fractureurethral distraction defect injuries. BJU Int. 2008;102(3):351-353.
- 94. Yang CC, Bradley WE. Somatic innervation of the human bulbocavernosus muscle. Clin Neurophysiol. 1999;110(3):412-418.

- Wieder JA, Brackett NL, Lynne CM, et al. Anesthetic block of the dorsal penile nerve inhibits vibratory-induced ejaculation in men with spinal cord injuries. Urology. 2000;55(6):915-917.
- 96. Barbagli G, De Stefani S, Annino F, *et al.* Muscle- and nerve-sparing bulbar urethroplasty: A new technique. Eur Urol. 2008;54(2):335-343.
- 97. Jordan GH, Eltahawy EA, Virasoro R. The technique of vessel sparing excision and primary anastomosis for proximal bulbous urethral reconstruction. J Urol. 2007;177(5):1799-1802.
- Turner-Warwick R. Principles of urethral reconstruction. In: Webster G, Kirby R, King L, et al., editors. Reconstructive urology. Boston: Blackwell Scientific Publications; 1993. p. 609-642.
- 99. Smith JC, Edwards D, Bryant GH. A practical method of measuring urethral resistance to micturition. Br J Urol. 1966;38(5): 542-546.
- 100. Smith JC. The measurement and significance of the urinary flow rate. Br J Urol. 1966;38(6):701-706.
- 101. Mundy AR. Adjuncts to visual internal urethrotomy to reduce the recurrence rate of anterior urethral strictures. Eur Urol. 2007;51(6):1467-1468.
- 102. Barbagli G, De Angelis M, Romano G, *et al.* Clinical outcome and quality of life assessment in patients treated with perineal urethrostomy for anterior urethral stricture disease. J Urol. 2009;182(2):548-557.
- Barbagli G, Guazzoni G, Lazzeri M. One-stage bulbar urethroplasty: Retrospective analysis of the results in 375 patients. Eur Urol. 2008;53(4):828-833.
- 104. Watkin N. Personal communication.
- 105. Andrich DE, Dunglison N, Greenwell TJ, et al. The long-term results of urethroplasty. J Urol. 2003;170(1):90-92.



# Dilation, Internal Urethrotomy and Stenting of Male Anterior Urethral Strictures

#### CHAIRS

Jill Buckley, United States Chris Heyns, South Africa

#### MEMBERS

Peter Gilling, New Zealand Jeff Carney, United States

Committee

# CONTENTS

3

### Dilation, Internal Urethrotomy and Stenting of Male Anterior Urethral Strictures

3.1	Introduction	_65
3.2	Methods	_65
3.3	Incision/Dilation of Male Anterior Urethral Strictures	_66
3.4	Review of the Literature on Incision and Dilation Outcomes	_66
3.5	Repeat Direct Vision Internal Urethrotomy/ Dilation	_68
3.6	Side Effects of Direct Vision Internal Urethrotomy	_68
3.7	Cost Effectiveness	_69
3.8	Laser Urethrotomy	_69
3.9	Direct Vision Internal Urethrotomy Plus Self-Dilation	_70

# Committee

3.10	Catheter Urinary Drainage			
3.11	Direct Vision Internal Urethrotomy with Adjunctive Agents			
3.12	Effect on Future Urethral Reconstruction			
3.13	Anterior Urethral Stenting			
3.14	Recomm	74		
	3.14.1	Primary direct vision internal urethrotomy and dilation	74	
	3.14.2	Repeat direct vision internal urethrotomy/dilation	74	
	3.14.3	Direct vision internal urethrotomy/dilation and intermittent catheterization	75	
	3.14.4	Laser urethrotomy	75	
	3.14.5	Anterior urethral stenting	75	
3.15	Referenc	es	76	



# 3.1 Introduction

Male urethral stricture is one of the oldest known urologic diseases, and continues to be a common and challenging urologic condition. The oldest and simplest form of management is urethral dilation, which can be performed with a number of different devices and is generally considered a palliative maneuver. In 1974, Sachse introduced direct vision internal urethrotomy (DVIU) to treat urethral strictures by cold-knife incision (1). Optical urethrotomy by either incision or ablation has been considered standard therapy for anterior urethral strictures and is regarded, along with dilation, as the initial treatment of choice for most urethral strictures. In general, open urethral reconstruction is the most successful management option for urethral strictures, but it requires surgical expertise and adequate operating room facilities, and has a longer recovery period.

A number of large series from the late 1990s have well characterized the success of incision or dilation of the urethra and delineated predictive factors of outcomes (2–4). Various modifications of the single cold-knife incision have been suggested, including a variety of different laser wavelengths and the introduction of anterior urethral stenting (5,6). However, there are no prospective, randomized studies to prove their claims of greater efficacy.

The long-term success rate of urethrotomy has continued on a steady downward trend from the results of 20 years ago, which suggested a cure rate of over 90% (2,7–9). The reported success rates of urethral stricture treatment are critically dependent on the criteria used for stricture diagnosis before and after treatment, and on the definition of success (in some studies this includes eventual outcome, despite multiple treatments).

Modalities used in determining the success of treatment include symptoms, uroflowmetry, urethral catheterization or calibration, urethrocystoscopy, urethrography (radiological or sonographic), post-void residual urine volume, absence of urinary tract infection, and requirement for subsequent treatment. Clearly, the success rates reported in various studies depend not only on the type of treatment given, but on the criteria used for stricture diagnosis before treatment, the type and duration of follow-up, and the modalities and criteria used to determine stricture recurrence and to define success.

## 3.2 Methods

An extensive review of the scientific literature concerning anterior urethral urethrotomy/dilation/ stenting was performed. Manuscripts were included that met the criteria set by the International Consultation on Urological Diseases (ICUD) urethral strictures committee and were classified by Level of Evidence using the Oxford Centre for Evidence-Based Medicine criteria adapted from the work of the Agency for Health Care Policy and Research as modified for use in previous ICUD projects. Recommendations were graded according to the levels of evidence and agreement of expert opinion.

## 3.3 Incision/Dilation of Male Anterior Urethral Strictures

A recent survey examining the practice patterns of board-certified American urologists found that 92.8% and 85.6% use dilation and/or incision, respectively, to treat anterior urethral strictures. Of the urologists that perform urethral reconstruction, only 0.7% perform more than 10 per year (10,11). The appeal of DVIU/dilation is its relative ease of performance, minimal resource requirements, and simplicity in not requiring expertise in urethral reconstruction. The procedure can be performed in the office (under local anesthesia), requires minimal recovery time, and has a low cost burden to the patient in terms of disability precluding work (12–14).

The goal of incision or dilation is to provide a minimally invasive treatment that achieves a patent urethra to allow unobstructed voiding with minimal side effects. For the urethra to remain patent, re-epithelialization must occur at a faster rate than wound contracture (15). For highly selected patients with optimal stricture characteristics (primary bulbar stricture, < 1 cm, soft), a stricture-free rate (SFR) of up to 50%–70% can be achieved. Thus, urethrotomy remains the first-line therapy for these select patients (2–4). The SFR is still well below that of anastomotic urethroplasty (90%–95%) (16,17), but urethrotomy can be justified by its simplicity and relatively low morbidity to the patient. Reported complication rates vary from 6%–22%, including pain, bleeding, urinary tract infection, and erectile dysfunction (2,4,8). What is clear from the literature is that repeat (> 2) DVIU/dilation for early stricture recurrence after previous DVIU/dilation is a palliative maneuver with expected recurrence (2,4,8,9,18). It thus is inappropriately and excessively used because of its convenience and familiarity when referral for urethral reconstruction could be curative.

The literature consists largely of case series with diverse patient populations that are not matched for age, stricture etiology, length, location, or primary versus recurrent strictures. Techniques vary from blind urethral dilation and incision to direct visualization and incision urethrotomy with a cold knife, hot knife, or various types of lasers. The definition of success was vague and poorly defined in most series and limited to one of the following: lack of symptoms, "acceptable" flow rates, radio-graphy, and (rarely) urethroscopy. Outcomes were largely based on short-term follow-up (< 1 year), often with no definition of how success was determined (19).

# 3.4 Review of the Literature on Incision and Dilation Outcomes

One randomized study performed in 1997 by Steenkamp *et al.* sought to determine whether DVIU and dilation were equally efficacious, which had been reported in prior Level 3 studies (Level 1) (3,20). Two well–matched groups of 104 and 106 patients were randomized to either incision or dilation, respectively. Although there was a higher reported success rate with DVIU, this was not statistically significant and the effectiveness of the two procedures were considered equivalent (3). This study

also found that incremental increases in length resulted in higher failure rates and recommended initial dilation for strictures < 2 cm, urethroplasty for strictures > 4 cm, and a trial of DVIU or dilation for strictures 2–4 cm in length. The same group of patients was analyzed for time to recurrence, outcomes of repeat incision/dilation, and long-term stricture-free rates using Kaplan-Meier curves out to 48 months. Investigators found that early recurrence (< 3 months) and repeat incision/dilation were poor prognostic factors. Urethral strictures that recurred at < 3 months and underwent repeat incision or dilation had an SFR of 30% at 24 months and 0% at 48 months. If a stricture recurred at > 6 months, then a second DVIU could achieve an SFR of up to 40%. Urethral strictures undergoing a third incision or dilation had a 100% recurrence rate (8).

A number of Level 3 studies on DVIU with short duration of follow-up have been published over the past 10–20 years. The mean follow-up in these case series was commonly < 12 months (range: 3-30 months), with a variety of endpoints, stricture locations, and success rates (46%-84%) being reported (21-23). Two of the better Level 3 series were published in the late 1990s.

Pansadoro and Emiliozzi analyzed 224 patients that underwent DVIU for short urethral strictures, with a median follow-up of 98 months (2). The overall SFR was 32%, but varied significantly based on the stricture characteristics of location, length, diameter, primary versus recurrent, and single versus multiple strictures. The bulbar, penile, and penoscrotal locations had SFRs of 42%, 16%, and 11%, respectively. Strictures < 1 cm had an SFR of 71%, versus 18% for those > 1 cm. A lumen diameter > 15 French (F) had an SFR of 69%, versus 34% for those < 15F. Primary versus repeat incisions had SFRs of 47% and 0%, respectively, and single strictures versus multiple strictures had SFRs of 50% and 16%, respectively (2).

A second large series by Albers *et al.* looked at 580 patients with over 3 years' follow-up (4). They reported an overall SFR of 55% with the best results again seen in short primary bulbar strictures. Longer strictures (> 1 cm) that had failed prior DVIU, multiple strictures, and penile strictures had much higher recurrence rates; therefore, the authors concluded that in these patients, urethroplasty should be performed rather than repeat incision or dilation (4).

These studies indicated that optimal results for urethrotomy can be achieved in patients with a single primary bulbar stricture that is < 1 cm long and > 15F in calibre. A single DVIU/dilation or primary urethroplasty could be offered as first-line therapy for penile or penobulbar strictures due to extremely poor SFR with DVIU/dilation, whereas repeated (> 2) DVIU/dilation is to be considered only as a palliative maneuver.

Contemporary series have also reported a wide range of SFRs (9,21,24). Case series published during the past decade have included 13 to 733 patients per study with 2 to 90 months' follow-up and success rates of 22% to 100%, remarkably similar to studies published during the preceding two decades (1980 to 1999), which included 15 to 580 patients with 6 to 72 months' follow-up and success rates varying from 22% to 95% (Level 3).

Santucci and Eisenberg recently stated that internal urethrotomy (IU) has a much lower success rate than previously reported. They performed a retrospective chart review of 136 patients who underwent IU from 1994 through 2009. They excluded 36 patients with complex strictures and 24 who were lost to follow-up. The stricture-free rates after one, two, three, four, and five IUs were 8%, 6%, 9%, 0%, and 0%, respectively, and the median times to recurrence were 7, 9, 3, 20, and 8 months, respectively (Level 3) (9).

Due to the various definitions of success, non-matched patient populations, unknown stricture length or location, and various standards of success and lengths of follow-up, it is impossible to compare one series to another. Contemporary series on urethrotomy/dilation add little additional information on the management of anterior urethral strictures.

## 3.5 Repeat Direct Vision Internal Urethrotomy/Dilation

In patients with stricture recurrence but favourable characteristics (single, < 1 cm bulbar stricture) and time to recurrence > 6 months, a second DVIU achieved an SFR of 9%-53% (Level 2/3) (2,5,8,9,23). Longer, multiple, penile, or distal strictures typically do not respond to repeat incision/ dilation (25).

Repeat DVIU offers no long-term cure after a third incision/dilation or if the stricture recurs within 3 months of the first incision. Such patients should be offered urethroplasty (4,5,8).

Incision/dilation followed by long-term self- or office dilation is an alternative option for men with severe comorbidities or limited life expectancy, or for those who have failed prior reconstruction with no further available surgical options (Level 4).

## 3.6 Side Effects of Direct Vision Internal Urethrotomy

A review of the literature showed that the most commonly reported complications of IU are urethral hemorrhage and perineal hematoma (each with a 20% incidence) (5). Other complication rates reported in various studies include scrotal edema (13%), creation of a false passage (10%), rectal perforation (10%), epididymo-orchitis, meatal stenosis and incontinence (each 9%), fever (3.6%), extravasation (3.4%), bacteremia (2.7%), urinary sepsis (2.1%), and scrotal abscess (1.4%). Erectile dysfunction has historically been reported in 2%–10% of cases; however, Schneider *et al.* found that of the 68 patients who did not have erectile problems before the operation, only one complained about erectile dysfunction following DVIU (26,27). It should be noted that most of these numbers are derived from single studies, and the reported 10% rate of rectal perforation is exceptional (Level 3).

# 3.7 Cost Effectiveness

Several recent studies have looked at cost-effective management of anterior urethral strictures and have shown that a single urethrotomy is cost effective when the expected success rate is > 35%-50%. Primary urethroplasty becomes more cost effective if a repeat urethrotomy is required. Wright *et al.* found that the most cost-effective strategy for the management of short bulbar urethral strictures is to reserve urethroplasty for patients in whom a single endoscopic attempt fails (28). For longer strictures, in which the success rate of DVIU is expected to be < 35%, urethroplasty as primary therapy is cost effective (28). Two similar studies confirmed that initial urethrotomy or dilation followed by urethroplasty in patients with recurrent strictures is the most cost effective (22,29).

These studies only evaluated the financial costs of the procedures and lost productivity during convalescence in developed countries. In regions of the world with constrained resources, the use of limited operating room facilities to perform urethroplasty rather than surgery for life-threatening urologic conditions should be considered. A paper from Nigeria reported the treatment problems in a community where strictures are common and resources are limited. In 134 men treated between 1993 and 1996, the combination of internal urethroplasty. It was estimated that IU was 10 times cheaper and faster to perform than urethroplasty, and offered the surgeon better protection from infection with human immunodeficiency virus (Level 3) (30).

## 3.8 Laser Urethrotomy

A variety of different laser wavelengths have been employed for the incision, resection, and vaporization of anterior urethral strictures over the last 30 years. Initially argon, excimer, and diode lasers were employed, as were low-power KTP and contact-tip Nd:YAG lasers. Over the past 10 years, holmium and thulium lasers have been added to the surgeon's armamentarium. There are no Level 2 studies and only a few small Level 3 series with short-term follow-up.

The holmium laser (2140 nm) was employed via a 365  $\mu$ m fibre through a semi-rigid ureteroscope by Matsuoka *et al.* to treat strictures of varying lengths and locations (31). At a mean of 25 months' follow-up, 11 of 28 (39%) strictures recurred. Several other small or limited follow-up (< 6 months) Level 3 series with a variety of strictures, definitions of success, and evidence of poor outcomes also used the holmium laser with reported recurrence rates of 19%–47% (32–34).

One series with a short follow-up (6 months) evaluated the thulium laser (2000 nm) in a large retrospective series (35). Over a 4-year period, 238 patients were prospectively evaluated with flow rates and symptom scores; 18% of the patients recurred over this short period, all within the first 3 weeks following catheter removal (Level 3) (36). The Nd:YAG laser (1064 nm) was used by Dogra *et al.* in 65 men and 10 children with obliterative post-traumatic strictures (37,38). It was also used for 21 anterior strictures by Gürdal *et al.* The strictures were treated with an initial incision at 12 o'clock with the remainder of the stricture being vaporized. At 24 months, 48% of strictures had recurred, with a steadily decreasing success rate at 6 and 12 months (39). Kamal *et al.* described the treatment of 22 patients, 14 of whom were previously untreated, with a diode laser (805 nm). At a mean follow-up of 26.7 months (range: 9–39 months), 3/14 patients with primary strictures and 7/8 with recurrent strictures after previous internal coldknife urethrotomy had failed (40).

The addition of lasers with a variety of different energy sources has not improved success rates, yet adds considerable cost with no proven benefit over cold-knife urethrotomy.

## 3.9 Direct Vision Internal Urethrotomy Plus Self-Dilation

Historically, many patients were placed on intermittent self-catheterization (ISC) after DVIU/dilation–in an attempt to prevent stricture recurrence. It is a traumatic procedure that some patients find painful, unpleasant, and burdensome, with risk of false passage, infection, abscess formation, and progression of the extent of urethral scarring potentially compromising future reconstruction (41,42).

Culty and Boccon-Gibod retrospectively found that prior urethral dilation was a negative predictor for patients undergoing membranous/bulbar anastomotic urethroplasty. Patients without prior urethral manipulation had a satisfactory result of more than 90%, versus ~60% in patients with previous surgical treatment (43). Several studies have evaluated a combination of urethrotomy and dilation (22,44–46). The contribution of dilation or clean intermittent self-catheterization (CISC) to failure rates could not be separated out in several of the series, but it was noted to add to the cost of treatment (22,46).

A small Level 2 study by Tunc *et al.* randomized 37 men with recurrent strictures to either serial dilation (n = 19) or repeat DVIU as required (n = 18) and followed them for a median of 30 months (46). At 1 year, two patients (10.5%) with serial dilation had stricture recurrence compared to 10 (55.6%) in the conservatively treated group. Lauritzen *et al.* evaluated a retrospective series of 217 men who had urethrotomy (47). A small subset of 55 patients, who were not randomized or matched to the larger cohort, were placed on ISC. The recurrence rate of 9% was significantly less in the ISC group than in the non-ISC group (31%) with mean follow-up of 29 months and 23 months, respectively (47). In order to demonstrate a benefit over DVIU alone, a prospective study would need to be carried out with matched patient populations and equal length of follow-up after stopping the ISC.

# 3.10 Catheter Urinary Drainage

The period of catheterization following incision/dilation varies, with no standard or proven optimal length of drainage and with most contemporary series reporting 3–10 days of catheterization. Various studies have described no post-operative catheter drainage up to 6 weeks (5). It remains unclear whether the period of catheterization after DVIU affects the stricture recurrence rate. Conclusions for optimal catheter drainage time cannot be drawn from the literature with small sample sizes that are not matched for type (primary versus recurrent), etiology, length, or location of the strictures. Silicone catheters are preferred for long periods of urinary drainage, as latex has been implicated as causative in the etiology of urethral strictures (Level 3) (48).

# 3.11 Direct Vision Internal Urethrotomy with Adjunctive Agents

In an effort to improve outcomes of DVIU, a few small series have been published on adjunctive agents used in combination with DVIU (49,50). A level 2 study randomized 40 patients with short bulbar strictures (mean length: 0.75 mm) to DVIU versus DVIU plus mitomycin C (MMC) injection (51). Recurrence with DVIU alone was 50%, compared to 10% in the DVIU plus MMC group. However, this was a highly selected group of young patients with short bulbar strictures and limited follow-up.

The same authors randomized 50 patients to DVIU versus DVIU plus urethral submucosal injection of triamcinolone, and found a decrease in stricture recurrence from 50% in DVIU alone to 21% in DVIU plus triamcinolone. As in the MMC study, this was a highly selected group of young patients with primary short bulbar strictures (< 1.0 cm) and limited follow-up (52). Additional small Level 3 series make reference to the use of adjunctive agents with DVIU, but are inherently limited by incomplete or vague follow-up data and/or definition of success.

### 3.12 Effect on Future Urethral Reconstruction

A few Level 3 series have shown that prior urethral manipulation was a risk factor for urethroplasty failure. A multivariate analysis looking at long-term outcomes of urethroplasty found that prior failed DVIU was correlated with an increased risk of failure following urethroplasty (53). Similarly, Roehrborn and McConnell found that the failure rate doubled from 14% to 28% when incision

or dilation had been performed prior to urethroplasty (54). Successful urethral reconstruction can, however, be achieved after failed DVIU, as shown by Barbagli *et al.*, with equal outcomes in primary urethroplasty versus urethroplasty after DVIU (55).

## 3.13 Anterior Urethral Stenting

Although the concept of stenting the urethra dates back to at least 1969, it was propagated by Milroy *et al.* in 1988, when they reported "a new treatment for urethral strictures" (6). Originally developed for endovascular use, a self-expanding woven tubular mesh stent made from an alloy of stainless steel was implanted in eight patients with urethral strictures. At a mean of 8 months' follow-up, all had a good calibre urethra. A later series of 10 patients implanted with the same stent for bulbar strictures reported a 30% stricture recurrence rate at 24 months' follow-up, with 50% of patients reporting post-void dribbling (Level 4) (56).

Four-year data reported by Milroy and Allen in 1996 showed an 84% patency rate but only included 32/50 patients (64%) and noted that 34% had narrowing within and/or outside the stent (57). Morgia *et al.* reported on a multicentre study that implanted 94 UroLume® stents in short urethral strictures (0.5–2.5 cm) (58). At a median of 29 months' follow-up, results were good in 52%, fair in 34%, and poor in 14% of patients. Patients experienced early complications of perineal discomfort (86%) and dribbling (14%), as well as painful erection (44%), mucous hyperplasia (44%), incontinence (14%), and recurrence (29%) (58).

Long-term data began to reveal the difficulties and shortcomings of the UroLume stent. De Vocht *et al.* evaluated patient satisfaction 10 years after placement of the UroLume stent and found that only 2/15 patients were satisfied with their stent (59). Four patients had their stents removed (two for intractable pain and two for stent obstruction), 50% had stent-related incontinence, and others reported discomfort with erection and/or ejaculation (59). Hussain *et al.* reported 12-year follow-up on 60 patients and showed that 58% had complications, with a re-operation rate of 45% for obstructing stent hyperplasia (32%), stent obstruction or stricture (25%), and stent encrustation or calcification (17%). Additionally, patients experienced post-micturition dribbling (32%) and recurrent urinary tract infections (27%) (60).

The North American Multicenter UroLume Trial originally included 179 patients (average age: 52 years) with recurrent short bulbar strictures. Two-year follow-up indicated that 85% of the patients required no additional treatments. Eleven-year follow-up only included 24 of the original 179 patients. The authors did not address the question of why only 13% of the original patients were available for review (61).

The original indication for the UroLume stent was for recurrent short bulbar urethral strictures and the original series placed them in men (average age: 52–53 years) who were optimal candidates for bulbar urethroplasty. Long-term follow-up revealed that up to 55% had stent-related complications, 45% requiring surgical intervention for perineal pain, post-voiding dribbling, incontinence, stent migration, stent obstruction, or recurrent strictures proximal or distal to the stent. Patency continued to decline over time, originally reported at 100% in the initial patients with short follow-up and decreasing to 45% at a mean follow-up of 77 months (56,59). Additionally, explanation can result in substantial urethral tissue loss and the need for challenging urethral reconstruction (62–64).

Various materials have been used to make urethral stents, such as stainless steel, metal alloys, and nondegradable and degradable polymers. Yachia and Beyar introduced the nitinol UroCoil<sup>™</sup> in 1991 as a temporary urethral stent designed to minimize tissue ingrowth to allow endoscopic removal (65). Twenty patients with recurrent bulbomembranous strictures were implanted with the UroCoil stent; 13 patients had the stent in place for 10 months and then successfully removed, with one reported recurrent stricture (66).

The Memokath<sup>TM</sup> stent (a removable, densely coiled, thermo-expandable stent made of nitinol) has been used to treat prostatic obstruction and detrusor sphincter dyssynergia in the posterior urethra and was recently evaluated for use in the anterior urethra. A phase III multicentre trial randomized 92 patients to dilation/incision followed by temporary Foley catheter drainage (n = 29) versus Memokath stenting (n = 63) for recurrent bulbar urethral strictures. The primary endpoint was urethral patency, defined as the ability to pass a 16F flexible cystoscope. Urethral patency was 3.5 times longer in the Memokath stented group, with all stents successfully removed. Durability effect on the stricture was not assessed. Side effects of the stent included urinary tract infections, hematuria, and penile pain. Stent migration occurred in 22% of patients. The ease of placement and removal of the Memokath stent may prove useful for recurrent bulbar strictures in medically unfit patients or patients unable to undergo formal urethral reconstruction; however, further investigation is needed (67).

To avoid the complications of metal urethral stents, there has been interest in developing bioabsorbable urethral stents. In 1993, Kemppainen *et al.* introduced a helical spiral bioabsorbable poly-Llactic acid (PLLA) stent in male rabbits. Isotalo *et al.* reported a pilot study with 22 patients in 1998 using these PLLA stents and found that the stent did completely degrade at 12 months but that there was a 59% re-stricture rate (68). A subsequent study with longer follow-up showed an ultimate success of 36% with new-generation bioabsorbable stents (69,70). Kotsar *et al.* introduced a new tubular configuration of a polylactide and polyglycolide braided biodegradable stent (felt to be more stable and resistant to breakdown), but found in animal studies that epithelial hyperplasia and local inflammation were still problematic (71). This led to the development of drug-eluting biodegradable stents aimed at improving the degradation time and success of the stent. These products are still in the experimental phase (71).

# 3.14 Recommendations

The following recommendations were made based on review of the available literature and expert opinion.

#### 3.14.1 **Primary direct vision internal urethrotomy and dilation**

- 1. Ure thral dilation and DVIU have equal clinical efficacy and the use of either modality is acceptable, depending on the availability of equipment and resources (B).
- 2. Primary DVIU/dilation is indicated as first-line therapy for short (< 1-2 cm), single, bulbar urethral strictures (A).
- 3. Primary DVIU/dilation may be used as first-line therapy for urethral strictures with unfavourable characteristics (penile, penobulbar, multiple, > 1–2 cm) (C).
- 4. Urethral reconstruction is recommended as a primary management option for long, multiple, and penile or penobulbar strictures when complete urethral obliteration is present (B).

#### 3.14.2 **Repeat direct vision internal urethrotomy/dilation**

- 1. A second DVIU/dilation can be indicated for recurrent urethral strictures with favourable characteristics (< 1–2 cm, single, bulbar stricture) with recurrence more than 3 months after previous treatment (B).
- 2. A third DVIU/dilation is not recommended, except if necessitated by patient comorbidities or economic resources (A).
- 3. Urethral reconstruction over repeat DVIU/dilation should be offered for urethral strictures that recur within 6 months or are refractory to a second DVIU/dilation (A).

#### 3.14.3 **Direct vision internal urethrotomy/dilation and intermittent catheterization**

1. DVIU/dilation combined with intermittent self-dilation may be used as a palliative maneuver for patients unwilling to undergo urethral reconstruction or medically unfit for surgery (B).

#### 3.14.4 Laser urethrotomy

1. Outcomes of laser urethrotomy suggest that it has no advantage over cold-knife urethrotomy, and due to the additional cost associated with the procedure, its routine use is not recommended (A).

#### 3.14.5 Anterior urethral stenting

- 1. Permanent urethral stenting is not recommended for patients with strictures who are considered to be candidates for urethral reconstruction (A).
- 2. Permanent urethral stenting may be considered in patients with a short, recurrent bulbar stricture who are medically unfit for urethroplasty and cannot tolerate intermittent self-dilation (B).
- 3. The appropriate circumstances for temporary urethral stenting have not been determined. The procedure is still largely experimental (B).

# 3.15 References

- 1. Sachse H. Treatment of urethral stricture: Transurethral slit in view using sharp section [Article in German]. Fortschr Med. 1974; 92(1):12-15.
- 2. Pansadoro V, Emiliozzi P. Internal urethrotomy in the management of anterior urethral strictures: Long-term followup. J Urol. 1996; 156(1):73-75.
- 3. Steenkamp JW, Heyns CF, de Kock ML. Internal urethrotomy versus dilation as treatment for male urethral strictures: A prospective, randomized comparison. J Urol. 1997;157(1):98-101.
- 4. Albers P, Fichtner J, Brühl P, et al. Long-term results of internal urethrotomy. J Urol. 1996;156(5):1611-1614.
- 5. Naudé AM, Heyns CF. What is the place of internal urethrotomy in the treatment of urethral stricture disease? Nat Clin Pract Urol. 2005;2(11):538-545.
- 6. Milroy EJ, Chapple CR, Cooper JE, et al. A new treatment for urethral strictures. Lancet. 1988;1(8600):1424-1427.
- 7. Smith PJ, Roberts JB, Ball AJ, et al. Long-term results of optical urethrotomy. Br J Urol. 1983;55(6):698-700.
- Heyns CF, Steenkamp JW, De Kock ML, et al. Treatment of male urethral strictures: Is repeated dilation or internal urethrotomy useful? J Urol. 1998;160(2):356-358.
- 9. Santucci R, Eisenberg L. Urethrotomy has a much lower success rate than previously reported. J Urol. 2010;183(5):1859-1862.
- Bullock TL, Brandes SB. Adult anterior urethral strictures: A national practice patterns survey of board certified urologists in the United States. J Urol. 2007;177(2):685-690.
- 11. Anger JT, Buckley JC, Santucci RA, *et al.* Trends in stricture management among male Medicare beneficiaries: Underuse of urethroplasty? Urology. 2011; 77(2): 481-5.
- Steenkamp JW, Heyns CF, de Kock ML. Outpatient treatment for male urethral strictures—Dilatation versus internal urethrotomy. S Afr J Surg. 1997;35(3):125-130.
- 13. Altinova S, Turkan S. Optical urethrotomy using topical anesthesia. Int Urol Nephrol. 2007;39(2):511-512.
- Ather MH, Zehri AA, Soomro K, et al. The safety and efficacy of optical urethrotomy using a spongiosum block with sedation: A comparative nonrandomized study. J Urol. 2009;181(5):2134-2138.
- 15. Tonkin JB, Jordan GH. Management of distal anterior urethral strictures. Nat Rev Urol. 2009;6(10):533-538.
- Barbagli G, De Angelis M, Romano G, et al. Long-term followup of bulbar end-to-end anastomosis: A retrospective analysis of 153 patients in a single center experience. J Urol. 2007;178(6):2470-2473.
- 17. Santucci RA, Mario LA, McAninch JW. Anastomotic urethroplasty for bulbar urethral stricture: Analysis of 168 patients. J Urol. 2002;167(4):1715-1719.
- 18. Andrich DE, Mundy AR. Urethral strictures and their surgical treatment. BJU Int. 2000;86(5):571-580.
- 19. Wong SS, Narahari R, O'Riordan A, *et al.* Simple urethral dilatation, endoscopic urethrotomy, and urethroplasty for urethral stricture disease in adult men. Cochrane Database Syst Rev. 2010(4):CD006934.
- Stormont TJ, Suman VJ, Oesterling JE. Newly diagnosed bulbar urethral strictures: Etiology and outcome of various treatments. J Urol. 1993;150(5 Pt 2):1725-1728.
- 21. Hizli F, Berkmen F, Gunes MN, *et al.* Outcomes of internal urethrotomy after transurethral resection related urethral strictures and literature review [Article in Turkish]. Turk Uroloji Dergisi. 2005;31(3):417-422.
- 22. Greenwell TJ, Castle C, Andrich DE, *et al.* Repeat urethrotomy and dilation for the treatment of urethral stricture are neither clinically effective nor cost-effective. J Urol. 2004;172(1):275-277.
- Mandhani A, Chaudhury H, Kapoor R, et al. Can outcome of internal urethrotomy for short segment bulbar urethral stricture be predicted? J Urol. 2005;173(5):1595-1597.

- Martov AG, Ergakov DV, Saliukov RV, et al. Long-term results of endoscopic treatment of urethral strictures [Article in Russian]. Urologiia. 2007(5):27-32.
- Zehri AA, Ather MH, Afshan Q. Predictors of recurrence of urethral stricture disease following optical urethrotomy. Int J Surg. 2009; 7(4):361-364.
- Graversen PH, Rosenkilde P, Colstrup H. Erectile dysfunction following direct vision internal urethrotomy. Scand J Urol Nephrol. 1991; 25(3):175-178.
- Schneider T, Sperling H, Lummen G, et al. Sachse internal urethrotomy. Is erectile dysfuction a possible complication? [Article in German]. Urologe A. 2001;40(1):38-41.
- Wright JL, Wessells H, Nathens AB, et al. What is the most cost-effective treatment for 1 to 2-cm bulbar urethral strictures? Societal approach using decision analysis. Urology. 2006;67(5):889-893.
- Rourke KF, Jordan GH. Primary urethral reconstruction: The cost minimized approach to the bulbous urethral stricture. J Urol. 2005; 173(4):1206-1210.
- Ogbonna BC. Managing many patients with a urethral stricture: A cost-benefit analysis of treatment options. Br J Urol. 1998; 81(5):741-744.
- Matsuoka K, Inoue M, Iida S, et al. Endoscopic antegrade laser incision in the treatment of urethral stricture. Urology. 2002; 60(6):968-972.
- Kamp S, Knoll T, Osman MM, et al. Low-power holmium:YAG laser urethrotomy for treatment of urethral strictures: Functional outcome and quality of life. J Endourol. 2006;20(1):38-41.
- Xiao J, Wu B, Chen LW, et al. Holmium laser urethrotomy for male urethral stricture [Article in Chinese]. Zhonghua Nan Ke Xue. 2008; 14(8):734-736.
- Hossain AZ, Khan SA, Hossain S, et al. Holmium laser urethrotomy for urethral stricture. Bangladesh Med Res Counc Bull. 2004; 30(2):78-80.
- 35. Guo FF, Lu H, Wang GJ, *et al.* Efficacy of transurethral 2 microm laser urethrotomy in the treatment of urethral stricture and atresia [Article in Chinese]. Zhonghua Yi Xue Za Zhi. 2008;88(18):1270-1272.
- 36. Guo FF, Lu H, Wang GJ, et al. Transurethral 2-microm laser in the treatment of urethral stricture. World J Urol. 2010;28(2):173-175.
- Dogra PN, Ansari MS, Gupta NP, et al. Holmium laser core-through urethrotomy for traumatic obliterative strictures of urethra: Initial experience. Urology. 2004;64(2):232-235.
- Dogra PN, Nabi G. Nd-YAG laser core-through urethrotomy in obliterative posttraumatic urethral strictures in children. Pediatr Surg Int. 2003;19(9-10):652-655.
- Gürdal M, Tekin A, Yüceba E, et al. Contact neodymium: YAG laser ablation of recurrent urethral strictures using a side-firing fiber. J Endourol. 2003;17(9):791-794.
- 40. Kamal BA. The use of the diode laser for treating urethral strictures. BJU Int. 2001;87(9):831-833.
- 41. Morey A. Urethral stricture is now an open surgical disease. J Urol. 2009;181(3):953-954.
- 42. Mangera A, Chapple C. Management of anterior urethral stricture: An evidence-based approach. Curr Opin Urol. 2010;20(6):453-458.
- Culty T, Boccon-Gibod L. Anastomotic urethroplasty for posttraumatic urethral stricture: Previous urethral manipulation has a negative impact on the final outcome. J Urol. 2007;177(4):1374-1377.
- 44. Harriss DR, Beckingham IJ, Lemberger RJ, *et al.* Long-term results of intermittent low-friction self-catheterization in patients with recurrent urethral strictures. Br J Urol. 1994;74(6):790-792.
- Kjaergaard B, Walter S, Bartholin J, et al. Prevention of urethral stricture recurrence using clean intermittent self-catheterization. Br J Urol. 1994;73(6):692-695.
- Tunc M, Tefekli A, Kadioglu A, et al. A prospective, randomized protocol to examine the efficacy of postinternal urethrotomy dilations for recurrent bulbomembranous urethral strictures. Urology. 2002;60(2):239-244.

- 47. Lauritzen M, Greis G, Sandberg A, *et al.* Intermittent self-dilatation after internal urethrotomy for primary urethral strictures: A case-control study. Scand J Urol Nephrol. 2009;43(3):220-225.
- 48. Pitkamaki KK, Tammela TL, Kontturi MJ. Recurrence of urethral stricture and late results after optical urethrotomy: Comparison of strictures caused by toxic latex catheters and other causes. Scand J Urol Nephrol. 1992;26(4):327-331.
- 49. Hebert PW. The treatment of urethral stricture: Transurethral injection of triamcinolone. J Urol. 1972;108(5):745-747.
- 50. Mundy AR. Adjuncts to visual internal urethrotomy to reduce the recurrence rate of anterior urethral strictures. Eur Urol. 2007; 51(6):1467-1468.
- Mazdak H, Meshki I, Ghassami F. Effect of mitomycin C on anterior urethral stricture recurrence after internal urethrotomy. Eur Urol. 2007;51(4):1089-1092.
- 52. Mazdak H, Izadpanahi MH, Ghalamkari A, *et al.* Internal urethrotomy and intraurethral submucosal injection of triamcinolone in short bulbar urethral strictures. Int Urol Nephrol. 2010;42(3):565-568.
- 53. Breyer BN, McAninch JW, Whitson JM, et al. Multivariate analysis of risk factors for long-term urethroplasty outcome. J Urol. 2010; 183(2):613-617.
- Roehrborn CG, McConnell JD. Analysis of factors contributing to success or failure of 1-stage urethroplasty for urethral stricture disease. J Urol. 1994;151(4):869-874.
- Barbagli G, Palminteri E, Lazzeri M, et al. Long-term outcome of urethroplasty after failed urethrotomy versus primary repair. J Urol. 2001;165(6 Pt 1):1918-1919.
- 56. Beier-Holgersen R, Brasso K, Nordling J, *et al.* The "Wallstent": A new stent for the treatment of urethral strictures. Scand J Urol Nephrol. 1993;27(2):247-250.
- 57. Milroy E, Allen A. Long-term results of Urolume® urethral stent for recurrent urethral strictures. J Urol. 1996;155(3):904-908.
- Morgia G, Saita A, Morana F, et al. Endoprosthesis implantation in the treatment of recurrent urethral stricture: A multicenter study. Sicilian-Calabrian Urology Society. J Endourol. 1999;13(8):587-590.
- 59. De Vocht TF, van Venrooij GE, Boon TA. Self-expanding stent insertion for urethral strictures: A 10-year follow-up. BJU Int. 2003;91(7):627-630.
- 60. Hussain M, Greenwell TJ, Shah J, *et al.* Long-term results of a self-expanding wallstent in the treatment of urethral stricture. BJU Int. 2004;94(7):1037-1039.
- 61. Shah DK, Paul EM, Badlani GH. 11-year outcome analysis of endourethral prosthesis for the treatment of recurrent bulbar urethral stricture. J Urol. 2003;170(4 Pt 1):1255-1258.
- 62. Chapple CR, Bhargava S. Management of the failure of a permanently implanted urethral stent A therapeutic challenge. Eur Urol. 2008;54(3):665-670.
- 63. Palminteri E, Gacci M, Berdondini E, *et al.* Management of urethral ste nt failure for recurrent anterior urethral strictures. Eur Urol. 2010; 57(4):615-621.
- 64. Palminteri E. Stents and urethral strictures: A lesson learned? Eur Urol. 2008;54(3):498-500.
- 65. Yachia D, Beyar M. Temporarily implanted urethral coil stent for the treatment of recurrent urethral strictures: A preliminary report. J Urol. 1991;146(4):1001-1004.
- 66. Yachia D, Beyar M. New, self-expanding, self-retaining temporary coil stent for recurrent urethral strictures near the external sphincter. Br J Urol. 1993;71(3):317-321.
- 67. Jordan G, van der Burght M. Memokath™044 A removable stent for treatment of recurrent bulbar urethral strictures. Results of the North American study group's multi-centre trial [abstract #1103324]. Presented at: The 26th Congress of the European Association of Urology; 2011 Mar 18-22; Vienna, Austria.
- Isotalo T, Tammela TL, Talja M, et al. A bioabsorbable self-expandable, self-reinforced poly-l-lactic acid urethral stent for recurrent urethral strictures: A preliminary report. J Urol. 1998;160(6 Pt 1):2033-2036.

- 69. Isotalo T, Talja M, Valimaa T, *et al.* A bioabsorbable self-expandable, self-reinforced poly-L-lactic acid urethral stent for recurrent urethral strictures: Long-term results. J Endourol. 2002;16(10):759-762.
- Isotalo T, Nuutinen JP, Vaajanen A, et al. Biocompatibility and implantation properties of 2 differently braided, biodegradable, self-reinforced polylactic acid urethral stents: An experimental study in the rabbit. J Urol. 2005;174(6):2401-2404.
- 71. Kotsar A, Isotalo T, Uurto I, *et al.* Urethral in situ biocompatibility of new drug-eluting biodegradable stents: An experimental study in the rabbit. BJU Int. 2009;103(8):1132-1135.






#### Anterior Urethra – Primary Anastomosis

#### CHAIRS

Allen F. Morey, United States Nick Watkin, United Kingdom

#### MEMBERS

Ofer Shenfeld, Israel Ehab Eltahawy, Egypt Carlos Giudice, Argentina

## CONTENTS

#### Anterior Urethra – Primary Anastomosis

4.1	Backgrou	nd	85
4.2	Introducti	on	85
4.3	Methods.		85
4.4	Discussic	n	86
	4.4.1	Composite success rate of excision and primary anastomosis	86
	4.4.2	Cost effectiveness of excision and primary anastomosis for short bulbar urethral strictures	87
	4.4.3	Complications of excision and primary anastomosis	87
	4.4.4	Applications and limitations of excision and primary anastomosis	88

4.5	Conclusio	on	_88
4.6	Recomm	endations	_89
	4.6.1	Composite success rate of excision and primary anastomosis	_89
	4.6.2	Cost effectiveness of excision and primary anastomosis versus endoscopic treatment	_89
	4.6.3	Excision and primary anastomosis complications	_90
	4.6.4	Excision and primary anastomosis indications and limitations	_90
4.7	Reference	es	_91



## 4.1 Background

Using PubMed, a literature search was performed for articles from 1985 to the present on the treatment of anterior urethral strictures by excision and primary anastomosis (EPA). The articles considered for analysis were those that had clear outcome data and selection criteria limited to patients having EPA for bulbar urethral strictures.

The studies were rated using the International Consultations on Urologic Diseases (ICUD) standards for level of evidence and grade of recommendation. A total of 16 series with > 10 patients were included for analysis. These were all level 3 studies and were subdivided into (a) three large series of > 150 patients from internationally recognized centres of excellence and (b) 13 smaller/mixed series of 13–72 patients.

The composite success rate reported among 1,262 men having EPA for bulbar urethral strictures was 93.8%. Excision and primary anastomosis should be considered the optimal treatment for healthy men with short bulbar strictures, regardless of etiology or prior treatment.

#### 4.2 Introduction

Although the treatment of urethral strictures continues to evolve, the treatment of short bulbar urethral strictures with EPA has retained an important role in the reconstructive armamentarium for the past several decades. This review is an attempt to synthesize the extant literature to clarify the outcomes and applications of EPA urethroplasty, and to present a consensus to guide management and future research.

#### 4.3 Methods

A committee was appointed by the ICUD. The chair conducted a 25-year English-language literature search through PubMed for peer-reviewed articles on strictures of the anterior urethra treated with EPA. In the literature from 1985 to the present, no randomized prospective trials (*Level 1*) or case control (*Level 2*) series were identified. Only reports of bulbar urethral cases were included in the analysis.

A total of 16 level 3 evidence series with > 10 patients were included for analysis and were subdivided into two groups based on the number of patients: three large series of > 150 patients from internationally recognized centres of excellence and 13 smaller/mixed series including 13–72 patients. Articles were excluded if they were duplicative listings, review articles, expert opinion without data to support the opinion, case series of < 10 patients, or series where outcomes were not separately identifiable and related to EPA cases. Prior to the search, the committee members agreed to extract the following data:

1. Composite success rate of EPA

- Complications of EPA
  Applications and limitations of EPA
- **2.** Cost effectiveness of EPA versus endoscopic stricture treatment

Other articles reviewed by the committee were eliminated when EPA patients in a mixed series could not be separately identified or when series were partially duplicative of other published results, had fewer than 10 patients in the series, or were review articles. The 16 articles providing the data for this review were rated using the ICUD standards for level of evidence and grade of recommendation (1,2).

## 4.4 Discussion

#### 4.4.1 **Composite success rate of excision and primary anastomosis**

Our analysis revealed a total of 16 high-quality reports demonstrating level 3 evidence, thus yielding a robust experience of EPA reported in over 1,200 cases spanning three decades (1–16). Although the definitions of success differed and the durations, stringencies, and methods of follow-up varied, a uniformly high level of success (>90%) was reported in similar patients across all but one series (**Table 1**).

Study Type	Series	n	Success Rate (Range) (%)
Large single institution	3	581	95.5 (91–98)
Mixed and smaller series	13	681	92.7 (83–100)
Overall	16	1,262	93.8

#### TABLE 1 25-year meta-analysis results for EPA urethroplasty for bulbar urethral strictures

Although none of the reported series was designed to show superiority of EPA over other methods of urethral reconstruction, the reported results confirm that an anastomotic approach yields superior outcomes compared with any other method of bulbar urethroplasty. The 93.8% success rate revealed in this broad 25-year analysis supports the earlier 15-year single institution analysis of Andrich *et al.*, which demonstrated that substitution urethroplasty is associated with a five-fold increase in complications and a four-fold increase in stricture recurrence when compared to EPA (1). Our meta-analysis suggests that in skilled hands, EPA can be expected to deliver a success rate as high as that of any other intervention in urology.

## 4.4.2 **Cost effectiveness of excision and primary anastomosis for short bulbar urethral strictures**

Since Sachse first introduced direct vision internal urethrotomy (DVIU) in 1974, endoscopic incision has become the most frequently used treatment for anterior urethral stricture (17). Although the simplicity and speed of outpatient endoscopic treatment have contributed to its popularity, long-term efficacy data have been lacking. At best, initial DVIU for short, non-traumatic strictures of the bulbar urethra has been associated with a success rate of only 39%–73%, with subsequent attempts performing even worse (18,19). Despite the observation that DVIU is almost never curative in longer strictures of the penile urethra and those with dense fibrosis, many urologists undertake repeated endoscopic procedures before referring stricture patients for definitive care (20).

Because short bulbar strictures are almost always safely resolved by EPA, a reduction of overall costs has been attributed to the performance of EPA in lieu of DVIU, despite its higher initial expense (21,22). In experienced hands, EPA is associated with a high level of effectiveness, short hospitalization times, and negligible complication rates (23). In summary, existing evidence supports neither the cost effectiveness nor a clinical advantage of repeated DVIU for refractory strictures in situations where referral for expert EPA urethroplasty is available.

#### 4.4.3 **Complications of excision and primary anastomosis**

We reviewed the available literature concerning the effects of EPA urethral reconstruction on male sexual function. Excluded from this review were surgery for pelvic fracture urethral disruption defects (due to the high incidence of pre-operative erectile dysfunction) and reconstruction in hypospadias-related strictures (due to the potential psychological impact of genital surgery during childhood and penile esthetic issues, including chordee). Factors influencing erectile function after urethroplasty include stricture location and length, patient age, reconstructive technique, and time elapsed since surgery.

Excision and primary anastomosis appears to have a negligible effect on sexual function. Barbagli *et al.* reported no post-operative impotence among 153 EPA cases (24). Coursey *et al.* found that bulbar urethroplasty has less patient-reported negative impact on erectile function than reconstruction of long strictures in the penile urethra (25). Similarly, Anger *et al.* reported no significant change in erectile function in a prospective study of men undergoing urethroplasty for bulbar strictures using anastomotic, augmented anastomotic, or buccal grafting techniques; however, a trend towards worse post-operative sexual outcomes was shown for older patients and those with lower pre-operative International Index of Erectile Function (IIEF) scores (26).

Erickson *et al.* found that when patients do report post-operative erectile dysfunction after urethral reconstruction, it tends to be transient, with the vast majority of patients recovering pre-operative erectile function within 6 months of surgery. Interestingly, this study showed an improvement in ejaculatory function in younger patients (27). Similarly, Andrich *et al.* showed a 10% incidence of erectile dysfunction after substitution urethroplasty, which decreased to 2% over 2–3 months (1).

In summary, while erectile function may be influenced by patient age, stricture length and location, and method of reconstruction, sexual complications after EPA urethroplasty appear to be negligible.

## 4.4.4 **Applications and limitations of excision and primary anastomosis**

It is apparent from this review that the quality of the existing evidence in support of EPA for management of short bulbar urethral strictures is exceptionally strong and based on multiple case series worldwide. As a result, the applications of EPA have expanded of late, with recent authors reporting using grafts only as necessary to complete the repair. Aside from the additional time and expense, potential hazards of oral mucosa harvest include donor-site hemorrhage, infection, chronic anesthesia, pain, parotid duct injury, limitation of mouth opening, and paresthesia (28,29).

Although previous authors suggested that a risk of chordee or penile shortening exists if more than 2 cm of urethra is excised (30), most recent reports indicate that the proximal bulbar urethra may be uniquely amenable to EPA for longer strictures, and that defects up to 5 cm may be reconstructable by EPA in selected cases (5,9,11,24). Failed, previously grafted areas in the proximal bulb have been completely excised and successfully reconstructed by primary anastomosis, suggesting, in retrospect, that EPA should have been the initial method of reconstruction (11). Urethral extensibility has been shown to be greater than penile extensibility (31,32). It has been well demonstrated that bulbar mobilization alone can allow up to 5 cm of lengthening during posterior urethroplasty without development of chordee or penile shortening (33,34).

#### 4.5 Conclusion

Our extensive review of the published literature suggests that EPA is associated with optimal outcomes and that complications are rare. Therefore, EPA should be performed, whenever deemed possible and appropriate, in men with short, isolated bulbar urethral strictures when expected success rates of other procedures (open or endoscopic) are < 90%.

#### 4.6 **Recommendations**

#### 4.6.1 **Composite success rate of excision and primary anastomosis**

1. Because the success rate of EPA urethroplasty is widely reported to be >90% for both primary and salvage procedures, EPA constitutes the optimal treatment for healthy men with short bulbar strictures, regardless of etiology or prior treatment (A).

2. Excision and primary anastomosis urethroplasty is most readily applicable to strictures of the bulbar urethra (A).

#### 4.6.2 **Cost effectiveness of excision and primary anastomosis versus endoscopic treatment**

- 1. Although short, non-traumatic bulbar strictures are most amenable to DVIU, performance of more than one endoscopic treatment is not cost effective when compared with the costs of EPA urethroplasty (A).
- Excision and primary anastomosis is appropriate as an initial treatment for patients with dense (obliterative and nearobliterative) bulbar strictures (especially those with a known history of perineal trauma), without prior attempts at endoscopic management (A).
- 3. Repeated endoscopic treatments may exacerbate spongiofibrosis, which may delay and complicate the performance of definitive urethroplasty (B).

#### 4.6.3 **Excision and primary anastomosis complications**

1. The risks of erectile dysfunction, post-micturition dribble, chordee, and sacculation after EPA urethroplasty are negligible; therefore, the risk of these post-operative complications should not be considered a contraindication to EPA urethroplasty.

#### 4.6.4 **Excision and primary anastomosis indications and limitations**

- 1. Excision and primary anastomosis should be performed, whenever deemed possible and appropriate, in men with short, isolated anterior bulbar urethral strictures when expected success rates from other procedures (open or endoscopic) are < 90% (A).
- 2. In general, longer strictures (2–4 cm) may be successfully treated with EPA in the proximal bulb versus the penile and distal bulbar urethra due to the favourable tissue characteristics of the proximal bulb region (B).
- 3. Graft and skin flap augmentation procedures tend to be successful less often than EPA and should be used primarily for strictures >2 cm within the distal bulbar and penile urethra, when a tension-free anastomotic repair is not achievable (B).

#### 4.7 References

- 1. Andrich DE, Dunglison N, Greenwell TJ, et al. The long-term results of urethroplasty. J Urol. 2003;170(1): 90-92.
- 2. Azoury BS, Freiha FS. Excision of urethral stricture and end to end anastomosis. Urology. 1976;8(2):138-140.
- Barbagli G, Guazzoni G, Massimo L. One-stage bulbar urethroplasty: Retrospective analysis of the results in 375 patients. Eur Urol. 2008;53(4):828-833.
- 4. Elgammal M. Straddle injuries to the bulbar urethra: Management and outcome in 53 patients. Int Braz J Urol. 2009;35(4):450-458.
- Eltahawy EA, Virasoro R, Schlossberg, SM, et al. Long-term followup for excision and primary anastomosis for anterior urethral strictures. J Urol. 2007;177(5):1803-1806.
- 6. Martinez-Piñeiro JA, Carcamo P, García Matres MJ, *et al.* Excision and anastomotic repair for urethral stricture disease: Experience with 150 cases. Eur Urol. 1997;32(4):433-441.
- 7. Lumen N, Hoebeke P, Oosterlinck W. Urethroplasty for urethral strictures: Quality assessment of an in-home algorithm. Int J Urol. 2010;17(2):167-174.
- 8. Micheli E, Ranieri A, Peracchia G, et al. End-to-end urethroplasty: Long-term results. BJU Int. 2002;90(1):68-71.
- 9. Morey AF, Kizer WS. Proximal bulbar urethroplasty via extended anastomotic approach–What are the limits? J Urol. 2006;175(6):2145-2149.
- 10. Santucci RA, Mario LA, McAninch JW. Anastomotic urethroplasty for bulbar urethral stricture: Analysis of 168 patients. J Urol. 2002;167(4):1715-1719.
- 11. Terlecki RP, Steele MC, Valadez C, et al. Grafts are unnecessary for proximal bulbar reconstruction. J Urol. 2010;184(6):2395-2399.
- 12. Lindell O, Borkowski J, Noll F, et al. Urethral stricture repair: Results in 179 patients. Scand J Urol Nephrol. 1993;27(2):241-245.
- 13. Kessler TM, Schreiter F, Kralidis G, *et al.* Long-term results of surgery for urethral stricture: A statistical analysis. J Urol. 2003;170(3):840-844.
- 14. DeCastro B, Anderson SB, Morey AF. End-to-end reconstruction of synchronous urethral strictures. J Urol. 2002;167(3):1389.
- 15. Panagakis A, Smith JC, Williams JL. One-stage excision urethroplasty for stricture. Br J Urol. 1978;50(6):410-414.
- 16. Lewis JB, Wolgast KA, Ward JA, *et al.* Outpatient anterior urethroplasty: Outcome analysis and patient selection criteria. J Urol. 2002;168(3):1024-1026.
- 17. Sachse H. Treatment of urethral stricture: Transurethral slit in view using sharp section [Article in German]. Fortschr Med. 1974;92(1):12-15.
- 18. Pansadoro V, Emiliozzi P. Internal urethrotomy in the management of anterior urethral strictures: Long-term followup. J Urol. 1996;156(1):73-75.
- 19. Santucci R, Eisenberg L. Urethrotomy has a much lower success rate than previously reported. J Urol. 2010;183(5):1859-1862.
- 20. Bullock TL, Brandes SB. Adult anterior strictures: A national practice patterns survey of board certified urologists in the United States. J Urol. 2007;177(2):685-690.
- 21. Rourke KF, Jordan GH. Primary urethral reconstruction: The cost minimized approach to the bulbous urethral stricture. J Urol. 2005;173(4):1206-1210.
- Wright JL, Wessells H, Nathens AB, et al. What is the most cost-effective treatment for 1 to 2-cm bulbar urethral strictures? Societal approach using decision analysis. Urology. 2006;67(5):889-893.
- Anema JG, Morey AF, McAninch JW. Complications related to the high lithotomy position during urethral reconstruction. J Urol. 2000;164(2):360-363.
- Barbagli G, De Angelis M, Romano G, *et al.* Long-term followup of bulbar end-to-end anastomosis: A retrospective analysis of 153 patients in a single center experience. J Urol. 2007;178(6):2470-2473.
- 25. Coursey JW, Morey AF, McAninch JW, et al. Erectile function after anterior urethroplasty. J Urol. 2001;166(6):2273-2276.

- 26. Anger JT, Sherman ND, Webster GW. The effect of bulbar urethroplasty on erectile function. J Urol. 2007;178(3 Pt 1):1009-1011.
- 27. Erickson BA, Granieri MA, Meeks JJ, *et al.* Prospective analysis of erectile dysfunction after anterior urethroplasty: Incidence and recovery of function. J Urol. 2010;183(2):657-661.
- 28. Bhargava S, Chapple CR. Buccal mucosal urethroplasty: Is it the new gold standard? BJU Int. 2004;93(9):1191-1193.
- 29. Wood DN, Allen SE, Andrich DE, *et al.* The morbidity of buccal mucosal graft harvest for urethroplasty and the effect of nonclosure of the graft harvest site on postoperative pain. J Urol. 2004;172(2):580-583.
- Guralnick ML, Webster GD. The augmented anastomotic urethroplasty: Indications and outcome in 29 patients. J Urol. 2001;165(5):1496-1501.
- 31. Kohler TS, Yadven M, Manvar A, et al. The length of the male urethra. Int Braz J Urol. 2008;34(4):451-454.
- 32. Da Silva EA, Sampaio FJ. Urethral extensibility applied to reconstructive surgery. J Urol. 2002;167(5):2042-2045.
- Wang P, Fan M, Zhang Y, *et al.* Modified urethral pull-through operation for posterior urethral stricture and long-term outcome. J Urol. 2008;180(6):2479-2485.
- Kizer WS, Armenakas NA, Brandes SB, et al. Simplified reconstruction of posterior urethral disruption defects: Limited role of supracrural rerouting. J Urol. 2007;177(4):1378-1381.



## Anterior Urethra – Lichen Sclerosus

#### CHAIRS

Kurt McCammon, United States Laurence Stewart, United Kingdom

#### MEMBERS

Michael Metro, United States Ramon Virasoro, Argentina

## CONTENTS

5

#### Anterior Urethra – Lichen Sclerosus

5.1	Introduction	_97
5.2	Etiology	_97
5.3	Epidemiology	_98
5.4	Clinical Features	_98
5.5	Diagnosis	_98
	5.5.1 Histological diagnosis	_98
5.6	Prognosis	_99

5.7	Malignant Potential of Lichen Sclerosus	99
5.8	Medical Management of Lichen Sclerosus	100
	5.8.1 Non-surgical management	101
	5.8.2 Surgical management	101
5.9	Conclusion	103
5.10	Recommendations	103
5.11	References	104



## 5.1 Introduction

Our group was tasked with reviewing the data on lichen sclerosus (LS) as it relates to urethral stricture, and with developing recommendations regarding the treatment of LS. A literature search was done using Medline and PubMed (US National Library of Medicine - National Institutes of Health). More than 65 papers were reviewed, most written within the past 10 years. Of these papers, 40 were used to make recommendations. Articles were evaluated using the levels of evidence adapted by the International Consultation on Urological Diseases (ICUD) from the Oxford Centre for Evidence-Based Medicine. Recommendations were based on the level of evidence and discussed among the committee members to reach consensus. Each member of the committee reviewed each paper and recommendations were made only when there was consensus among the whole committee.

Lichen sclerosus is a chronic inflammatory, hypomelanotic, lymphocyte-mediated skin disorder, which in men involves the prepuce and glans, and frequently leads to phimosis, meatal stenosis, and urethral strictures.

Lichen sclerosus was first described in 1875 by Weir (1). In 1928, Stühmer coined the term balanitis xerotica obliterans (BXO) and proposed a traumatic etiology (2). The association between LS and BXO was noted by Freeman and Laymon (3,4). The International Society for the Study of Vulvar Disease has formally adopted the term lichen sclerosus (5), and this committee recommends that the term LS be used instead of BXO.

#### 5.2 Etiology

The pathogenesis of LS is still undetermined. One proposed mechanism is an autoimmune event. Autoantibodies to extracellular matrix protein 1 (ECM1) were detected in the serum of 67% of LS patients and in only 7% of the control group (6). Reports of LS associated with vitiligo, alopecia areata, thyroid disease, and diabetes mellitus also suggest a possible autoimmune basis. Reported oxidative damage of lipids, DNA, and protein in LS patients may explain the mechanism of sclerosis, autoimmunity, and carcinogenesis of LS (7).

There has been no significant association found that would suggest a genetic basis for LS. There are conflicting data linking human leukocyte antigens and LS. At least 11% of patients with LS do have a family member also affected (8).

No significant association with infectious disease has been found. Some reports have linked LS to *Borrelia burgdorferi* (9), but a recent controlled case series found no association (10).

## 5.3 Epidemiology

Lichen sclerosus is an embarrassing condition for those afflicted and is commonly unrecognized by many physicians. The range of medical specialties involved in the management of the disease contributes to the discordance of reports. The estimated prevalence is 1 in 300 to 1 in 1000. Traditionally, peak incidence was reported in males aged 30–50 years (11), but a contemporary male epidemiologic study reported a nearly double incidence of LS in the age group of 21–30 years (12). The female-to-male ratio is estimated to be between 6:1 and 10:1 (11,13). Most reports show higher frequencies in white male and female populations (13), but a recent publication showed the incidences in black and Hispanic male populations to be double the incidence among white males (12).

#### 5.4 Clinical Features

In males, LS is usually insidious, but can also present as an aggressive process. Lichen sclerosus affects the foreskin and glans in 57%–100% of cases and the meatus in 4%–37%, with approximately 20% of patients having involvement of the urethra (14,15). Extra-genital presentation is rare. The most common symptom is leucoderma (16). The whitish appearance of the skin is secondary to decreased melanin production, reduced transfer of melanosomes to keratinocytes, and loss of melanocytes (17). Itching, ecchymosis, dysuria, and decreased force of stream are also frequent complaints. Disease progression may lead to phimosis, thereby causing a decrease in the force of stream. Glans fissures may appear after sexual intercourse.

## 5.5 Diagnosis

Diagnosis of LS remains primarily dependent on history, physical examination, and histology, yet a recent development of antigen-specific enzyme-linked immunosorbent assay (ELISA) for circulating autoantibodies to ECM1 in LS may be useful as a diagnostic marker and indicator of disease severity (18).

#### 5.5.1 Histological diagnosis

In the early and evolving stages of LS, hydropic (vacuolar) degeneration of the basal cell layer is seen, there is edema of the papillary and reticular dermis, and inflammatory infiltrate (of lymphocytes) occurs at the dermo-epidermal junction. The intermediate stage is identified by homogenization of collagen in the papillary dermis. Hyperkeratosis, stratum malpighii atrophy, pale staining, and band inflammatory cell infiltrate at the dermo-epidermal junction are seen in the late stages.

The differential diagnosis of LS includes lichen planus, vitiligo, psoriasis, and vulvar intra-epithelial neoplasia.

## 5.6 Prognosis

Can early detection and consequent medical treatment of LS prevent urethral involvement? A recent epidemiological study in the UK suggests that early detection and treatment may prevent the development of severe symptoms and possibly allow patients to avoid surgery (15).

#### 5.7 Malignant Potential of Lichen Sclerosus

The pre-malignant potential of LS of the vulva has been well recognized for some time (19). But the potential development of squamous carcinoma in men with LS affecting the penis has until recently been less clear.

The association between LS and penile cancer varies. A review of 20 cases of penile cancer found LS on the same pathology slides as cancer in eight cases (40%). Review of the case notes revealed two further cases with previous histology of LS that was not present on the cancer slides. Lichen sclerosus was therefore present in 50% of the penile cancer cases. The presence of LS was also associated with less aggressive cancer in seven out of eight cases. All cases associated with LS were well differentiated, as compared with only three cases out of 12 not associated with LS (20).

Another study, of 207 cases of penile cancer, found LS in 68 cases (33%). They also found a significant association between the presence of LS and both low grade and low stage of penile cancer. An association between LS and non–human papillomavirus (HPV) cancers was also noted (i.e., a negative correlation with warty tumours and giant condyloma; however, they did not test for HPV directly) (21).

In a further study of 155 cases of penile cancer and carcinoma in situ (CIS), Pietrzak *et al.* found LS in 44 cases (28%). Although cancer associated with LS occurred at a younger age and was of a lower grade and stage, this trend did not reach statistical significance. Most of the cases occurred synchronously (39/44 = 89%), and three cases (7%) occurred within a background of LS, but in two cases (4%) the LS had been surgically cured previously and the original pathology was not available at the time of review. The authors raised the question of long-term surveillance recommendations in cases of LS (22).

Two groups have looked at populations of patients presenting with LS. Depasquale *et al.* reviewed a series of LS patients treated at a single centre and found 12 cases of penile cancer among 522 LS cases (2.3%). The association with grade and stage was not reported. Seven of the patients with penile cancer had had previous circumcision, confirming the need to send all circumcision specimens for histology and the importance of long-term surveillance (14). Barbagli *et al.* reported on a multicentre study of 130 cases of LS and found 11 cases of either cancer or CIS (8.4%). One of these cases arose in LS following a partial amputation for penile cancer and as such, may simply represent a recurrence of

cancer. Excluding this case leaves an association of 10/129 (7.8%). In contrast with the results of other studies, only one of the cases of squamous cell cancer was well differentiated. Epithelial dysplasia was present in 5/10 cases (50%). Five patients had had previous circumcision. The mean time from diagnosis of LS to diagnosis of cancer or CIS was 12 years (23).

#### 5.8 Medical Management of Lichen Sclerosus

The goals for treatment of LS should be to alleviate symptoms of discomfort and to prevent development of urethral stenosis or stricture. Management of LS also includes monitoring the patient for the development of squamous cell carcinoma. Before any topical treatment is initiated, biopsy may be necessary to confirm the absence of squamous cell carcinoma and confirm the presence of LS.

Traditional non-surgical treatment for LS consists of topical steroids or emollients to alleviate the skin manifestations of the disease. Periodic urethral or meatal dilation is used when stenosis occurs or to prevent its occurrence. Steroid administration inhibits the chronic inflammatory response and may be helpful in lessening initial symptoms and preventing or slowing disease progression. In a double-blind, placebo-controlled, randomized study of 40 boys clinically diagnosed with LS, 41% of those treated with steroids showed improvement in clinical symptoms (24).

Although the ideal topical agent has not yet been studied or identified scientifically, clobetasol propionate (0.05%) twice daily for 2–3 months with gradual dose lowering has been used with success (25). Interestingly, the drug is not approved by the Food and Drug Administration for the management of LS.

While clobetasol is commonly used, betamethasone (0.05%), mometasone, and hydrocortisone (2.5%–10%) use has also been reported. Side effects of topical steroids include cutaneous atrophy, adrenal suppression, hypopigmentation, and contact sensitivity symptoms such as burning, itching, dryness, flaking, and maceration. Potent steroids should be avoided in children, and patients should be instructed to wash their hands after use to prevent contact with other sensitive areas (e.g., the eyes) and to prevent partner exposure.

The macrolide-derived immunomodulator tacrolimus (FK506), used systemically in transplant medicine, has been used topically in LS, and success has been reported in the treatment of LS involving the glans and penis (26). Tacrolimus works by inhibiting the production of interleukin-2 and the subsequent T-cell activation. Systemic absorption is minimal. There is a great deal of data available on its use in psoriasis and other inflammatory skin conditions, but minimal data exist on its use in LS.

Topical testosterone has also been reported to have a beneficial effect, but has not been extensively studied in men with LS (27). In the laboratory, it has been shown that LS tissue shows down-regulation or loss of the androgen receptor. Secrest *et al.* noted that 77.8% of patients with LS were hypogonadal and that the aggressive replacement of systemic testosterone with topical testosterone was

associated with improvement in early results (28). In theory, adding local testosterone may improve the clinical effects of LS, but other studies have shown that clobetasol was still superior to testosterone propionate (29,30).

There have also been reports on the use of topical calcineurin inhibitors such as pimecrolimus in topical steroid–resistant LS (31).

The systemic aromatic retinoid acitretin is used for psoriasis and has also been studied for the treatment of severe, topical steroid–resistant, LS (32). In a case-control study of 49 patients, 36.4% of those treated with acitretin achieved a complete response, versus only 6% of the control group, while 36.4% versus 12.5%, respectively, achieved a partial response. Acitretin patients received 35 mg daily for 20 weeks. Well-known and common side effects include cheilitis (dry, cracking lips) in 75% of patients and skin peeling in 48%.

#### 5.8.1 Non-surgical management

#### Photodynamic Therapy

Photodynamic therapy involves the discovery of a lesion that has an inappropriate fluorescence and the subsequent performance of a selective excision of diseased tissue, in which an oxygen-dependent reaction between photosensitizing dye and light leads to the destruction of the tissue. A study of 28 women with vulvar LS treated with 5-aminolevulinic acid (ALA) was performed. The ALA was used as a photosensitizer because it is preferentially absorbed and induces protoporphirin IX accumulation in changed tissue. Six courses of photodynamic therapy with a Diomed 630 laser were performed. In this study, 37.5% of patients had no histological evidence of LS after therapy. The tissue also showed increased microvessel density and decreased lymphocytic infiltration (33).

There have also been reports of continuous-wave carbon dioxide (CO2) laser vaporization being used successfully in cases of LS that do not involve the meatus or the urethra. Laser energy is used to precisely treat lesions, and re-epithelialization takes place by 6 days post-treatment (34).

#### 5.8.2 Surgical management

There is no surgical gold standard for the treatment of urethral strictures in patients with LS. All recommendations have been based on non-randomized studies and expert opinion. Surgical management is dependent on the progression of disease and consists of circumcision, meatal dilation, meatotomy, and urethral reconstruction.

#### Circumcision

Circumcision was used by Depasquale *et al.* in 287 patients with a diagnosis of LS. Of these patients, 276 (92%) were cured and needed no further treatment. These results have been confirmed by others and therefore have important implications for the treatment of LS. If LS recurs after circumcision, a repeat circumcision is not recommended, because it can lead to hidden penis and severe phimosis, making treatment more difficult. Meatotomy rarely results in cure. This is most likely due to the fact that the condition is a skin disorder involving the meatus (14).

#### Meatotomy

Meatal stenosis is a less severe condition than pan-urethral involvement of LS. Even so, meatal stenosis can lead to significant complications. Simple meatotomy is generally ineffective in patients with LS. Morey *et al.* showed that an extended meatotomy in patients with refractory stenosis was successful in 14 of 16 patients (87%) (35).

Malone described a ventral/dorsal meatotomy with an inverted V-shaped relaxing incision with the apex of the V close to the proximal limit of the dorsal meatotomy. No recurrences or fistulas were reported in the series. Satisfaction with the procedure from a cosmetic standpoint was also good, with 100% of patients pleased with their cosmesis and only 15% of patients complaining of spraying of stream (36).

#### Urethral reconstruction

When medical management fails or patients are not candidates for circumcision or meatotomy, urethral reconstruction must be considered.

The use of flap repairs using genital skin has been described in patients with LS. The initial success of flaps in the repair of LS has been encouraging, but with longer follow-up, recurrence rates have increased. Venn and Mundy reported on 12 patients with LS who were treated with stricturotomy and penile skin flap urethrostomy, and they showed a 100% stricture recurrence rate (37). With the use of a ventral transverse skin island, Virasoro *et al.* noted a 50% recurrence rate. However, not all patients had a biopsy to confirm LS; therefore, those who did well may not have had true LS (38). Currently, the use of genital skin is not considered to be appropriate in patients with confirmed LS.

Non-genital skin—buccal mucosal grafts with either a one- or two-stage approach—has proven to be the tissue of choice. Buccal mucosa has a panlaminar plexus, which allows it to be thinned, and the deep lamina preserves the physical characteristics. Thinning reduces the total graft mass while preserving beneficial physical characteristics without adversely affecting vascular characteristics. Another graft that has had good results is the lingual mucosal graft. Das reported an 83% success rate using the lingual mucosal graft as a dorsal graft in a single-staged procedure (39).

One-stage urethral reconstruction with a dorsal graft can be performed if the urethral lumen is 6–7 French. For strictures in the penile urethra, a circumferential incision is made and the penis is degloved. If the stricture extends beyond the penoscrotal junction, a midline perineal incision is made. The urethra is dissected from the corpora cavernosa along the entire length of the stricture. A dorsal urethrotomy is performed and then the mucosal graft is secured to the corpora cavernosa and the urethra is secured to the graft. Dubey *et al.* have shown good results using this technique: 22 of 25 patients (88%) had success at a mean follow-up of 32.5 months (40). Kulkarni *et al.* confirmed these good results with a 91% success rate with a mean follow-up of 38 months (41).

In a two-stage reconstruction, a midline penile incision is made along the full length of the urethral stricture. Complete urethral plate excision is usually recommended, due to the involvement of LS in the remaining urethra. The first stage involves securing the buccal graft to the tunica albuginea. The second stage, tubularization, occurs 6–12 months later. Success rates of the two-stage approach vary from 72%–80%.

It is not always appropriate to reconstruct the urethra completely, and a perineal urethrostomy should be considered in patients with the most severe disease. Perineal urethrostomy success rates vary from 72%–100%.

#### 5.9 Conclusion

Lichen sclerosus is now the accepted term, and balanitis xerotica obliterans is no longer an acceptable term. A short course of topical steroids may be beneficial for some patients. If patients have persistent LS, they need long-term surveillance because of the possible development of squamous cell carcinoma.

If caught early, LS can be controlled, preventing progression, but once the disease has progressed, it is very difficult to treat. Surgical treatment can be curative if the disease is caught early. The use of genital skin is not recommended in patients with urethral involvement. Oral mucosa grafts have been shown to be successful in patients with LS, although long-term data are still needed.

#### 5.10 Recommendations

- 1. The accepted term for this condition is lichen sclerosus (LS) and the term balanitis xerotica obliterans (BXO) should no longer be used (A).
- 2. The use of short-term topical steroids should be considered in patients with early LS (A).
- 3. Circumcision can be used for LS confined to the foreskin or glans (A).
- 4. Genital skin should not be used for urethral reconstruction in patients with LS (A).
- 5. Long-term follow-up in patients with persistent LS is required to evaluate the patient for malignant transformation (B).

## 5.11 References

- 1. Weir RF. Ichthyosis of the tongue and vulva. NY State J Med. 1875;21:240-256.
- Stühmer A. Balanitis xerotica obliterans (post operationem) und ihre beziehungen zur kraurosis glandis et preaeputii penis [Article in German]. Arch Dermatol Syphilol. 1928; 156: 613-623.
- 3. Freeman C, Laymon CW. Balanitis xerotica obliterans. Arch Dermatol Syphilol. 1941;44(4):547-559.
- 4. Laymon CW, Freeman C. Relationship of balanitis xerotica obliterans to lichen sclerosus et atrophicus. Arch Dermatol Syphilol. 1944;49: 57-59.
- 5. Friedrich EG Jr. New nomenclature for vulvar disease. Obstet Gynecol. 1976;47:122-124.
- 6. Oyama N, Chan I, Neill SM, et al. Autoantibodies to extracellular matrix protein 1 in lichen sclerosus. Lancet. 2003;362(9378):118-123.
- 7. Sander CS, Ali I, Dean D, et al. Oxidative stress is implicated in the pathogenesis of lichen sclerosus. Br J Dermatol. 2004;151(3):627-635.
- 8. Sherman V, McPhearson T, Baldo M, *et al.* The high rate of familial lichen sclerosus suggests a genetic contribution: An observational cohort study. J Eur Acad Dermatol Venereol. 2010;24(9):1031-1034.
- 9. De Vito JR, Merogi AJ, Vo T, *et al.* Role of Borrelia burgdorferi in the pathogenesis of morphea/scleroderma and lichen sclerosus et atrophicus: A PCR study of thirty-five cases. J Cutan Pathol. 1996;23(4):350-358.
- Edmonds E, Mavin S, Francis N, et al. Borrelia burgdorferi is not associated with genital lichen sclerosus in men. Br J Dermatol. 2009;160(2):459-460.
- 11. Wallace HJ. Lichen sclerosus et atrophicus. Trans St Johns Hosp Dermatol Soc. 1971;57(1): 9-30.
- 12. Kizer WS, Prarie T, Morey AF. Balanitis xerotica obliterans: Epidemiologic distribution in an equal access health care system. South Med J. 2003;96(1): 9-11.
- 13. Meffert JJ, Davis BM, Grimwood RE. Lichen sclerosus. J Am Acad Dermatol. 1995;32(3):393-416.
- 14. Depasquale I, Park AJ, Bracka A. The treatment of balanitis xerotica obliterans. BJU Int. 2000;86(4):459-465.
- Riddell L, Edwards A, Sherrard J. Clinical features of lichen sclerosus in men attending a department of genitourinary medicine. Sex Transm Infect. 2000;76(4):311-313.
- 16. Mollet I, Ongenae K, Naeyaert JM. Origin, clinical presentation, and diagnosis of hypomelanotic skin disorders. Dermatol Clin. 2007;25(3):363-371.
- 17. Carlson JA, Grabowski R, Mu XC, *et al.* Possible mechanisms of hypopigmentation in lichen sclerosus. Am J Dermatopathol. 2002;24(2):97-107.
- 18. Oyama N, Chan I, Neill SM, *et al.* Development of antigen-specific ELISA for circulating autoantibodies to extracellular matrix protein 1 in lichen sclerosus. J Clin Invest. 2004;113(11):1550-1559.
- Neill SM, Lessana-Leibowitch M, Pelisse M, et al. Lichen sclerosus, invasive squamous cell carcinoma, and human papillomavirus. Am J Obstet Gynecol. 1990;162(6):1633-1634.
- Powell J, Robson A, Cranston D, et al. High Incidence of lichen sclerosus in patients with squamous cell carcinoma of the penis. Br J Dermatol. 2001;145(1):85-89.
- 21. Velazquez EF, Cubilla AL. Lichen sclerosus in 68 patients with squamous cell carcinoma of the penis: Frequent atypias and correlation with special carcinoma variants suggests a precancerous role. Am J Surg Pathol. 2003;27(11):1448-1453.
- 22. Pietrzak P, Hadway P, Corbishley CM, *et al.* Is the association between balanitis xerotica obliterans and penile carcinoma underestimated? BJU Int. 2006;98(1):74-76.
- Barbagli G, Palminteri E, Mirri F, et al. Penile carcinoma in patients with genital lichen sclerosus: A multicenter survey. J Urol. 2006;175(4):1359-1363.

- 24. Kiss A, Csontia A, Pirot L, *et al.* The response of balanitis xerotica obliterans to local steroid application compared with placebo in children. J Urol. 2001;165(1):219-220.
- 25. Val I, Almeida G. An overview of lichen sclerosus. Clin Obstet Gynecol. 2005;48(4):808-817.
- 26. Pandher BS, Rustin MHA, Kaisary AV. Treatment of balanitis xerotica obliterans with topical tacrolimus. J Urol. 2003;170(3):923.
- 27. Pasieczny TA. The treatment of balanitis xerotica obliterans with testosterone propionate ointment. Acta Derm Venereol. 1977;57(3):275-277.
- 28. Secrest CL, Rollins R, Hardin BM. A breakthrough in the treatment of balanitis xerotica obliterans [abstract]. J Urol. 2008;179(4):258.
- 29. Ayhan A, Guven S, Guvendag Guven ES, *et al.* Topical testosterone versus clobetasol for vulvar lichen sclerosus. Int J Gynaecol Obstet. 2007;96(2):117-121.
- 30. Powell JJ, Wojnarowska F. Lichen sclerosus. Lancet. 1999;353(9166):1777-1783.
- 31. Yesudian PD. The role of calcineurin inhibitors in the management of lichen sclerosus. Am J Clin Dermatol. 2009;10(5): 313-318.
- Ioannides D, Lazaridou E, Apalla Z, et al. Acitretin for severe lichen sclerosus of male genitalia: A randomized, placebo controlled study. J Urol. 2010;183(4):1395-1399.
- Olejek A, Kozak-Darmas I, Kellas-Sleczka S, et al. Effectiveness of photodynamic therapy in the treatment of lichen sclerosus: Cell changes in immunohistochemistry. Neuro Endocrinol Lett. 2009;30(4):547-551.
- Rosemberg SK, Jacobs H. Continuous wave carbon dioxide treatment of balanitis xerotica obiliterans. Urology. 1982;19(5): 539-541.
- Morey AF, Lin HC, DeRoda CA, et al. Fossa navicularis reconstruction: Impact of stricture length on outcomes and assessment of extended meatotomy (first stage Johanson) maneuver. J Urol. 2007;177(1):184-187.
- 36. Malone P. A new technique for meatal stenosis in patients with lichen sclerosus. J Urol. 2004;172(3):949-952.
- 37. Venn SN, Mundy AR. Urethroplasty for balanitis xerotica obliterans. Br J Urol. 1998;81(5):735-737.
- Virasora R, Eltahawy EA, Jordan GH. Long-term follow-up for reconstruction of strictures of the fossa navicularis with a single technique. BJU Int. 2007;100(5):1143-1145.
- 39. Das SK, Kumar A, Sharma GK, et al. Lingual mucosal graft urethroplasty for anterior urethral strictures. Urology. 2009;73(1):105-108.
- Dubey D, Sehgal A, Srivastava A, et al. Buccal mucosal urethroplasty for balanitis xerotica obliterans related urethral strictures: The outcome of 1 and 2-stage techniques. J Urol. 2005;173(2):463-466.
- 41. Kulkarni S, Barbagli G, Kirpekar D, *et al.* Lichen sclerosus of the male genitalia and urethra: Surgical options and results in a multicenter international experience with 215 patients. Eur Urol. 2009;55(4):945-954.



6

# **C**6

The Management of Anterior Urethral Stricture Disease Using Substitution Urethroplasty

#### **CHAIRS**

Christopher Chapple, United Kingdom Anthony Atala, United States

#### MEMBERS

Daniela Andrich, United Kingdom Guido Barbagli, Italy André Cavalcanti, Brazil Sanjay Kulkarni, India Altaf Mangera, United Kingdom Yosuke Nakajima, Japan

## CONTENTS

#### The Management of Anterior Urethral Stricture Disease Using Substitution Urethroplasty

6.1	Background	_111
6.2	Introduction	_111
6.3	Methods	_111
6.4	Pre-Operative Assessment	_112
6.5	Pre-Operative Counselling	_113
6.6	Choice of Urethral Reconstruction Technique	_113
6.7	Augmentation Urethral Reconstruction	_115
6.8	Grafts Versus Flaps	_116

6.9	Oral Mucosal Grafts	118
6.10	Acellular Matrices and Tissue Engineering	119
6.11	Graft Positioning	120
6.12	Patient Follow-Up	122
6.13	Recommendations	122
6.14	References	124
6.15	Appendix	129



## 6.1 Background

An electronic literature search of the PubMed database was conducted to identify articles dealing with substitution/augmentation urethral reconstruction of the anterior urethra. The evidence was categorized by stricture site, surgical technique, and transferred tissue used. A committee was appointed by the International Consultation on Urological Diseases (ICUD) under the auspices of the Société Internationale d'Urologie (SIU), which met in October 2010 to discuss and evaluate the evidence gathered. Recommendations were based on the ICUD modified system.

The committee assessed the evidence for the various techniques for substitution urethral reconstruction and recommends that there is no evidence of superiority of one technique over another for the bulbar urethra, whereas in the penile urethra a two-stage technique has higher reported success rates than a one-stage technique. In addition, recommendations are proposed for the best methods of follow-up of patients after substitution urethral reconstruction.

## 6.2 Introduction

There are many management options available for urethral stricture disease commencing with less invasive urethral dilatation, urethral stenting and urethrotomy, progressing to anastomotic and substitution urethral reconstruction. Each patient must be treated based upon their individual circumstances and with due regard for consent. In this article we present the consensus decision of the committee appointed by the ICUD on the management of anterior urethral strictures that are too lengthy for an anastomotic procedure requiring substitution of the urethra.

#### 6.3 Methods

A committee was appointed by the ICUD. The chair conducted an electronic literature search in September 2010 through PubMed (US National Library of Medicine - National Institutes of Health) for peer-reviewed articles on strictures of the anterior urethra treated by substitution/augmentation urethral reconstruction. Search terms included: substitution urethral reconstruction, augmentation urethral reconstruction, dorsal onlay, ventral onlay, lateral onlay, bulbar urethral reconstruction, penile urethral reconstruction, Asopa, Palminteri, and panurethral urethral reconstruction. Non-English articles and articles dealing with solely pediatric cases were excluded. After removal of duplicates, 80 articles were identified. From these, 11 were further excluded because the outcomes could not be categorized for the mixed populations described, and three review articles were excluded because the data were not original. The remaining 66 articles were categorized by technique according to the site of surgery and the graft used. The committee met at the SIU meeting in Marrakech, Morocco in October 2010 to discuss the presented evidence and provide recommendations for the proposed techniques for substitution of the bulbar and penile urethra. The evidence for each graft was also considered. Recommendations were formulated by consensus committee opinion, and are based on the ICUD modified system.

#### 6.4 **Pre-Operative Assessment**

In order to counsel the patient adequately, it is important to have a clear anatomical assessment of the site and length of the stricture to be able to give an opinion as to what form of urethral surgery is likely to be necessary. It is well recognized that the majority of men presenting with normal bladder function will usually have a tight stricture at the time of first presentation. Indeed, it was first described in 1968 by Smith (1) that the effective diameter of the unobstructed male urethra was in the order of 11 French gauge, and until the stricture narrowed beyond this point, there would be no significant interference with flow and hence, patients would not necessarily be aware that there was a significant problem.

The identification of the extent of urethral damage is important. The current standard of care is to use a combined ascending and descending urethrogram to image the urethra, supplemented where necessary by urethroscopy. An ischemic urethra looks white or grey, and healthy well–vascularized tissue appears pink. The length of urethral narrowing may not correspond directly to the length of ischemic spongiofibrosis and thus to the length of graft required (**Figure 1**). It has been suggested that intracorporal injection of contrast (2,3) or ultrasonography (4,5) may be useful.

#### **FIGURE 1**

Diagrammatic representation of the length of narrowing caused by the stricture, ischemic spongiofibrosis, and the length of substitution graft required.

(Turner Warwick, 1988)



## 6.5 **Pre-Operative Counselling**

Pre-operatively, the patient must be warned about the risks of the procedure, as well as of possible complications, the failure rate, the need for additional procedures, the need for follow-up, and the rate of recurrence. Much has been publicized about the risk of erectile dysfunction and three papers have appeared in the literature over the last decade relating to this.

Coursey *et al.* reported, in a retrospective study, that with an experienced surgeon, most men who undergo anterior urethral reconstruction are no more likely to have impaired sexual function than those who undergo circumcision (6). Alterations in the penile appearance and sexual performance may occur after anterior urethral reconstruction, but these are usually transient and more likely when the stricture is long than with a short stricture requiring an anastomotic procedure.

Anger and colleagues supported this view, suggesting that surgery had an insignificant long-term effect on erectile dysfunction and that surgical complexity made no difference to the incidence of erectile dysfunction (7).

Erickson and colleagues confirmed these findings. Both papers, however, suggested that there was an increasing risk of erectile dysfunction with increasing age and with a preceding history of erectile problems (8).

A prospective study has recently been reported suggesting that there is a risk of erectile dysfunction within the first few months following surgery (9), but that with time this improves, and that most men who develop erectile dysfunction of any sort will have full recovery by 7 months. The authors did note that persistence of erectile dysfunction was seen in some men, but that long-term follow-up would be necessary before they could categorically provide advice based on this information.

## 6.6 Choice of Urethral Reconstruction Technique

The factors limiting the potential for using anastomotic urethral reconstruction are anatomical considerations and the length of the stricture. In determining the type of urethral reconstruction that is appropriate, one must consider the length of the stricture, its likely cause (in particular if lichen sclerosus is present), and what previous surgery has been carried out.

The etiology of a stricture has an influence on any decision, since inflammatory strictures and those associated with lichen sclerosus have a tendency to be longer; the latter also have a tendency to recur because of recrudescence of the underlying disease process. The bulbar urethra is surrounded by the thickest portion of the corpus spongiosum and is eccentrically placed toward the dorsum. Thus,

the dorsal aspect of the surrounding tissues of the corpus spongiosum are thin, while ventrally they are thick. As the urethra extends distally, it becomes more centrally placed in relation to the corpus spongiosum, and through the glans it is relatively ventrally placed (**Figure 2**).

FIGURE 2

Diagrammatic representation of corporal thickness in the bulbar and penile urethra



Anastomotic urethral reconstruction involves excision of the stricture and primary anastomosis of the urethral ends. Surgeons cannot simply excise a stricture and restore continuity as when operating on bowel, because of the potential for causing chordee. It is a useful rule that the bulbar urethra should not be mobilized distal to the penoscrotal junction, and therefore if the stricture is long it may be necessary to carry out a substitution procedure. Similarly, it is very uncommon to be able to perform an anastomotic urethral reconstruction in the penile urethra, except in the context of a very limited traumatic injury of the penile urethra such as seen with penile fracture injuries.

Traditionally, only strictures less than 3 cm were considered suitable for an anastomotic procedure. However, by freeing up the urethra and separating the corpora, another few centimetres may be gained in length.

Morey *et al.* compared anastomotic procedures carried out for a stricture length ranging from 2.6 to 5.0 cm and reported success rates of 91%, as compared to a control group with stricture lengths less than 2.5 cm. However, the series had only 11 patients in each group and the mean follow-up period was 22 months (10).

Three large series looking at the success rates of anastomotic urethral reconstruction have recently been reported, with Santucci *et al.* (11), Barbagli *et al.* (12), and Eltahawy *et al.* (13) reporting success rates between 91% and 98%.

It is often possible to carry out an anastomotic urethral reconstruction for strictures longer than 2–3 cm using techniques (covered elsewhere) to straighten the natural curve of the bulbar urethra, thus shortening its course (**Figure 3**).



Clearly, the amount of length that can be gained will depend upon the anatomy of the individual male, including the length and elasticity of the distal urethral segment, and more particularly, the size of the penis and urethra themselves. It is now clearly established that anastomotic urethral reconstruction in the bulbar urethra, when performed by an experienced surgeon, is associated with a success rate of up to 95% (11–13). The length of a urethral stricture dictates the complexity of the necessary surgery; longer lesions present more of a surgical challenge. The remainder of this analysis gives an overview of the various techniques for augmentation urethral reconstruction and reviews the evidence relating to their use.

#### 6.7 Augmentation Urethral Reconstruction

Augmentation urethral reconstruction can be a one-stage or a two-stage procedure.

There are three potential options with a one-stage procedure:

- To excise the stricture and restore a roof or floor strip of native urethra augmented by a patch—an augmented anastomotic procedure;
- 2. To incise the stricture and carry out a patch augmentation—an onlay augmentation procedure
- **3.** To excise the stricture and put in a circumferential patch—a tube augmentation. This option is associated with a failure rate as high as 30% (14,15).

A two-stage procedure involves excision of the stricture and the abnormal urethra and reconstruction of a roof strip, which is allowed to heal prior to second-stage tubularization.
## 6.8 Grafts Versus Flaps

Controversy previously existed regarding whether one should use a graft or flap, but it is now clearly established from a review of the literature that the stricture recurrence rate is 14.5%–15.7% using either a flap or graft (16). It can therefore be concluded that in most instances, there is no advantage of a flap over a graft in terms of stricture recurrence rate. A randomized controlled trial carried out by Dubey *et al.* confirmed that the efficacy of grafts and flaps was identical, but there was a much higher morbidity with penile skin flaps, which were also technically more complex, and were thus less likely to be preferred by patients (17).

In carrying out an augmentation procedure, one must also consider whether full-thickness tissue or partial-thickness tissue should be used; partial-thickness tissue has a greater propensity to contract than does full-thickness tissue.

Alternative therapeutic options that have been suggested in the past include scrotal skin (18), extragenital skin (19), bladder epithelium (20), and colonic mucosa (21). In contemporary practice, genital skin and oral mucosa are most commonly used, although there is interest in the potential for tissue engineering in the future (22). Genital skin flaps are particularly useful when dealing with strictures in the penile urethra, where an onlay flap of penile skin can be especially helpful. The use of penile skin in patients with lichen sclerosus is addressed elsewhere.

Jenkins *et al.* found the scrotal pull-through procedure to have a high incidence of complications (23) and Blandy reported on the significant long-term morbidity associated with the use of scrotal skin, which should not be used except in unusual circumstances.

A number of flap designs have been described, varying in terms of the orientation of the skin island and the dissection of the fascial pedicle. A number of eponymous flap procedures (named after the authors who first described them) have been recognized. We would suggest a more pragmatic approach. When considering a penile flap, firstly identify an area of hairless penile skin of adequate length for use in the reconstruction of the urethral defect. It is important that the patient is not shaved before coming to the operating room, so that the position of hair can be identified peri-operatively. Next, based on the anatomy of the penis, decide the configuration of the flap, i.e., transverse, longitudinal, or oblique. Thereafter, determine the elevation technique of the fascial pedicle. Remember that the skin is a "passenger" on the subcutaneous tissues/fascial tissues. Ventral onlay skin flaps are particularly useful in the management of penile strictures with etiologies other than lichen sclerosus.

When considering the bulbar urethra, the current standard of care is to use a graft in the majority of cases, since the efficacy of grafts and flaps appears to be virtually identical. Indeed, it is well recognized that a number of complications can occur following flap urethral reconstruction, including penile hematoma, skin necrosis, fistula formation, and if one is using a distal flap derived from the prepuce, penile and glans torsion. In the longer term, flaps are associated with a higher risk of sacculation (diverticulum formation).

Barbagli and colleagues have reviewed their experience using dorsal onlay skin graft urethral reconstruction and reported a series of 38 patients in which 65.8% of cases were considered successful at a mean follow-up of 111 months (24). It is of interest that the majority of the recurrences in this series occurred within the first year. A similar experience has been reported in patients with no underlying progressive condition, such as lichen sclerosus, who underwent augmentation urethral reconstruction objectively assessed using urethrography or endoscopy (25).

Andrich *et al.* reported that in the longer term, the recurrence rate after an augmentation procedure is far worse than would be expected based on the existing literature, with a recurrence rate of 42% at 15 years for augmentation and 14% for anastomotic procedures (26). However, this study reported on a mixed population of cases at a tertiary centre and probably represents a worst-case scenario. The complexity of the underlying stricture and whether it is a first time or repeat procedure will obviously determine the subsequent success rate. Chapple *et al.* have previously demonstrated that, if assessed by flexible cystoscopy, the majority of recurrences for straightforward strictures (not associated with lichen sclerosus, which is a potentially progressive disease process) are present within the first 3–6 months following surgery (25).

The results of the different configurations of augmentation urethral reconstruction are summarized in **Table 1**. The complete dataset is included in the Appendix in **Tables 1–8**.

Technique	Total Patients Reported	Average Follow-Up (Months)	Average Success Rate (%)
Dorsal onlay bulbar	934	42.2	88.3
Ventral onlay bulbar	563	34.4	88.8
Lateral onlay bulbar	6	77	83
Asopa	89	28.9	86.7
Palminteri	53	21.9	90.6
One-stage penile	432	32.8	75.6
Two-stage penile	129	22.2	90.5
Panurethral	240	30.1	88.2

### **TABLE 1** Average data for the different configurations of augmentation urethral reconstruction

# 6.9 Oral Mucosal Grafts

The majority of patients undergoing augmentation urethral reconstruction, and particularly patients with lichen sclerosus, are optimally managed by an oral mucosa patch augmentation. The use of oral mucosa was first described in 1941 by Humby and Higgins (27) and was reintroduced into pediatric urology in 1992 by Bürger *et al.* (28). Oral mucosa is simple to harvest, tough, resilient, and easy to handle. It is taken as a full-thickness unit and for most patients the donor areas are adequate. It takes very effectively and has a thick epithelium with a thin lamina propria and a dense panlaminar vascular plexus, which allows early inosculation. In the majority of cases, there is acceptable morbidity at the donor site. This mucosa is used to being wet and appears to be resilient to skin diseases such as lichen sclerosus. It has privileged immunology, and pre-clinical work suggests that it shows fibroblast behaviour that results in less fibrosis, offering quite a different profile than that of skin.

Oral mucosa can be harvested from the cheek (buccal mucosa), from the lip (labial mucosa), or from the undersurface of the tongue (lingual mucosa). If an extensive amount of oral mucosa is to be harvested, or if the patient has a small mouth, then nasal intubation is useful for anesthesia, but in most cases is not essential.

In harvesting buccal mucosa, the parotid duct is identified opposite the upper second molar tooth. The length of the graft is identified and marked. Infiltration with 1 in 200,000 adrenaline solution is helpful and the buccal mucosa is excised in the plane superficial to the underlying muscle. Labial mucosa can be managed in a similar fashion, but is much thinner and more difficult to handle, and is associated with greater morbidity. In patients where a greater amount of oral mucosa is required, lingual mucosa is harvested from the under surface of the tongue (29). Lingual mucosa is slightly thinner than buccal mucosa. The landmarks to be identified are the lingual duct and the lingual nerve. A comparative study of buccal and lingual mucosa has reported that grafts from these sites are very similar in macroscopic appearance (30). The initial results using lingual mucosa have been reproduced by others and appear to be equivalent to those of buccal mucosa (30–32).

Reported complications of oral mucosal grafts include intra-operative hemorrhage, post-operative infection, pain, swelling, and damage to salivary ducts. In some cases, patients note initial limitation of oral opening, although this is usually transient. Occasionally there can be loss or alteration of sensation within the cheek. A permanent palpable scar due to formation of a fibrous band may be noticed by the patient. Both numbness and deformity have also been reported, particularly after the harvesting of tissue from the lower lip.

Barbagli *et al.*, in a survey of 295 patients, reported that 98.4% would undergo the surgery again and concluded that harvesting from a single cheek with closure of the donor site was a safe procedure with high patient satisfaction (33).

After the harvesting of oral mucosa, excess subcutaneous tissues must be cleared from the deep surface of the graft.

Contemporary evidence suggests that closure of the donor site is not essential. Gentle apposition may be useful in helping to control bleeding; other techniques include the use of fibrin glue, which can be applied locally (but is very expensive), as well as standard diathermy hemostasis.

Overzealous closure of the cheek donor site appears to worsen pain and may result in peri-oral numbness, difficulty with mouth opening, and alterations in salivary function (34,35). It is established that harvesting oral mucosa from the lower lip should be done sparingly because of significantly greater long-term morbidity and lower satisfaction rates in patients. There seems to be little indication for harvesting tissue from the lower lip in the majority of cases, and neuropathy of the mental nerve is thus avoided (36).

### 6.10 Acellular Matrices and Tissue Engineering

There has been interest in the use of acellular bladder matrix, with positive results being reported by El-Kassaby *et al.* However, this is a viable option only if there is a healthy, well vascularized urethral bed with limited residual ischemic spongiofibrosis and healthy urethral mucosa at both ends (37). Regrettably, this is not often the case where there is a long stricture requiring augmentation. Positive results were reported by Fiala and colleagues using porcine small intestinal submucosa (SIS) matrix (38). However, a recent update suggests that with longer-term follow-up, the success rate may deteriorate (39). Hauser *et al.* reported a poor success rate using SIS (40).

In the future, bioengineered buccal mucosa may be of use, particularly for complex strictures where lengthy amounts of oral mucosa are necessary, and ongoing preclinical research is being conducted (22,41). Tissue requires a donation of keratinocytes and fibroblasts obtained from a patient prior to surgery, via a small biopsy carried out under local anesthesia. These cells are cultured and attached to the matrix to create a lengthy piece of tissue. Longer culture periods allow cells to multiply and potentially generate even larger amounts of tissue. Providing the biopsy is taken from the patient undergoing urethral reconstruction, there is no allergenic response as long as the underlying matrix is immunologically inert. Other researchers have evaluated the use of urothelial cells obtained from the lower urinary tract. The principal problems with using biological matrices relate to a marked exudative process and an unpredictable degree of tissue contraction.

# 6.11 Graft Positioning

The relative efficacies of graft onlay placement have been examined. Barbagli and colleagues (42) initially reported dorsal graft urethral reconstruction using skin, and subsequently buccal mucosa (a modification of the Monseur technique) (43). Initially, this was applied in the context of an augmented anastomotic repair. Recent debate surrounds the advocacy of transection of the corpus spongiosum because of concern over further damage to the urethral blood supply. If there is a severely ischemic area of corpus spongiosum, transection is unlikely to be important, as the residual blood flow through the ischemic area is not likely to be significant.

The dorsal onlay approach with an anastomosis provides a very effective technique, which is easy to use and durable (44), and the majority of authors in the field (45–47) report success rates on the order of 90%, although a large retrospective analysis by Barbagli *et al.* (12) suggests a success rate of 70%. As demonstrated previously by Andrich *et al.* (26), it is likely that the success rate depends on the complexity of the cases operated on and the type/duration of follow-up. However, a reasonable success rate to quote to patients would be on the order of 85% at 5 years.

Concerning onlay augmentation, the options are a ventral, lateral, or dorsal approach. Barbagli *et al.* prefer a dorsal or lateral approach, as the thickness of the corpus spongiosum both dorsally and laterally is far less than ventrally (48). There is likely to be less bleeding from an incision in this plane and potentially less interference with blood supply as one extends into the proximal and distal "more normal" urethra. Barbagli *et al.* reported comparable success rates on the order of 82%–85% using ventral, dorsal, or lateral grafts in a small series of 50 patients (48). Recently, Kulkarni *et al.* reported a one-sided anterior dorsal approach, preserving the bulbospongiosus muscle and lateral vascular and nerve supply to the urethra, as having a success rate of 92% (49) in a small series of 24 patients with a short mean follow-up of 22 months.

A review of dorsal and ventral onlay grafting has suggested comparable success rates of 88% at 3 years, regardless of which approach is used for the onlay (50). Asopa *et al.* described a ventral sagittal urethrotomy transurethral lumen approach, with placement of a dorsal inlay graft (51). Fifty-eight men underwent treatment, with a mean follow-up of 42 months and a success rate of 87% (52). Palminteri and colleagues have suggested that, in addition to placement of a dorsal graft via the Asopa approach, a ventral onlay could be applied as well. A success rate of 89% with a mean follow-up of 22 months in 48 cases was reported (53).

One-stage tube repairs should not be used routinely and it is clear from a review of the literature that the revision rate for a two-stage procedure prior to formal closure is on the order of 20%-25%, which equates well with the finding of Greenwell *et al.* of a 30% failure rate with a tube urethral reconstruction (15).

An important indication for a two-stage procedure is complex reoperative situations, such as the length of obliterative stenosis of the urethra, whether reconstruction is required after the patient failed urethral stent placement, etc. In short, if total luminal replacement of the urethra is required, a two-stage procedure is likely the best option.

Two-stage reconstruction should be considered whenever there is concern about the success of any reconstructive procedure in the penile urethra, particularly following hypospadias repair or in the presence of lichen sclerosus. The two-stage skin reconstruction is appropriate for failed hypospadias repair. However, oral mucosa seems to be a better choice for lichen sclerosus, as is covered elsewhere. A small literature base reports on staged reconstruction (14), but it must be emphasized that the literature reports a 22.5% revision rate for a first-stage urethral reconstruction (54). When the patient is given information about a two-stage procedure, he must be warned that the second stage can only be completed when the first stage is adequate for closure. Therefore, if there are one or more revision procedures, it may in fact be a three- (or more) stage procedure.

In carrying out penile surgery, the important factor to bear in mind is the tendency for chordee, and use of an artificial erection is advised during the reconstruction. For a two-stage procedure using either skin or oral mucosa, this is easily accomplished using a standard technique. Following first-stage urethral reconstruction, 10%–39% of patients show contraction due to scarring of the initial graft, and this requires new grafting techniques (55).

Second-stage closure requires tubularization of the first-stage procedure, and the aim is to achieve a roof of 25–30 mm to provide a satisfactory augmentation of the urethral lumen, allowing for the inevitable contraction that occurs during subsequent healing. It is essential to avoid overlaying suture lines and to provide for tissue to be interposed between urethral closure and skin closure. Thus, if the tissues of the penis are thin, then mobilization of a tunica dartos flap or tunica vaginalis island from the scrotum is appropriate.

Complications following second-stage urethral reconstruction (fistula formation, glans dehiscence, and meatal stenosis) have been reported in 30% of patients (55).

Andrich and Mundy reported that there is a tendency for recurrence in the marsupialized segment of the urethra, particularly in lichen sclerosus patients, and that therefore a perineal urethrostomy may be a more reliable form of management for full-length urethral strictures, particularly in elderly patients (56). Peterson and colleagues also support this view (57).

### 6.12 Patient Follow-Up

Follow-up protocols after urethral reconstructive procedures vary among series. The most commonly used method is uroflowmetry (50). Deterioration in the flow rate is often used as an indication for further evaluation of patients. However, for voiding symptoms to appear and flow rates to diminish, there has to be a significant reduction in the calibre of the urethra. Smith (58,59) has shown that urethral calibre usually has to be less than 10 French for flow rates to diminish below normal.

Anatomical assessment of the repair site potentially provides the most accurate information with regard to success and the potential for recurrent stricture formation. Although contrast urethrography is most widely used in this context, direct visualization is likely to provide the best information relating to the stricture and the urethra in general. Despite the development and widespread use of flexible cystoscopy, there are few reported series where urethroscopy has been used in the long-term follow-up of urethral reconstruction patients (50).

A crucial parameter is patient satisfaction, which can be assessed via a patient-reported outcome measure (PROM). Although this will not give an indication of surgical healing or allow for earlier identification of complications, it is designed to give a complete picture of patient improvement and satisfaction. Recently, a urethral surgery PROM has been validated in English (60) and Italian (61). However, aspects such as donor site morbidity have not been included in the assessment.

### 6.13 Recommendations

- 1. The first operation is likely to be the most successful, and preference should be given to the simplest technique that is likely to be most effective, avoiding augmentation urethral reconstruction if possible (Level 3; A).
- 2. If augmentation (substitution) urethral reconstruction is being considered, an onlay flap for strictures in the penile urethra can also be considered (Level 3; B).
- 3. In most cases, grafts are preferred over flaps for augmentation urethral reconstruction, particularly in the bulbar urethra, since there is a greater morbidity with the use of flaps compared to with grafts, and they have similar efficacy (Level 2; B).
- 4. One-stage penile augmentation (substitution) urethral reconstruction is less successful than a two-stage procedure, except in carefully selected groups (Level 3; B).

- 5. There is no significant difference in outcome between a ventral, lateral, dorsal, or combined approach to augmentation (substitution) urethral reconstruction (Level 2; A).
- 6. Tube substitution procedures should be avoided (Level 3-4; A).
- 7. Scrotal skin should be avoided where possible because of the high associated morbidity (Level 3; A).
- 8. Oral mucosa is the most versatile augmentation (substitution) material (Level 3; A).
- 9. Oral mucosa is currently considered the substitution material of choice for reconstruction of stricture secondary to lichen sclerosus (Level 3; A).
- 10. Neither bladder nor colonic mucosa are recommended for use as primary alternatives for lengthy augmentation in cases of lichen sclerosus, as they require a more invasive harvesting approach (Level 3; C).
- 11. There is no evidence that transection of the corpus spongiosum during a primary augmentation (substitution) procedure leads to a worse outcome (Level 3; B).
- 12. Patient-reported outcome measures for evaluating the results of urethral surgery require further development for the future (Level 4; A).
- 13. Objective assessment with urethrography or endoscopy is recommended to determine the success rate of surgery in terms of stricture recurrence (Level 4; A).
- 14. Any technique that requires the ingrowth of endogenous epithelial and fibroblast cells using acellular matrix is unlikely to be applicable to an extensive stricture with a poorly vascularized graft bed. The direction for tissue engineering remains investigational and should not be used outside an ethics committee-approved research trial. Future research should be focus on the development of cell-seeded matrices that can be used for long strictures with extensive spongiofibrosis or a poorly vascularized graft bed (Level 3; B).

### 6.14 References

- 1. Smith JC. Urethral resistance to micturition. Br J Urol. 1968;40(2):125-156.
- 2. Chapple C, Barbagli G, Jordan G, et al. Consensus statement on urethral trauma. BJU Int. 2004;93(9):1195-1202.
- 3. Beckert R, Gilbert P, Kreutzig T. Spongiosography: A valuable adjunct to the diagnosis of urethral strictures. J Urol. 1991;146(4):993-996.
- Barbagli G, Azzaro F, Menchi I, et al. Bacteriologic, histologic and ultrasonographic findings in strictures recurring after urethrotomy. A preliminary study. Scand J Urol Nephrol. 1995;29(2):193-195.
- Davies TO, McCammon KA, Jordan GH. Bulbar urethral reconstruction: Does ultrasound add to preoperative planning? [abstract]. J Urol. 2009;181(4):16.
- 6. Coursey JW, Morey AF, McAninch JW, et al. Erectile function after anterior urethroplasty. J Urol. 2001;166(6):2273-2276.
- 7. Anger JT, Sherman ND, Webster GD. The effect of bulbar urethroplasty on erectile function. J Urol. 2007;178(3 Pt 1):1009-1011.
- 8. Erickson BA, Wysock JS, McVary KT, *et al.* Erectile function, sexual drive, and ejaculatory function after reconstructive surgery for anterior urethral stricture disease. BJU Int. 2007;99(3):607-611.
- 9. Erickson BA, Granieri MA, Meeks JJ, *et al.* Prospective analysis of erectile dysfunction after anterior urethroplasty: Incidence and recovery of function. J Urol. 2010;183(2):657-661.
- 10. Morey AF, Kizer WS. Proximal bulbar urethroplasty via extended anastomotic approach–What are the limits? J Urol. 2006;175(6):2145-2149.
- 11. Santucci RA, Mario LA, McAninch JW. Anastomotic urethroplasty for bulbar urethral stricture: Analysis of 168 patients. J Urol. 2002;167(4):1715-1719.
- 12. Barbagli G, Guazzoni G, Lazzeri M. One-stage bulbar urethroplasty: Retrospective analysis of the results in 375 patients. Eur Urol. 2008;53(4):828-833.
- 13. Eltahawy EA, Virasoro R, Schlossberg SM, *et al.* Long-term followup for excision and primary anastomosis for anterior urethral strictures. J Urol. 2007;177(5):1803-1806.
- 14. Patterson JM, Chapple CR. Surgical techniques in substitution urethroplasty using buccal mucosa for the treatment of anterior urethral strictures. Eur Urol. 2008;53(6):1162-1171.
- 15. Greenwell TJ, Venn SN, Mundy AR. Changing practice in anterior urethroplasty. BJU Int. 1999;83(6):631-635.
- 16. Wessells H, McAninch JW. Current controversies in anterior urethral stricture repair: Free-graft versus pedicled skin-flap reconstruction. World J Urol. 1998;16(3):175-180.
- 17. Dubey D, Vijjan V, Kapoor R, *et al.* Dorsal onlay buccal mucosa versus penile skin flap urethroplasty for anterior urethral strictures: Results from a randomized prospective trial. J Urol. 2007;178(6):2466-2469.
- 18. Jordan GH. Scrotal and perineal flaps for anterior urethral reconstruction. Urol Clin North Am. 2002;29(2):411-416, viii.
- 19. Vyas PR, Roth DR, Perlmutter AD. Experience with free grafts in urethral reconstruction. J Urol. 1987;137(3):471-474.
- Kinkead TM, Borzi PA, Duffy PG, et al. Long-term followup of bladder mucosa graft for male urethral reconstruction. J Urol. 1994;151(4):1056-1058.
- 21. Xu YM, Qiao Y, Sa YL, et al. Urethral reconstruction using colonic mucosa graft for complex strictures. J Urol. 2009;182(3):1040-1043.
- 22. Bhargava S, Patterson JM, Inman RD, *et al.* Tissue-engineered buccal mucosa urethroplasty-Clinical outcomes. Eur Urol. 2008;53(6):1263-1269.
- Jenkins BJ, Badenoch DF, Fowler CG, et al. Long-term results of treatment of urethral injuries in males caused by external trauma. Br J Urol. 1992;70(1):73-75.

- 24. Barbagli G, Morgia G, Lazzeri M. Dorsal onlay skin graft bulbar urethroplasty: Long-term follow-up. Eur Urol. 2008;53(3):628-633.
- 25. Chapple CR, Goonesinghe SK, Nicholson T, *et al.* The importance of endoscopic surveillance in the follow up of patients with urethral stricture disease. J Urol. 2002;167(Suppl):16.
- 26. Andrich DE, Dunglison N, Greenwell TJ, et al. The long-term results of urethroplasty. J Urol. 2003;170(1):90-92.
- 27. Humby G, Higgins T. A one-stage operation for hypospadias. Br J Surg. 1941;29(113):84-92.
- Bürger RA, Müller SC, el-Damanhoury H, et al. The buccal mucosal graft for urethral reconstruction: A preliminary report. J Urol. 1992;147(3):662-664.
- 29. Simonato A, Gregori A, Lissiani A, *et al.* The tongue as an alternative donor site for graft urethroplasty: A pilot study. J Urol. 2006;175(2):589-592.
- 30. Simonato A, Gregori A, Ambruosi C, *et al.* Lingual mucosal graft urethroplasty for anterior urethral reconstruction. Eur Urol. 2008;54(1):79-85.
- 31. Das SK, Kumar A, Sharma GK, et al. Lingual mucosal graft urethroplasty for anterior urethral strictures. Urology. 2009;73(1):105-108.
- 32. Barbagli G, De Angelis M, Romano G, *et al.* The use of lingual mucosal graft in adult anterior urethroplastyu: Surgical steps and short-term outcome. Eur Urol. 2008;54(3):671-676.
- 33. Barbagli G, Romano G, De Angelis M, *et al.* Complications and patient satisfaction in 349 patients who underwent oral graft harvesting from a single cheek. Eur Urol Supplement. 2010;9(2):141.
- 34. Wood DN, Allen SE, Andrich DE, *et al.* The morbidity of buccal mucosal graft harvest for urethroplasty and the effect of nonclosure of the graft harvest site on postoperative pain. J Urol. 2004;172(2):580-583.
- 35. Muruganandam K, Dubey D, Gulia AK, *et al.* Closure versus nonclosure of buccal mucosal graft harvest site: A prospective randomized study on post operative morbidity. Indian J Urol. 2009;25(1):72-75.
- Kamp S, Knoll T, Osman M, et al. Donor-site morbidity in buccal mucosa urethroplasty: Lower lip or inner cheek? BJU Int. 2005;96(4):619-623.
- El-Kassaby A, AbouShwareb T, Atala A. Randomized comparative study between buccal mucosal and acellular bladder matrix grafts in complex anterior urethral strictures. J Urol. 2008;179(4):1432-1436.
- 38. Fiala R, Vidlar A, Vrtal R, *et al.* Porcine small intestinal submucosa graft for repair of anterior urethral strictures. Eur Urol. 2007;51(6):1702-1708.
- 39. Fiala R, Vidlar A, Vrtal R. Porcine small intestinal submucosa in the treatment of anterior urethral strictures. BJU Int. 2009;103(Suppl 4):12-46.
- 40. Hauser S, Bastian PJ, Fechner G, *et al.* Small intestine submucosa in urethral stricture repair in a consecutive series. Urology. 2006;68(2):263-266.
- 41. Bhargava S, Chapple CR, Bullock AJ, *et al.* Tissue-engineered buccal mucosa for substitution urethroplasty. BJU Int. 2004; 93(6):807-811.
- 42. Barbagli G, Selli C, Tosto A, et al. Dorsal free graft urethroplasty. J Urol. 1996;155(1):123-126.
- 43. Monseur J. Widening of the urethra using the supra-urethral layer [Article in French]. J Urol (Paris). 1980;86(6):439-449.
- 44. Mundy AR. Anastomotic urethroplasty. BJU Int. 2005;96(6):921-944.
- 45. EI-Kassaby AW, EI-Zayat TM, Azazy S, *et al.* One-stage repair of long bulbar urethral strictures using augmented Russell dorsal strip anastomosis: Outcome of 234 cases. Eur Urol. 2008;53(2):420-424.
- 46. Abouassaly R, Angermeier KW. Augmented anastomotic urethroplasty. J Urol. 2007;177(6):2211-2215.
- Rourke K. Outcomes and complications of urethral reconstruction using dorsal onlay augmented anastomosis with buccal mucosa: Is this the evolving gold standard for treatment of the long segment bulbar urethral stricture? [abstract]. J Urol. 2009;181(4):13.

- 48. Barbagli G, Palminteri E, Guazzoni G, *et al.* Bulbar urethroplasty using buccal mucosa grafts placed on the ventral, dorsal or lateral surface of the urethra: Are results affected by the surgical technique? J Urol. 2005;174(3):955-957.
- 49. Kulkarni S, Barbagli G, Sansalone S, *et al.* One-sided anterior urethroplasty: A new dorsal onlay graft technique. BJU Int. 2009;104(8):1150-1155.
- 50. Mangera A, Patterson JM, Chapple CR. A systematic review of graft augmentation urethroplasty techniques for the treatment of anterior urethral strictures. Eur Urol. 2011;59(5):797-814.
- 51. Asopa HS, Garg M, Singhal GG, *et al.* Dorsal free graft urethroplasty for urethral stricture by ventral sagittal urethrotomy approach. Urology. 2001;58(5):657-659.
- 52. Pisapati VL, Paturi S, Bethu S, *et al.* Dorsal buccal mucosal graft urethroplasty for anterior urethral stricture by Asopa technique. Eur Urol. 2009;56(1):201-205.
- 53. Palminteri E, Manzoni G, Berdondini E, *et al.* Combined dorsal plus ventral double buccal mucosa graft in bulbar urethral reconstruction. Eur Urol. 2008;53(1):81-89.
- Andrich DE, Greenwell TJ, Mundy AR. The problems of penile urethroplasty with particular reference to 2-stage reconstructions. J Urol. 2003;170(1):87-89.
- 55. Barbagli G, De Angelis M, Palminteri E, et al. Failed hypospadias repair presenting in adults. Eur Urol. 2006;49(5):887-894.
- Andrich DE, Mundy A. Outcome of different management options for full-length anterior urethral strictures [abstract] J Urol. 2009;181(4):13.
- 57. Peterson AC, Palminteri E, Lazzeri M, *et al.* Heroic measures may not always be justified in extensive urethral stricture due to lichen sclerosus (balanitis xerotica obliterans). Urology. 2004;64(3):565-568.
- 58. Smith JC. The measurement and significance of the urinary flow rate. Br J Urol. 1966;38(6):701-706.
- 59. Rollema HJ. Uroflowmetry. In: Krane RJ, Siroky MB, editors. Clinical neuro-urology. Boston: Brown and Co; 1991. p. 201-243.
- 60. Jackson MJ, Sciberras J, Mangera A, *et al.* Defining a patient-reported outcome measure for urethral stricture surgery. Eur Urol. 2011;60(1):60-68.
- 61. Barbagli G, Romano G, Sansalone S, *et al.* Italian validation of the English PROM-USS-Q questionnaire in patients undergoing anterior urethroplasty [Article in Italian]. Urologia. 2011;78(2):98-107.
- 62. Morey AF, McAninch JW. When and how to use buccal mucosal grafts in adult bulbar urethroplasty. Urology. 1996;48(2):194-198.
- 63. Wessells H, McAninch JW. Use of free grafts in urethral stricture reconstruction. J Urol. 1996;155(6):1912-1915.
- 64. Pansadoro V, Emiliozzi P, Gaffi M, *et al.* Buccal mucosa urethroplasty for the treatment of bulbar urethral strictures. J Urol. 1999;161(5):1501-1503.
- 65. Andrich DE, Leach CJ, Mundy AR. The Barbagli procedure gives the best results for patch urethroplasty of the bulbar urethra. BJU Int. 2001;88(4):385-389.
- 66. Andrich DE, Mundy AR. Substitution urethroplasty with buccal mucosal-free grafts. J Urol. 2001;165(4):1131-1133.
- 67. Meneghini A, Cacciola A, Cavarretta L, *et al.* Bulbar urethral stricture repair with buccal mucosa graft urethroplasty. Eur Urol. 2001;39(3):264-267.
- 68. Palminteri E, Lazzeri M, Guazzoni G, et al. New 2-stage buccal mucosal graft urethroplasty. J Urol. 2002;167(1):130-132.
- 69. Lewis JB, Wolgast KA, Ward JA, *et al.* Outpatient anterior urethroplasty: Outcome analysis and patient selection criteria. J Urol. 2002;168(3):1024-1026.
- 70. Kane CJ, Tarman GJ, Summerton DJ, *et al.* Multi-institutional experience with buccal mucosa onlay urethroplasty for bulbar urethral reconstruction. J Urol. 2002;167(3):1314-1317.
- 71. Heinke T, Gerharz EW, Bonfig R, *et al.* Ventral onlay urethroplasty using buccal mucosa for complex stricture repair. Urology. 2003;61(5):1004-1007.
- 72. Pansadoro V, Emiliozzi P, Gaffi M, *et al.* Buccal mucosa urethroplasty in the treatment of bulbar urethral strictures. Urology. 2003;61(5):1008-1010.

- 73. Elliott SP, Metro MJ, McAninch JW. Long-term followup of the ventrally placed buccal mucosa onlay graft in bulbar urethral reconstruction. J Urol. 2003;169(5):1754-1757.
- 74. Dubey D, Kumar A, Bansal P, *et al.* Substitution urethroplasty for anterior urethral strictures: A critical appraisal of various techniques. BJU Int. 2003;91(3):215-218.
- Fichtner J, Filipas D, Fisch M, et al. Long-term outcome of ventral buccal mucosa onlay graft urethroplasty for urethral stricture repair. Urology. 2004;64(4):648-650.
- 76. Kellner DS, Fracchia JA, Armenakas NA. Ventral onlay buccal mucosal grafts for anterior urethral strictures: Long-term followup. J Urol. 2004;171(2 Pt 1):726-729.
- 77. Berger AP, Deibl M, Bartsch G, *et al.* A comparison of one-stage procedures for post-traumatic urethral stricture repair. BJU Int. 2005;95(9):1299-1302.
- McLaughlin MD, Thrasher JB, Celmer A, et al. Buccal mucosal urethroplasty in patients who had multiple previous procedures. Urology. 2006;68(6):1156-1159.
- 79. Palminteri E, Berdondini E, Colombo F, *et al.* Small intestinal submucosa (SIS) graft urethroplasty: Short-term results. Eur Urol. 2007;51(6):1695-1701.
- Levine LA, Strom KH, Lux MM. Buccal mucosa graft urethroplasty for anterior urethral stricture repair: Evaluation of the impact of stricture location and lichen sclerosus on surgical outcome. J Urol. 2007;178(5):2011-2015.
- 81. Barbagli G, De Stefani S, Annino F, *et al.* Muscle- and nerve-sparing bulbar urethroplasty: A new technique. Eur Urol. 2008;54(2):335-343.
- 82. Dalela D, Sinha RJ, Sankhwar SN, *et al.* Ventral bulbar augmentation: A new technical modification of oral mucosa graft urethroplasty for stricture of the proximal bulbar urethra. Urol J. 2010;7(2):115-119.
- Barbagli G, Selli C, di Cello V, et al. A one-stage dorsal free-graft urethroplasty for bulbar urethral strictures. Br J Urol. 1996;78(6):929-932.
- Barbagli G, Palminteri E, Rizzo M. Dorsal onlay graft urethroplasty using penile skin or buccal mucosa in adult bulbourethral strictures. J Urol. 1998;160(4):1307-1309.
- 85. Iselin CE, Webster GD. Dorsal onlay graft urethroplasty for repair of bulbar urethral stricture. J Urol. 1999;161(3):815-818.
- Barbagli G, Palminteri E, Lazzeri M, et al. Long-term outcome of urethroplasty after failed urethrotomy versus primary repair. J Urol. 2001;165(6 Pt 1):1918-1919.
- 87. Joseph JV, Andrich DE, Leach CJ, et al. Urethroplasty for refractory anterior urethral stricture. J Urol. 2002;167(1):127-129.
- Barbagli G, Palminteri E, Lazzeri M, et al. Interim outcomes of dorsal skin graft bulbar urethroplasty. J Urol. 2004;172(4 Pt 1): 1365-1367.
- 89. Raber M, Naspro R, Scapaticci E, *et al.* Dorsal onlay graft urethroplasty using penile skin or buccal mucosa for repair of bulbar urethral stricture: Results of a prospective single center study. Eur Urol. 2005;48(6):1013-1017.
- Dubey D, Kumar A, Mandhani A, et al. Buccal mucosal urethroplasty: A versatile technique for all urethral segments. BJU Int. 2005;95(4):625-629.
- 91. Barbagli G, De Stefani S, Sighinolfi MC, *et al.* Bulbar urethroplasty with dorsal onlay buccal mucosal graft and fibrin glue. Eur Urol. 2006;50(3):467-474.
- Donkov II, Bashir A, Elenkov CH, et al. Dorsal onlay augmentation urethroplasty with small intestinal submucosa: Modified Barbagli technique for strictures of the bulbar urethra. Int J Urol. 2006;13(11):1415-1417.
- Xu YM, Qiao Y, Sa YL, et al. Substitution urethroplasty of complex and long-segment urethral strictures: A rationale for procedure selection. Eur Urol. 2007;51(4):1093-1098.
- 94. Radopoulos D, Tzakas C, Dimitriadis G, *et al.* Dorsal on-lay preputial graft urethroplasty for anterior urethra strictures repair. Int Urol Nephrol. 2007;39(2):497-503.
- 95. Foinquinos RC, Calado AA, Janio R, *et al.* The tunica vaginalis dorsal graft urethroplasty: Initial experience. Int Braz J Urol. 2007;33(4):523-529.

- O'Riordan A, Narahari R, Kumar V, *et al.* Outcome of dorsal buccal graft urethroplasty for recurrent bulbar urethral strictures. BJU Int. 2008;102(9):1148-1151.
- 97. Kulkarni S, Barbagli G, Kirpekar D, *et al.* Lichen sclerosus of the male genitalia and urethra: Surgical options and results in a multicenter international experience with 215 patients. Eur Urol. 2009;55(4):945-954.
- 98. Manoj B, Sanjeev N, Pandurang PN, *et al.* Postauricular skin as an alternative to oral mucosa for anterior onlay graft urethroplasty: A preliminary experience in patients with oral mucosa changes. Urology. 2009;74(2):345-348.
- 99. Fransis K, Vander Eeckt K, Van Poppel H, *et al.* Results of buccal mucosa grafts for repairing long bulbar urethral strictures. BJU Int. 2010;105(8):1170-1172.
- 100. Schwentner C, Seibold J, Colleselli D, *et al.* Dorsal onlay skin graft urethroplasty in patients older than 65 years. Urology. 2010;76(2):465-470.
- 101. Arlen AM, Powell CR, Hoffman HT, *et al.* Buccal mucosal graft urethroplasty in the treatment of urethral strictures: Experience using the two-surgeon technique. ScientificWorldJournal. 2010;10:74-79.
- 102. Venn SN, Mundy AR. Early experience with the use of buccal mucosa for substitution urethroplasty. Br J Urol. 1998;81(5):738-740.
- 103. Metro MJ, Wu HY, Snyder HM 3rd, *et al.* Buccal mucosal grafts: Lessons learned from an 8-year experience. J Urol. 2001; 166(4):1459-1461.
- 104. Dubey D, Sehgal A, Srivastava A, *et al.* Buccal mucosal urethroplasty for balanitis xerotica obliterans related urethral strictures: The outcome of 1 and 2-stage techniques. J Urol. 2005;173(2):463-466.
- 105. Barbagli G, Morgia G, Lazzeri M. Retrospective outcome analysis of one-stage penile urethroplasty using a flap or graft in a homogeneous series of patients. BJU Int. 2008;102(7):853-860.
- 106. Kumar MR, Himanshu A, Sudarshan O. Technique of anterior urethroplasty using the tunica albuginea of the corpora cavernosa. Asian J Surg. 2008;31(3):134-139.
- 107. Singh BP, Pathak HR, Andankar MG. Dorsolateral onlay urethroplasty for anterior urethral strictures by a unilateral urethral mobilization approach. Indian J Urol. 2009;25(2):211-214.
- 108. Xu YM, Fu Q, Sa YL, *et al.* Treatment of urethral strictures using lingual mucosas urethroplasty: Experience of 92 cases. Chin Med J (Engl). 2010;123(4):458-462.
- 109. Venn SN, Mundy AR. Urethroplasty for balanitis xerotica obliterans. Br J Urol. 1998;81(5):735-737.
- 110. Meeks JJ, Erickson BA, Gonzalez CM. Full-thickness abdominal skin graft for long-segment urethral stricture reconstruction. Int Braz J Urol. 2008;34(5):602-607.
- 111. Gupta NP, Ansari MS, Dogra PN, et al. Dorsal buccal mucosal graft urethroplasty by a ventral sagittal urethrotomy and minimalaccess perineal approach for anterior urethral stricture. BJU Int. 2004;93(9):1287-1290.
- 112. Xu YM, Sa YL, Fu Q, *et al.* Oral mucosal grafts urethroplasty for the treatment of long segmented anterior urethral strictures. World J Urol. 2009;27(4):565-571.
- 113. Mathur RK, Sharma A. Tunica albuginea urethroplasty for panurethral strictures. Urol J. 2010;7(2):120-124.
- 114. Singh PB, Das SK, Kumar A, *et al.* Dorsal onlay lingual mucosal graft urethroplasty: Comparison of two techniques. Int J Urol. 2008;15(11):1002-1005.

# 6.15 Appendix

Table Key			
BLM	bladder mucosa	LM	lingual mucosa
BM	buccal mucosa	OM	oral mucosa
CM	colonic mucosa	PAS	post-auricular skin
DIVU	direct inline visual urethrotomy	PS	penile skin
FTS	full-thickness skin	PVRU	post-void residual urine
GS	groin skin	SIS	porcine small intestinal submucosa
IIEF	International Index of Erectile Function	SS	scrotal skin
IPSS	International Prostate Symptom Score	TA	tunica albuginea
ISD	intermittent self-dilatation	Τ.).	tunico veginalio
LBM	labial mucosa	I V	tunica vaginans

#### **TABLE 1** Outcomes and follow-up of ventral onlay bulbar urethral reconstruction

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Morey <i>et al.</i> 1996 (62)	13	18	BM	Uroflowmetry/ symptom score Urethrography 3 & 12 mo	Any instrumentation	100
Wessells <i>et al.</i> 1996 (63)	27	23	BM 7 BLM 2 PS 21	Uroflowmetry 3 & 12 mo Urethrography 2/3 wk, 3 & 12 mo	Any instrumentation, radiographic presence of stricture	100 100 90
Pansadoro <i>et al.</i> 1999 (64)	7	20	BM	Uroflowmetry Urethrography 2 wk, 6 & 12 mo, then annually	Stricture recurrence on urethrography	86
Andrich <i>et al.</i> 2001 (65,66)	29	48–60	BM	Uroflowmetry 3, 6, & 12 mo, then annually Urethrography 6 & 18 mo Urethroscopy in last 45 cases	Development of symptoms leading to urethrogram or urethroscopy	86
Meneghini <i>et al.</i> 2001 (67)	20	6–28	BM	Uroflowmetry 3, 6, 9, & 12 mo Urethrography 6 & 12 mo	Any objective or subjective modification of uroflowmetry leading to urethral instrumentation	80
Palminteri <i>et al.</i> 2002 (68)	24	18	BM	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk & 12 mo Urethroscopy 12 mo	Any instrumentation	95.8
Lewis <i>et al.</i> 2002 (69)	22	12—54	BM	Uroflowmetry 3 & 12 mo Urethrography 3 & 12 mo	Any instrumentation	86
Kane <i>et al.</i> 2002 (70)	53	25	BM	Uroflowmetry 3, 6, & 12 mo, then annually with symptom score Urethrography 3 wk & 3 mo	Recurrence on radiological studies and requiring intervention	94

#### **TABLE 1** Outcomes and follow-up of ventral onlay bulbar urethral reconstruction, Cont'd

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Heinke <i>et al.</i> 2003 (71)	38 (30 bulbar)	22.8	BM	Uroflowmetry 6 & 12 mo & PVRU estimation Urethrography 3 wk, repeat if deteriorating Q <sub>max</sub>	Failure after repeat intervention (some patients also performing ISD)	81.6
Pansadoro <i>et al.</i> 2003 (72)	9	41	BM	Uroflowmetry – periodic Urethrography 2 wk, 6 & 12 mo, then annually	Recurrence of symptoms	89
Elliott <i>et al.</i> 2003 (73)	60	47	BM	Urethrography 3 wk, 3, 6, & 12 mo, then as required	Stream reduced or symptoms recurred	90
Dubey <i>et al.</i> 2003 (74)	18	45.7	6 PS 7 BM 6 BLM	Uroflowmetry 6 mo (all patients performed ISD 16 F up to 6 mo) Urethrography 6, 12, & 18 mo, then as required	Need for urethral calibration/dilatation with/without DIVU after 18 mo	77.8
Fichtner <i>et al.</i> 2004 (75)	32 (15 bulbar)	82.8	BM	Uroflowmetry 6 & 12 mo with symptom score & PVRU estimation Urethrography 3 wk	Symptomatic recurrence	87
Kellner <i>et al.</i> 2004 (76)	18	50	BM	Uroflowmetry 3, 6, & 12 mo, then annually Urethrography 3 wk, then as required	Abnormal voiding Need for intervention	87 (includes 5 penile)
Berger e <i>t al.</i> 2005 (77)	7	70.7	BM	Uroflowmetry 3, 6, & 12 mo, then annually Urethrography 3 wk	Stream or symptoms deteriorate	43
Barbagli <i>et al.</i> 2005 (48)	17	42	BM	Uroflowmetry 3, 6, & 12 mo, then annually Urethrography 3 wk, then as required Urethroscopy if Q <sub>max</sub> < 14 mL/s	Any instrumentation	83

#### TABLE 1 Outcomes and follow-up of ventral onlay bulbar urethral reconstruction, Cont'd

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
McLaughlin <i>et al.</i> 2006 (78)	58 (48 reported)	29.6	BM	Symptom score at 12 mo No routine urethrography Urethroscopy if deterioration in symptoms	Any recurrence found on urethroscopy if subjective deterioration in symptoms	94
Palminteri <i>et al.</i> 2007 (79)	1	21	SIS	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk & 12 mo or if Q <sub>max</sub> < 14 mL/s Urethroscopy 3 & 12 mo	Abnormal voiding Any instrumentation Evidence of stricture on urethrography	100
Fiala <i>et al.</i> 2007 (38)	10	31.2	SIS	Urethrography 3, 6, 9, 12, & 18 mo, then annually Urethrography if Q <sub>max</sub> < 15 mL/s or IPSS > 7	Stricture on urethrography	90
Levine <i>et al.</i> 2007 (80)	12	58.1	BM	Urethrography 2 wk	Any instrumentation	83
Dubey <i>et al.</i> 2007 (17)	8 (15 bulbo- penile)	22.6	BM	Uroflowmetry Urethrography 3 wk, then as required Urethral calibration 16 F or urethroscopy 1, 3, 7, 10, & 16 mo, then annually	Recurrence of stricture	89.9 (includes bulbar)
Barbagli <i>et al.</i> 2008 (24)	93	36	OM	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 2/3 wk Urethrography & urethroscopy if Q <sub>max</sub> < 14 mL/s	Any instrumentation	91.4

#### **TABLE 1** Outcomes and follow-up of ventral onlay bulbar urethral reconstruction, Cont'd

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Barbagli <i>et al.</i> 2008 (81)	6	15.25	OM	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk, 6 & 12mo Cystourethrography & urethroscopy if O <sub>max</sub> < 14 mL/s	Any instrumentation	100
Dalela <i>et al.</i> 2010 (82)	13	16.4	BM	Uroflowmetry & PVR estimation Urethrography if $\Omega_{max} < 14 \text{ mL/s}$ Urethroscopy if $\Omega_{max} < 14 \text{ mL/s}$	Q <sub>max</sub> < 14mL/s	84.6

#### TABLE 2 Outcomes and follow-up of dorsal onlay bulbar urethral reconstruction

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Barbagli <i>et al.</i> 1996 (83)	20	46	FTS	Uroflowmetry 4, 8, & 12 mo Urethrography 2/3 wk & once more, or if Q <sub>max</sub> < 14 mL/s	Recurrence on urethrography	95
Barbagli <i>et al.</i> 1998 (84)	37	21.5 (13.5 BM)	31 PS 6 BM	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk, repeat if Q <sub>max</sub> < 14 mL/s	Any instrumentation	92 (100 BM)
Pansadoro <i>et al.</i> 1999 (64)	23	20	BM	Uroflowmetry Urethrography 2 wk, 6 & 12 mo, then annually	Stricture recurrence on urethrography	100
lselin <i>et al.</i> 1999 (85)	29	19	PS or BM	Urethrography 3 wk, 3, 12, & 18 mo	Radiographic evidence of recurrence	97
Barbagli <i>et al.</i> 2001 (86)	40	43	PS	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 2/3 wk, then 4 mo or if Q <sub>max</sub> < 14mL/s	Any instrumentation	85

#### TABLE 2 Outcomes and follow-up of dorsal onlay bulbar urethral reconstruction, Cont'd

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Andrich <i>et al.</i> 2001 (66)	42	48-60	BM	Uroflowmetry 3, 6, & 12 mo, then annually Urethrography 6 & 18 mo Urethroscopy in last 45 cases	Development of symptoms leading to urethrogram or urethroscopy to confirm recurrence	95
Joseph <i>et al.</i> 2002 (87)	14	32	BM or PAS	Uroflowmetry 12 & 18mo Urethrography 3 wk, 12 & 18 mo	Recurrence on urethrography	100
Pansadoro <i>et al.</i> 2003 (72)	56	41	BM	Uroflowmetry — periodic Urethrography 2 wk, 6 & 12 mo, then annually	Recurrence of symptoms	98
Dubey <i>et al.</i> 2003 (74)	16	22	BM	Uroflowmetry 6 mo (all patients performed ISD 16 F up to 6 mo) Urethrography 6, 12, & 18 mo, then as required	Need for urethral calibration/dilatation with/without DIVU after 18 mo	87
Andrich <i>et al.</i> 2003 (54)	51	6	BM or FTS	Uroflowmetry 6 wk, 3 & 6 mo Urethrography 6 mo	Restricturing on urethrography	98
Barbagli <i>et al.</i> 2004 (88)	45	71	PS	Uroflowmetry 3, 6, & 12 mo, then annually Urethrography 3 wk, then as required Urethroscopy if Q <sub>max</sub> < 14 mL/s	Any instrumentation	73
Berger <i>et al.</i> 2005 (77)	40	70.7	BM	Uroflowmetry 3, 6, & 12mo, then annually Urethrography 3 wk	Stream or symptoms deteriorate	95
Raber <i>et al.</i> 2005 (89)	30	51	17 PS 13 (BM)	Uroflowmetry 6, 12, & 18 mo with IPSS & IIEF scores Urethrography 3 wk, repeated as required Urethroscopy as required	O <sub>max</sub> < 20 mL/s Symptoms requiring intervention (DIVU or ISD)	76 (85)

#### TABLE 2 Outcomes and follow-up of dorsal onlay bulbar urethral reconstruction, Cont'd

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Dubey <i>et al.</i> 2005 (90)	41	36.2	BM	Uroflowmetry 3, 6, 9, & 12 mo with ongoing urethral calibration (16 F) Urethrography at 3 mo, then as required	Symptom recurrence or inability to pass 16 F catheter	90
Barbagli <i>et al.</i> 2005 (48)	27	42	BM	Uroflowmetry 3, 6, & 12 mo, then annually Urethrography 3 wk, then as required Urethroscopy if $\Omega_{max} < 14$ mL/s	Any instrumentation	85
Barbagli <i>et al.</i> 2006 (91)	6	16	BM	Uroflowmetry 6 & 12 mo, then annually Urethrography 2 wk, 6 & 12 mo, then annually	Any instrumentation	100
Donkov <i>et al.</i> 2006 (92)	9	18	SIS	Uroflowmetry 6 wk, 18 mo Urethroscopy 3 mo	Decreased flow rate or stricture recurrence	89
Simonato <i>et al.</i> 2006 (29)	8	18	LM	Uroflowmetry 3 & 12 mo Urethrography 2 wk, 3 & 12 mo Urethroscopy 3 & 12 mo	Q <sub>max</sub> < 15 mL/s Need for instrumentation	87.5
Xu <i>et al.</i> 2007 (93)	12	57	BM	Uroflowmetry 14–18 d, 3–6 mo (most patients) Urethrography 14–18 d Urethroscopy in some patients at 12 mo	Any complication	77 (includes tubularized BLM & CM grafts
Palminteri <i>et al.</i> 2007 (79)	3	21	SIS	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk & 12 mo or if $\Omega_{max} < 14 \text{ mL/s}$ Urethroscopy 3 & 12 mo	Abnormal voiding Any instrumentation Evidence of stricture on urethrography	100
Radopoulos <i>et al.</i> 2007 (94)	16	49.9	PS	Uroflowmetry 3/4 & 12 mo Urethrography 3/4 & 12 mo	Abnormal voiding Any instrumentation Evidence of stricture on urethrography	81

#### TABLE 2 Outcomes and follow-up of dorsal onlay bulbar urethral reconstruction, Cont'd

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Foinquinos <i>et al.</i> 2007 (95)	7	1—5	TV	Uroflowmetry & urethrography	Poor uroflowmetry Poor urethrography	100
Levine <i>et al.</i> 2007 (80)	21	53	BM	Urethrography 2 wk	Any instrumentation	86
Dubey <i>et al.</i> 2007 (17)	4	22.6	BM	Uroflowmetry Urethrography 3 wk, then as required Urethral calibration 16 F or urethroscopy 1, 3, 7, 10, & 16 mo, then annually	Recurrence of stricture	89.9 (includes penile)
Barbagli <i>et al.</i> 2008 (24)	22 38	41 111	OM PS	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 2/3 wk Urethrography & urethroscopy if Q <sub>max</sub> < 14 mL/s	Any instrumentation	77.3 65.8
Barbagli <i>et al.</i> 2008 (81)	6	15.25	OM	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk, 6 & 12 mo Urethrography & urethroscopy if Q <sub>max</sub> < 14 mL/s	Any instrumentation	100
O'Riordan <i>et al.</i> 2008 (96)	52	34	BM	Urethrography 3 wk Symptoms/interview	Any instrumentation	86
Simonato <i>et al.</i> 2008 (30)	11	17.7	LM	Uroflowmetry 3 & 12 mo Urethrography 2 wk, 3 & 12 mo Urethroscopy 3 & 12 mo	Inability to void, a post void residual Any instrumentation	81.8
Kulkarni <i>et al.</i> 2009 (97)	88	56	OM	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk Urethrography if Q <sub>max</sub> < 12 mL/s	Any instrumentation	91
Das <i>et al.</i> 2009 (31)	6	9	LM	Uroflowmetry 3 & 6 mo Urethrography 3 wk, 3 & 6 mo	O <sub>max</sub> < 15 mL/s Need for instrumentation	83.3 (includes penile)

#### **TABLE 2** Outcomes and follow-up of dorsal onlay bulbar urethral reconstruction, Cont'd

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Kulkarni <i>et al.</i> 2009 (49)	12	22	OM	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk Urethrography & urethroscopy if Q <sub>max</sub> < 14 mL/s	Any instrumentation	92
Manoj <i>et al.</i> 2009 (98)	8	21.7	PAS	Uroflowmetry 3 & 6 mo, annually in some patients Urethrography 3 wk, repeat if Q <sub>max</sub> < 14 mL/s	Any instrumentation	100
Fransis <i>et al.</i> 2009 (99)	30	23	BM	Uroflowmetry/PVRU 3 & 12 mo, then annually Urethrography 6 mo Urethroscopy when required	Abnormal voiding, stricture on urethrography, and need for instrumentation	94
Schwentner <i>et al.</i> 2010 (100)	42	57.2	29 PS 13 GS	Uroflowmetry/PVRU 3, 6, 9, & 12 mo Urethrography at catheter removal, then as required	Presence of symptoms and low flow rate	90.5
Arlen <i>et al.</i> 2010 (101)	22	10.5	BM	Urethrography 3/4 wk Urethroscopy if symptoms developed	Any instrumentation	83.3

#### **TABLE 3** Outcomes and follow-up of lateral onlay bulbar urethral reconstruction

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Barbagli <i>et al.</i> 2005 (48)	6	42	BM	Uroflowmetry 3, 6, & 12 mo, then annually Urethrography 3 wk, then as required Urethroscopy if Q <sub>max</sub> < 14 mL/s	Need for instrumentation	83
Barbagli <i>et al.</i> 2008 (24)	6 (same patients as above)	77	OM	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 2/3 wk, then as required Urethroscopy if Q <sub>max</sub> < 14 mL/s	Need for instrumentation	83

#### **TABLE 4** Outcomes and follow-up of one-stage penile urethral reconstruction

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Venn <i>et al.</i> 1998 (102)	28 patch 11 tube	36	BM	Regular uroflowmetry Urethrography 6 mo	Recurrence on urethrography	96.4 54.5
Andrich <i>et al.</i> 2001 (66)	41	24–60+	BM	Uroflowmetry 3, 6, & 12 mo, then annually Urethrography 6 & 18 mo Urethroscopy in last 45 cases	Development of symptoms leading to urethrogram or urethroscopy to confirm recurrence	100
Metro <i>et al.</i> 2001 (103)	14	63.6	BM	Uroflowmetry 6 & 12 mo with symptom score	Need for ISD > 6 mo	57.1
Andrich <i>et al.</i> 2003 (54)	20	6	BM or FTS	Uroflowmetry 6 wk, 3 & 6 mo Urethrography 6 mo	Restricturing	95
Fichtner <i>et al.</i> 2004 (75)	17	82.8	BM	Uroflowmetry 6 & 12 mo with symptom score & PVRU estimation Urethrography 3 wk	Symptomatic recurrence	88.2
Dubey <i>et al.</i> 2005 (90)	16	36.2	BM	Uroflowmetry 3, 6, 9, & 12 mo with ongoing urethral calibration (16 F) Urethrography 3 mo, then as required	Symptom recurrence or inability to pass 16 F catheter	85.7
Dubey <i>et al.</i> 2005 (104)	25	32.5	BM	Uroflowmetry 3, 6, 9, & 12 mo, then every 6 mo with ongoing urethral calibration (16 F) Urethrography 3 wk	Symptomatic recurrence	88
Kellner <i>et al.</i> 2004 (76)	5	50	BM	Uroflowmetry 3, 6, & 12 mo, then annually Urethrography 3 wk, then as required	Abnormal voiding Need for intervention	87 (includes 18 bulbar)
Palminteri <i>et al.</i> 2007 (79)	1 3 bulbo- penile	21	SIS	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk & 12 mo or if Q <sub>max</sub> < 14 mL/s Urethroscopy 3 & 12 mo	Abnormal voiding Any instrumentation Evidence of stricture on urethrography	0 33 bulbopenile

#### **TABLE 4** Outcomes and follow-up of one-stage penile urethral reconstruction, Cont'd

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Fiala <i>et al.</i> 2007 (38)	9 31 bulbo- penile	31.2	SIS	Urethrography 3, 6, 9, 12, & 18 mo, then annually Urethrography if Q <sub>max</sub> < 15 mL/s or IPSS > 7	Stricture on urethrography	55.5 84 bulbopenile
Radopoulos <i>et al.</i> 2007 (94)	5	49.9	PS	Urethrography & flow rate 3/4 mo & 12 mo	Abnormal voiding Any instrumentation Evidence of stricture on urethrography	30
Foinquinos <i>et al.</i> 2007 (95)	4	1–5	TV	Uroflowmetry & urethrography	Poor uroflowmetry Poor urethrography	100
Levine <i>et al.</i> 2007 (80)	13	45	BM	Urethrography 2 wk	Any instrumentation	70 ventral onlay 66 dorsal onlay
Barbagli <i>et al.</i> 2008 (105)	45	55	PS 23 (OM 22)	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 2 wk Urethrography, ultrasonography, & urethroscopy if Q <sub>max</sub> < 14 mL/s	Any instrumentation	78 (82)
Kumar <i>et al.</i> 2008 (106)	41	18	TA	Urethrography — no description of timing	Poor calibre at urethrogram Poor urethral lumen at urethrosonogram Patient unsatisfied and dilatation required Q <sub>max</sub> < 20 mL/s	67
Simonato <i>et al.</i> 2008 (30)	8 penile 5 bulbo- penile	17.7	LM	Uroflowmetry 3 & 12 mo Urethrography 2 wk, 3 & 12 mo Urethroscopy 3 & 12 mo	Inability to void, a post-void residual Any instrumentation	100 penile 60 bulbopenile
Kulkarni <i>et al.</i> 2009 (97)	8	56	OM	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk Urethrography if Q <sub>max</sub> < 12 mL/s	Any instrumentation	100

#### **TABLE 4** Outcomes and follow-up of one-stage penile urethral reconstruction, Cont'd

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Das <i>et al.</i> 2009 (31)	6	9	LM	Uroflowmetry 3 & 6 mo Urethrography 3 wk, 3 & 6 mo	Q <sub>max</sub> < 15 mL/s Any instrumentation	83.3 (includes bulbar)
Singh <i>et al.</i> 2009 (107)	8	19	BM	Uroflowmetry, urethrography, & urethroscopy – no description of timing	Q <sub>max</sub> < 15 mL/s Abnormal urethrogram or urethroscopy Need for any intervention	88 (includes 8 panurethral)
Manoj <i>et al.</i> 2009 (98)	12	21.7	PAS	Uroflowmetry 3 & 6 mo, annually in some patients Urethrography 3 wk, repeat if Q <sub>max</sub> < 14 mL/s	Any instrumentation	92
Xu <i>et al.</i> 2010 (108)	56	17.2	LM	Uroflowmetry 2 or 3 mo, then 6 mo Urethrography if $\Omega_{max} < 15$ mL/s Urethroscopy if $\Omega_{max} < 15$ mL/s	Not described	87 (includes bulbar cases)

### **TABLE 5** Outcomes and follow-up of penile urethral reconstruction via the two-stage technique

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Venn <i>et al.</i> 1998 (109)	16	36	BM	Not described	Not described	93.8
Andrich <i>et al.</i> 2003 (54)	58	6	BM or FTS	Uroflowmetry 6 wk, 3 & 6 mo Urethrography 6 mo	Restricturing	98
Dubey <i>et al.</i> 2005 (90)	15	24.2	BM	Uroflowmetry 3, 6, 9, & 12 mo with ongoing urethral calibration (16 F) Urethrography 3 mo, then as required	Symptom recurrence or inability to pass 16 F catheter	86.7
Dubey <i>et al.</i> 2005 (104)	14	32.5	BM	Uroflowmetry 3, 6, 9, & 12 mo, then every 6 mo with ongoing urethral calibration (16 F) Urethrography 3 wk	Symptomatic recurrence	78.6
Levine <i>et al.</i> 2007 (80)	5	36	BM	Urethrography 2/3 wk	Any instrumentation	80
Meeks <i>et al.</i> 2008 (110)	6	17	FTS	Not described	Failure of graft to take	100
Kulkarni <i>et al.</i> 2009 (97)	15	56	0M	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk Urethrography if Q <sub>max</sub> < 12 mL/s	Any instrumentation	73

#### **TABLE 6** Outcomes and follow-up of panurethral urethral reconstruction

Authors	No. Treated	No. of stages	Follow- Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Andrich <i>et al.</i> 2003 (54)	24	2	6	BM or FTS	Uroflowmetry 6 wk, 3 & 6 mo Urethrography 6 mo	Restricturing	91.7
Gupta <i>et al.</i> 2004 (111)	4 8 bulbo- penile	1	12	BM	Uroflowmetry 3 mo Urethrography 3 wk Urethroscopy 3 mo	Q <sub>max</sub> < 15 mL/s Reduced-calibre urethra	92
Dubey <i>et al.</i> 2005 (90)	12	1	36.2	BM	Uroflowmetry 3, 6, 9, & 12 mo with ongoing urethral calibration (16 F) Urethrography 3 mo, then as required	Symptom recurrence or inability to pass 16 F catheter	83.3
Singh <i>et al.</i> 2009 (107)	8	1	19	BM	Uroflowmetry, urethrography, urethroscopy — no description of timing	Q <sub>max</sub> < 15 mL/s Abnormal urethrogram/ urethroscopy Any intervention	88 (includes 8 penile)
Xu <i>et al.</i> 2009 (21)	36	1	53.6	СМ	Uroflowmetry 3 or 4 mo Urethrography at catheter removal Most patients uroflowmetry & urethrography every 3 to 6 mo or if Q <sub>max</sub> < 15 mL/s	Abnormal voiding Any intervention	85.7
Manoj <i>et al.</i> 2009 (98)	15	1	21.7	PAS	Uroflowmetry 3 & 6 mo, annually in some patients Urethrography 3 wk, repeat if Q <sub>max</sub> < 14 mL/s	Any instrumentation	80
Kulkarni <i>et al.</i> 2009 (49)	12	1	22	OM	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk Urethrography/ urethroscopy if Q <sub>max</sub> < 14 mL/s	Any instrumentation	92
Xu <i>et al.</i> 2009 (112)	25	1	26.8	9 BM x 2 7 LM x 2 9 LM + BM	Uroflowmetry Urethrography if problems	Any instrumentation	92

TABLE 6	Outcomes	and follow-	up of par	nurethral	urethral	reconstruction,	Cont'd
---------	----------	-------------	-----------	-----------	----------	-----------------	--------

Authors	No. Treated	No. of stages	Follow- Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Das <i>et al.</i> 2009 (31)	18	1	9	LM	Uroflowmetry 3 & 6 mo Urethrography 3 wk, 3 & 6 mo	Q <sub>max</sub> < 15 mL/s Any instrumentation	83.3 (includes bulbar)
Mathur <i>et al.</i> 2010 (113)	86	1	36	TA	Uroflowmetry & patient satisfaction 6, 12, 24, & 36 mo Urethrography 6, 12, 24, & 36 mo Urethroscopy in 10 patients	Good calibre or partially narrowed urethra (urethrography), $Q_{max} < 20 \text{ mL/s}$ , requiring > 1 dilatation/year	89.5

#### TABLE 7 Outcomes and follow-up of urethral reconstruction via the Asopa technique

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Asopa <i>et al.</i> 2001 (51)	12	8–40	10 PS 2 BM	Uroflowmetry at last follow-up Urethrography 7 wk Urethroscopy in 4 cases	Any instrumentation	91.7
Palminteri <i>et al.</i> 2007 (79)	7	21	SIS	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk & 12 mo or if Q <sub>max</sub> < 14 mL/s Urethroscopy 3 & 12 mo	Abnormal voiding Any instrumentation Evidence of stricture on urethrography	100
Singh <i>et al.</i> 2008 (114)	25	12	LM	Uroflowmetry 3, 6, & 12 mo Urethrography 3 wk, 3, 6, & 12 mo	Qmax < 15 mL/s, abnormal urethrogram or urethroscopy, any intervention	80
Pisipati <i>et al.</i> 2009 (52)	45	42	BM	Uroflowmetry 3 & 6 mo, then every 6 mo Urethrography 3 wk Urethroscopy 3 mo	Q <sub>max</sub> <15 mL/s	87

Authors	No. Treated	Follow-Up (mo)	Type of Graft	Follow-Up Method	Definition of Failure	Success Rate (%)
Palminteri <i>et al.</i> 2007 (79)	5	21	SIS	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk & 12 mo or if O <sub>max</sub> < 14mL/s Urethroscopy 3 & 12 mo	Abnormal voiding Any instrumentation Evidence of stricture on urethrography	100
Palminteri <i>et al.</i> 2008 (53)	48	22	BM	Uroflowmetry 4, 8, & 12 mo, then annually Urethrography 3 wk Urethrography & urethroscopy if Q <sub>max</sub> < 14 mL/s	Abnormal voiding Need for instrumentation	89.6



# Pelvic Fracture Urethral Injuries (PFUI)

#### CHAIRS

Reynaldo G. Gómez, Chile Tony Mundy, United Kingdom

#### MEMBERS

Deepak Dubai, India Abdel Wahab El-Kassaby, Egypt Firdaoessaleh, Indonesia Ron Kodama, Canada Richard Santucci, United States

# CONTENTS

### Pelvic Fracture Urethral Injuries (PFUI)

7.1	Introduction	149
7.2	Methods	149
7.3	Anatomy of the Male Urethra	150
	7.3.1 Anatomy of the posterior urethra	151
	7.3.2 Urinary continence and sphincteric mechanism	152
7.4	Mechanism of Posterior Urethral Injury	154
	7.4.1 Pelvic fracture pattern	154
	7.4.2 Mechanism of urethral injury	155
7.5	Classification	157
	7.5.1 Anatomical radiological classification	157
	7.5.2 Extended anatomical classification	157
	7.5.3 American Association for the Surgery of Trauma Classification	158
	7.5.4 Anatomical and Functional Classification	159
7.6	Clinical Presentation, Diagnosis, and Imaging:	
	Associated Injuries	162

	164	
	164	
ny and		

	7.7.1	Early catheter realignment	164
	7.7.2	Suprapubic catheter cystostomy and delayed reconstruction	172
7.8	Urethral S	Stenosis/Obliteration: Reconstructive	
	Options a	nd Their Outcomes	173
	7.8.1	Operative procedure: bulbomembranous anastomotic urethroplasty	173
	7.8.2	Staging investigations to predict the type of surgery required.	174
	7.8.3	Inferior pubectomy	175
	7.8.4	The role of supracrural rerouting in bulbomembranous anastomotic urethroplasty	175
	7.8.5	Outcomes of primary bulbomembranous anastomotic urethroplasty for pelvic fracture urethral injury	175
	7.8.6	Reconstructive options for failed bulbomembranous anastomotic urethroplasty	176
	7.8.7	Outcomes of re-do urethroplasty for pelvic fracture urethral injury	176

7.7 Acute Management\_\_\_

7

7.9	Complex Scenarios and Complications of Pelvic Fracture Urethral Injury: Erectile Dysfunction, Incontinence, and Fistula		176
	7.9.1	Erectile dysfunction	177
	7.9.2		180
	7.9.3	Fistula	184
7.10	Recomm	endations	186
	7.10.1	Anatomy, mechanisms of injury, and classification	186
	7.10.2	Clinical presentation, diagnosis, imaging: associated injuries	186
	7.10.3	Acute management	187
	7.10.4	Urethral stenosis/obliteration: reconstructive options and	
		their outcomes	188
	7.10.5	Complex scenarios and complications	189
	7.10.6	Future research	189
711	Referenc	es	190

### 7.1 Introduction

Posterior urethral injuries are most frequently associated with traffic accidents, but they may also occur after a fall from a height or severe compression to the pelvic area. The urethral injury may be isolated or may be associated with injuries to other organs, most commonly with pelvic trauma and fractures of the bony pelvis. Urethral injury may also accompany injury to internal organs, such as the bladder or rectum, and the vagina in females. Posterior urethral injury complicates pelvic fracture in 2%–25% of patients (Level 3) (1–5).

The presence of physical signs is variable and directly related to the elapsed time after the injury (1). Prompt recognition and appropriate management of these injuries is essential, since it may significantly impact subsequent morbidity. Comprehensive and immediate treatment of accompanying visceral injury is also mandatory.

Urethral injuries are rarely life-threatening in the acute stage. However, they can result in very significant delayed morbidity. Strictures, incontinence, and erectile dysfunction (ED) are well-recognized associated problems that can cause life-long disability. The severity and duration of such complications can be reduced if urethral injury is efficiently diagnosed and appropriately treated.

Injuries to the posterior urethra associated with a pelvic fracture have been traditionally known as pelvic fracture urethral distraction defects (PFUDD). This term was introduced by Turner-Warwick (6) with the assumption that the vast majority of these injuries were complete injuries. However, current evidence now shows that a large percentage are actually partial injuries, and even complete ruptures do not always present as a separation of the urethral ends; therefore, this term is inadequate, since in many cases there is neither distraction nor defect. For this reason, use of the PFUDD acronym should be discontinued and replaced by PFUI (pelvic fracture urethral injury).

### 7.2 Methods

An online literature search was performed using the key words: *pelvic fracture urethral distraction defect, posterior urethral distraction defect, posterior urethral distraction defect, posterior urethral distraction defect, posterior urethral defect, membranous urethral injury, urethra and pelvic fracture, PFUDD, posterior urethroplasty, anastomotic urethroplasty, anastomotic reconstruction, and urethral realignment.* A total of 270 articles were found, dated up to March 30, 2010. Publications pertaining to PFUI in females and children were excluded. Relevant articles were reviewed and summarized. Some textbook chapters were also included where appropriate. The search included publications from the past 20 years, as well as some especially significant papers dating as far back as 1912.

The levels of evidence were rated according to the guidelines of the Oxford Centre for Evidence-Based Medicine (**Table 1**).

Level	Type of Evidence
1a	Evidence obtained from meta-analysis of randomized trials
1b	Evidence obtained from at least one randomized trial
2a	Evidence obtained from one well-designed controlled study without randomization
2b	Evidence obtained from at least one other type of well-designed quasi-experimental study
3	Evidence obtained from well-designed non-experimental studies, such as comparative studies, correlation studies, and case reports
4	Evidence obtained from expert committee reports or opinions or clinical experience of respected authorities

#### TABLE 1 Summary of Levels of Evidence

For the grading of recommendations, the ICUD modified system was used: a grade A recommendation means "highly recommended," usually based on strong evidence (level 1a or 1b), but a grade A recommendation can also be established if there is consensus, even if the studies to provide such strong evidence are missing. In this review, there were no level 1 studies and very few level 2 studies. A grade B recommendation means "probably recommended." Grade C means "optional" and grade D means "no recommendation possible." However, the recommendation must be read in context, so a grade A recommendation can also mean "definitely must not do."

The evidence in the literature was discussed in October 2010 at an ICUD meeting on the occasion of the Société Internationale d'Urologie (SIU) Congress in Marrakech, Morocco. Recommendations were formulated by the PFUI subcommittee (consisting of the authors of this chapter) and discussed by the full ICUD faculty. This chapter provides a summary of the evidence and recommendations, followed by a review of the literature with critical analysis of the levels of evidence used to determine the various grades of recommendation.

### 7.3 Anatomy of the Male Urethra

Anatomists subdivide the urethra as described in *Terminologica Anatomica* (Federative Committee on Anatomical Terminology, 1998) (7). From a urological point of view, the urethra is divided into several segments with different pathophysiological, clinical, and surgical considerations (8).

The adult male urethra is a tubular conduit, approximately 18–20 cm long, extending from the bladder neck to the external opening, or meatus, at the tip of the penis (Level 4) (9,10). At the level of the perineal membrane, it is divided into two parts: the posterior urethra and the anterior urethra (**Figure 1**).

- The relatively short **posterior urethra** (about 4 cm) lies inside the pelvis proximal to the corpus spongiosum and is part of the urogenital sphincter mechanism. It may be further divided into three smaller segments (the pre-prostatic, prostatic, and membranous urethra), which will be described in detail later in this chapter (Level 4) (10,11).
- The relatively long **anterior urethra** (about 16 cm) is completely surrounded by the corpus spongiosum. It lies proximally in the perineum and distally in the penis. It is further divided into three segments (10):
  - The **bulbar urethra** is the proximal component, surrounded by the bulbospongiosus and entirely located within the perineum.
  - The **penile urethra** continues inside the corpus spongiosum, extending from the penoscrotal junction to the glans penis.
- The **fossa navicularis** is an expansion of the most distal segment of the urethra; it lies inside the glans and ends at the external meatus.



#### FIGURE 1

Anatomy of the male urethra

#### 7.3.1 Anatomy of the posterior urethra

The posterior urethra begins at the level of the bladder neck (BN), extends as a channel through the prostate, and continues, piercing the perineal diaphragm to end at the proximal bulbospongiosus, where it becomes the anterior urethra.

The first part of the posterior urethra is the pre-prostatic urethra, which is about 1 cm in length, extending from the bladder base to the prostate gland. Peri-urethral glands, which may contribute to benign prostatic hyperplasia, can be found in this zone. The main part of the pre-prostatic (or internal sphincter) mechanism, also known as the lissosphincter, is located here as well (10,12).
The prostatic urethra is about 3–4 cm in length and runs inside the prostate, continuous proximally with the pre-prostatic urethra and emerging distally at the anterior-inferior point of the gland, where it becomes the membranous urethra. As it passes through the prostatic substance, the urethra turns anteriorly at an angle of about 35°, lying closer to the anterior than the posterior part of the gland. The urethral crest is a midline ridge in the posterior wall of the prostatic urethra that indents the lumen, making it appear crescent-shaped in transverse section. On each side of this ridge there is a shallow depression, the prostatic sinus, whose floor receives the openings of some 15–20 prostatic ducts (10). The verumontanum (or colliculus seminalis) is a 0.5 cm long elevation located at about the mid-part of the urethral crest, and contains the slit-like orifice of the prostatic utricle. The paired ejaculatory ducts empty into the prostatic urethra at this level (11). Striated muscle fibres can be found distal to the verumontanum; they increase towards the prostatic apex but never form a true sphincter at this level. The most distal part of the prostatic urethra is immobile and closely adherent to the posterior aspect of the anterior pubic arch, to which it is fixed by the paired puboprostatic ligaments (10).

The membranous urethra extends between the prostatic apex and the proximal corpus spongiosum. The membranous urethra is the only segment of the urethra that is unprotected by surrounding spongy tissue or prostatic parenchyma, making it more susceptible to external trauma (13). The membranous urethra is the shortest (about 1.5 cm) and least distensible section of the urethra. It courses from the prostate to the bulb of the penis, piercing the perineal membrane about 2.5 cm postero-inferior to the symphysis pubis. The wall of the membranous urethra consists of an epithelial lining and a muscle coat separated by a layer of fibroelastic connective tissue. The muscle coat includes a relatively thin inner layer of smooth muscle bundles, which are proximally continuous with those of the prostatic urethra, and a prominent outer layer of circularly oriented striated skeletal muscle bundles, which form the striated or external urethral sphincter. This sphincter is also known as the intrinsic rhabdosphincter. The bulbourethral glands are located inside this muscle and drain into the membranous urethra during sexual arousal (10).

# 7.3.2 Urinary continence and sphincteric mechanism

Urinary continence is under the control of the urethral sphincter complex, which has two components: an internal lissosphincter composed mainly of smooth muscle and an external rhabdosphincter composed mainly of skeletal muscle. The urethral sphincter complex extends around the urethra from the internal bladder orifice to the perineal membrane. While the lissosphincter has its main part at the vesical orifice and is thinner distally along the urethra, the rhabdosphincter is most marked around the membranous urethra and becomes gradually less distinct proximally towards the bladder (15). In cross-sectional reconstructions, the trigone and anterior fibromuscular stroma of the prostate appear as a single unit in continuity, which may contribute to the continence mechanism at the BN. Behind the prostatic urethra is a layer of transversely arranged smooth muscle, which is thickest above and in front of the ejaculatory ducts. This muscle is continuous with the anterior longitudinal layer of the bladder, with the transverse muscle of the trigone, and with the stroma of the prostate. Although not a true sphincter, it is thought that it may act as one (12). The striated urethral sphincter appears circular, with abundant tissue posteriorly, and is longer anteriorly than posteriorly (14). The lissosphincter is primarily related to the function of continence at rest, whereas the rhabdosphincter has a dual function: active continence during straining and semen propulsion during ejaculation (15). While each sphincteric unit may independently maintain passive continence, once its confrere has been injured, the striated component may only assist with active continence (e.g., interruption of voiding) (9).

The lissosphincter is composed of smooth muscle fibres, which provide passive continence via tonic sympathetic activity (13). In addition to the smooth muscle bundles that run in continuity from the BN down to the prostatic urethra, and distinct from the smooth muscle within the prostate, these smooth muscle bundles surround the BN and pre-prostatic urethra arranged as a circular collar (16), which has its own distinct adrenergic innervation (17). The bundles that form this lissosphincter are small compared with the smooth muscle bundles of the detrusor and are separated by a relatively larger connective tissue component, rich in elastic fibres. Unlike the detrusor and the rest of the urethral smooth muscle, the internal sphincter is almost totally devoid of parasympathetic cholinergic nerves but is richly supplied with sympathetic noradrenergic nerves (17). Contraction of this sphincter serves to prevent the retrograde flow of ejaculate through the proximal urethra into the bladder, and can maintain continence when the external sphincter has been damaged, such as after PFUI. This internal sphincter is extensively disrupted in the majority of men undergoing BN surgery (for example, trans-urethral resection of the prostate), which results in retrograde ejaculation (10).

The rhabdosphincter mechanism is a combined voluntary and involuntary unit (13). Continence is the result of the joint action of the radial folds of urethral mucosa, the submucosal connective tissue, the intrinsic urethral smooth muscle, the urethral striated muscle (which is the most important component), and the pubo-urethral part of the levator ani muscle, which is essential in resisting surges of intra-abdominal pressure (coughing or exercise). The external sphincter represents the point of highest intra-urethral pressure in the normal contracted state and is typically about 2 cm long and about 3–5 mm thick. The intrinsic striated muscle fibres are devoid of muscle spindles and in cross section, they are unusually small (15–20  $\mu$ m in diameter). Physiologically they belong to the slow twitch type, unlike the pelvic floor musculature, which is a heterogeneous mix of slow and fast twitch fibres of larger diameter. The slow twitch fibres of the external sphincter are capable of sustained contraction over relatively long periods of time and actively contribute to the tone, which closes the urethra and maintains urinary continence (10).

The external urethral sphincter covers the ventral side of the prostate. Distally, at the level of the membranous urethra, the urogenital diaphragm does not completely encircle the membranous urethra, but rather forms an incomplete horseshoe-shaped sling that offers posterior and lateral support (13). Supporting this distal sphincter mechanism is an extrinsic peri-urethral striated muscle composed of the pubo-urethral part of the levator ani muscle, which is under voluntary control. Anatomical studies have shown that the rhabdosphincter is separated from the anterior and lateral aspects of the membranous urethra by a delicate ventral connective tissue sheath. Meticulous surgical dissection of this sheath in the anterior midline allows for separation of the muscle and the urethral wall without damage to either structure, an approach that can be very useful for reconstructive surgery at the membranous urethra level (Level 2) (18).

# 7.4 Mechanism of Posterior Urethral Injury

The urethra is vulnerable to pelvic fracture injuries due to its close relationship with the bones of the pubic arch and because of its attachments to the puboprostatic ligaments and perineal membrane. In men, the external portion is also susceptible to direct trauma from bone fragments arising from the pubic rami. The distal membranous urethra is especially at risk, and its injury may disrupt the active continence mechanism.

PFUIs have been classically described as prostatomembranous disruption injuries (1,19–22). However, in recent times it has been realized that in most cases they occur distal to the external urethral sphincter at the bulbomembranous junction (Level 2) (23) (Level 3) (5,24–26).

Pre-operative identification of the actual site of injury is very important, but sometimes emergency retrograde urethrography (RUG) cannot clearly differentiate between suprasphincteric and infrasphincteric injury. This is because some patients may fail to pass the contrast to the proximal part during emergency imaging or due to inadvertent excessive peri-urethral extravasation of contrast. For this reason, in many cases this identification can only be done intra-operatively during dissection of the proximal urethral end. Sometimes the location of the actual site is only established during the post-operative urethrogram by noticing the site of the anastomosis. In most cases, this is distal to the external urethral sphincter.

# 7.4.1 **Pelvic fracture pattern**

Pelvic fractures are typically classified by mechanism of injury and patterns of stability. The most widely used classification is Tile's classification. This divides the fracture according to the compromise of the pelvic ring and degrees of instability: Type A fractures are pelvic ring fractures that are stable. Type B fractures are rotationally unstable but vertically stable, and include anteroposterior compression (open-book) and lateral compression fractures. Type C fractures are rotationally and vertically unstable, and include Malgaigne's fracture (5,27).

Some studies have reported a correlation with the likelihood of rectal and lower urinary tract injuries. Aihara and colleagues retrospectively reviewed 362 pelvic fractures and found that a widened symphysis was predictive of rectal injury, a widened symphysis and sacroiliac joint involvement was predictive of bladder injury, and a widened symphysis plus fracture of the inferior pubic ramus was predictive of urethral injury (**Table 2**). Although these associations were statistically significant, the overall prevalence of rectal and urologic injuries was low. Therefore, the predictive values of these radiologic findings were also low, being only 5% for urethral, 9% for rectal, and 20% for bladder injuries (Level 3) (28).

# **TABLE 2** Relative risk (RR) for rectal or lower urinary tract injury relative to pelvic fracture pattern

	Rectum	Bladder	Urethra
Symphysis pubis	RR = 3.3, <i>p</i> < 0.001	RR = 2.1, <i>p</i> < 0.001	RR = 2.9, <i>p</i> = 0.003
Sacroiliac joint	RR = 2.1, <i>p</i> = 0.014	RR = 2.0, <i>p</i> < 0.001	RR = 1.8, <i>p</i> = 0.04
Sacrum	_	RR = 1.6, <i>p</i> = 0.002	RR = 4.6, <i>p</i> = 0.008

Another study revealed that the highest risk of urethral injury was found in cases with straddle fracture when combined with diastasis of the sacroiliac joint (24 times more than the rest of pelvic fractures); this was followed by straddle fracture alone (3.85 times) and Malgaigne's fracture (3.4 times). Urethral injury was consistently associated with pubic arch fractures. Involvement of the posterior pelvic arch, with fractures of the anterior arch, considerably increased the risk of urethral injury. The risk was also greater with an increase in the number of broken rami. Stretching of the membranous urethra usually precedes its rupture, which characteristically occurs at the bulbomembranous junction (Level 3) (24).

Beyond the pelvic fracture pattern itself, which is important for urethral injuries, is the disruption of the pelvic ring, leading to an unstable pelvis, either rotationally, vertically, or both (Tile B and C). Stable pelvic fractures (Tile A) are almost never associated with PFUI.

### 7.4.2 Mechanism of urethral injury

Despite these correlations, the pelvic fracture pattern alone does not predict the presence of a lower urinary tract injury. Disruption of the pelvic ring generates strong shearing forces that may damage nearby structures. When this occurs, the type of lower urinary tract injury appears to be related to the fracture mechanism and to the pattern of injury to the soft tissues and supporting attachments (puboprostatic ligaments and perineal membrane) that surround the posterior urethra (5). Displacement of the anterior pubic arch may apply traction to the urethra through its connecting ligaments. This traction will not occur if these ligaments rupture at the time of injury. The exact pattern of ligament behaviour depends on the applied force's vector. Following this principle, Andrich *et al.* correlated five possible urethral injury mechanisms (avulsion, anterior tear, crush, laceration, and disruption/distraction) with the fracture mechanism according to Tile's classification (Level 3) (5). Urethral injury can also occur by direct switchblade laceration by pelvic bone fragments.

In children, the injury is usually at the BN and through the prostatic urethra (**Figure 2**). This is because children lack a well-developed prostate to support the posterior urethra. Unlike BN injuries in adults, which tend to be longitudinal, pediatric BN tears are most frequently transverse (Level 3) (29). These BN distraction injuries should be explored abdominally and repaired by direct anastomosis of the distracted bladder to the base of the prostatic urethra (Level 4) (24).

**FIGURE 2** Male patient, 6 years old, road traffic accident with resultant BN distraction injury.

**A** Retrograde urethrogram



**B** Antegrade cystogram



C Combined antegrade and retrograde urethrocystogram



# 7.5 Classification

Having a useful classification is important to guide clinical and surgical management decisions and to evaluate the outcomes of different treatment modalities. An ideal classification should include all possible injuries, but also needs to be practical, easily remembered, and useful as a clinical and research tool.

Several classifications have been proposed for PFUI, following anatomical, radiological, mechanistic, and functional criteria (Level 3) (20,30–32), (Level 4) (33) However, none of them has obtained wide-spread acceptance, perhaps because some are not comprehensive and others are not clinically useful.

### 7.5.1 Anatomical radiological classification

Colapinto and McCallum proposed an anatomic classification based on the patterns of contrast extravasation on RUG (Level 3) (20):

- **Type 1:** The urethra is stretched because of rupture of the puboprostatic ligaments and hematoma surrounds the urethra. Although stretched, the urethra is not severed.
- **Type 2:** Partial or complete rupture of the membranous urethra above the urogenital diaphragm or perineal membrane. On urethrography, contrast material is seen extravasating exclusively above the perineal membrane into the pelvis.
- **Type 3:** Partial or complete rupture of the membranous urethra with disruption of the urogenital diaphragm. Injury may extend to the proximal bulbar urethra. Contrast extravasates into both the pelvis and the perineum.

This classification does not include injuries to the BN and prostatic urethra, which are important because they may compromise the internal sphincter mechanism. Another criticism is that the type 3 injury may involve the proximal bulbar urethra, which is part of the anterior urethra (Level 3) (31). Type 3 injuries are the most common (about 85% of cases), while types 1 and 2 together account for only 15% of cases (Level 3) (30,31), (Level 4) (9). In fact, there were no type 2 injuries in the original series of Colapinto and McCallum and this type was included only because it was the classically described injury. Another limitation is that this classification groups partial and complete injuries into the same category; but these injuries may have a totally different treatment and prognosis.

# 7.5.2 **Extended anatomical classification**

Goldman and colleagues proposed an extended, anatomically based classification of blunt urethral injuries, not necessarily restricted to PFUI. In addition to the Colapinto and McCallum categories, this classification includes blunt injuries to the BN and prostatic urethra, and also to the anterior urethra (Level 3) (31) (**Table 3**).

Injury Type	Injury Description	Urethrographic Appearance
I	Stretching or elongation of the otherwise intact posterior urethra	Intact but stretched urethra
II	Urethral disruption above the urogenital diaphragm while the membranous segment remains intact	Contrast agent extravasation above the urogenital diaphragm only
111	Disruption of the membranous urethra, extending below the urogenital diaphragm and involving the anterior urethra	Contrast agent extravasation below the urogenital diaphragm, possibly extending to the pelvis or perineum; intact bladder neck
IV	Bladder neck injury extending into the proximal urethra	Extraperitoneal contrast agent extravasation; bladder neck disruption
IVa	Bladder base injury simulating a type IV injury	Peri-urethral contrast agent extravasation; bladder base disruption
V	Isolated anterior urethral injury	Contrast agent extravasation below the urogenital diaphragm, confined to the anterior urethra

#### **TABLE 3** Goldman, Sandler, and Corriere classification (Goldman et al., 1997)

Injury types I to III equal Colapinto and McCallum's types 1 to 3, respectively; type IVa is not really a urethral injury and type V results most frequently from straddle injuries, not necessarily associated with a pelvic fracture. Again, this classification includes partial and complete ruptures in the same category.

# 7.5.3 **American Association for the Surgery of Trauma Classification**

The American Association for the Surgery of Trauma (AAST) included a classification of PFUI as part of the Organ Injury Scale definition. Unlike the previous proposals, this classification focuses on the degree of injury suffered by the urethra itself, concentrated more on the degree of disruption and urethral separation than on the anatomical location of the injury (Level 4) (33) (**Table 4**).

Injury Typ	pe Injury Description	Urethrographic Appearance	Treatment
1	Contusion	Normal	None
2	Stretch injury	Elongation of the urethra without extravasation	Conservative management with suprapubic or urethral catheterization
3	Partial disruption	Extravasation of contrast agent from the urethra with opacification of the bladder	Conservative management with suprapubic or urethral catheterization
4	Complete disruption	Extravasation of contrast agent from the urethra without opacification of the bladder and with urethral separation of < 2 cm	Endoscopic realignment or delayed graft urethroplasty
5	Complete disruption	Complete transection with urethral separation of > 2 cm or extension of injury into the prostate or vagina	Endoscopic realignment or delayed graft urethroplasty

#### **TABLE 4** AAST classification of urethral injury (Moore *et al.*, 1995)

An injury to part of the circumference of the urethra without laceration is a contusion. A complete rupture of part of the circumference of the urethra is a partial injury, and a rupture of the complete circumference of the urethra without any continuity between the two ends is a complete injury (Level 2) (4). Unfortunately, differentiation between a partial and a complete rupture may be difficult and urethrography may be equivocal, since extravasation without filling of the prostatic urethra or bladder does not necessarily imply a complete rupture. This explains the wide variation in the reported incidence of partial vs. total injuries (Level 3) (34). Complete disruptions range from 6% in one series (Level 4) (35) to 97% in another (Level 3) (36). In the Ennemoser *et al.* series, the incidence of partial and complete injuries was 59% and 41%, respectively (Level 3) (34) Webster *et al.* summarized several series and found an average of 65% for complete disruptions vs. 34% for partial tears (Level 2) (37).

### 7.5.4 Anatomical and functional classification

More recently, Al Rifaei *et al.* proposed another classification incorporating anatomical and functional criteria (Level 3) (32). This classification also retained elements of previous classifications, but added subcategories for proximal prostatic injuries and attempted to distinguish injuries based on evaluation of the sphincteric mechanism:

- **Type 1**: Prostatic injury; 1a: proximal avulsion of the prostate; 1b: partial or complete trans-prostatic rupture.
- **Type 2**: Stretching of the membranous urethra (Colapinto and McCallum type 1).
- **Type 3**: Incomplete or complete supradiaphragmatic rupture of the prostatomembranous urethra (Colapinto and McCallum type 2).

- **Type 4**: Incomplete or complete infradiaphragmatic rupture of the prostatomembranous urethra (Colapinto and McCallum type 3).
- **Type 5**: Variable combined urethral injuries affecting more than one level; injury to the proximal sphincteric mechanism (BN) combined with prostatic and/or membranous urethral injury.

This classification has several drawbacks, because it also combines partial and complete injuries, includes injuries of the BN in type 1a but also in type 5, and considers as separate categories proximal avulsion of the prostate and trans-prostatic ruptures, which really does not make much sense. Moreover, it combines adult and pediatric injuries, which may be confusing, since children have important anatomic differences from adults (Level 3) (38–40).

**Table 5** shows a comparison of the different classifications of PFUI. Although the Colapinto and AAST grading are the most commonly used, none of them has found universal acceptance. An ideal classification should include all possible injuries, categorizing them under a comprehensive but simple and practical system. Since none of the existent classifications has been successful, a simplified and useful proposal to be validated could be:

- **Type 1**: Contusion a partial injury to part of the circumference of the urethra.
- **Type 3:** Complete injury complete rupture of the complete circumference of the urethra.
- **Type 2:** Partial injury a complete rupture of part of the circumference of the urethra.

A suffix added to types 2 and 3 could indicate whether they are complicated by bladder neck, rectal, perineal, or other significant injury.

Criteria	Author	Staging
Anatomical and radiological	Colapinto and McCallum, 1977	Retrograde urethrography
Extended anatomical	Goldman <i>et al.</i> , 1997	Radiological anatomy of the urethra, bladder neck, and bladder base
Urethral wall injury	Moore <i>et al.,</i> 1995	Clinical examination and RUG
Anatomical and functional	Al Rifaei <i>et al.</i> , 2001	Clinical examination, catheterizability, RUG, surgical findings, sphincter injury

#### **TABLE 5** Classifications of Pelvic Fracture Urethral Injuries (PFUI)

Recently, another classification has been proposed in the European Association of Urology guidelines on urethral trauma (41,42) (**Table 6**). This system has not been validated clinically, is not exclusive for PFUI, and combines injuries to the anterior and posterior urethra in type 3, which may be confusing.

# **TABLE 6**European Association of Urology classification (Lynch *et al.*, 2005; Martinez-<br/>Piñeiro *et al*, 2010)

Classification	Description	Advised Clinical Management
Туре 1	Stretch injury. Elongation of the urethra without extravasation on urethrography	No treatment required
Туре 2	Contusion. Blood at the urethral meatus; no extravasation on urethrography	Can be managed conservatively with suprapubic cystostomy or urethral catheterization
Туре 3	Partial disruption of anterior or posterior urethra. Extravasation of contrast at injury site with contrast visualized in the proximal urethra or bladder	Can be managed conservatively with suprapubic cystostomy or urethral catheterization
Туре 4	Complete disruption of anterior urethra. Extravasation of contrast at injury site without visualization of proximal urethra or bladder	Will require open or endoscopic treatment, primary or delayed
Туре 5	Complete disruption of posterior urethra. Extravasation of contrast at injury site without visualization of bladder	Will require open or endoscopic treatment, primary or delayed
Туре 6	Complete or partial disruption of posterior urethra with associated tear of the bladder neck or vagina	Requires primary open repair

The fundamental problem is that there are no accurate staging methods to define the actual injury. Acute staging is mainly dependent on RUG, which has many limitations in the emergency setting, where RUG is performed with a diagnostic aim but not necessarily with a staging aim. Therefore, diagnosis of a rupture may be established, but the images obtained may not allow for precise staging. Patients with pelvic fractures may not be placed easily in the anterior oblique position needed to properly visualize the whole urethra and excessive contrast extravasation may obscure the exact site of rupture. In some patients with partial ruptures, RUG may fail to visualize the posterior urethra and bladder, due to contraction of the external sphincter because of pain, thus mimicking a complete rupture.

Although well-conducted urethrography has been shown capable of correctly classifying most urethral injuries, this requires a trained radiologist or urologist, who may not always be available (Level 4) (43,44). The radiological examination is then at best presumptive. Also, most patients do not undergo endoscopy or operative exploration and many patients are catheterized before they are seen by a urologist. This means that in many patients, the diagnosis is based primarily on catheterizability and secondarily on radiography, and both of these may be presumptive.

Having a universal and accurate classification is important because it would allow for effective treatment planning and proper comparison of the outcomes of different management strategies. Improvement of the diagnostic staging methods is needed to develop a useful classification in the future.

# 7.6 Clinical Presentation, Diagnosis, and Imaging: Associated Injuries

PFUI must be suspected in all patients with pelvic fractures. Pelvic fractures occur secondary to high-energy impact trauma and are most commonly caused by motor vehicle accidents, pedestrian injuries, falls, and industrial work accidents. Patients with pelvic fractures often have major associated intra-abdominal injuries, with solid organ injuries being the most common (Level 3) (45,46). It has been reported that 2%–25% of patients with pelvic fractures have an associated urethral injury (Level 3) (1–3,5). However, these studies are usually single-institution cohort studies. In a recent study by Bjurlin *et al.*, using the National Trauma Data bank, the overall incidence of genitourinary (bladder and urethra) injury in both sexes was 4.6%. Of 31,380 identified study patients with pelvic fractures, there were 355 urethral injuries (1.1%), most of them occurring in men.

The Abbreviated Injury Scale (AIS) is a consensus-derived score given to individual organs. Each individual score is between 1 (minor) and 6 (almost always fatal). The severity of pelvic fracture is directly correlated with the risk of lower genitourinary injuries. Patients with AIS pelvic fracture scores  $\geq$  4 have a significantly higher incidence of lower genitourinary trauma compared to those with AIS scores of  $\leq$  3. (Level 3) (46). Studies have also shown that pelvic fracture patterns that include disruption of the pelvic ring have a higher incidence of urethral injury. Those include vertical shear fractures (Malgaigne) and pubic arch fractures, including widening of the symphysis pubis (Level 3) (1,2,5,24,28,46–48). In a prospective study of 203 patients with pelvic fractures, Koraitim *et al.*, found urethral injuries in 19% of patients (Level 3) (24). The pelvic fractures associated with the highest risk of urethral injury were straddle injuries associated with sacroiliac joint separation, followed by straddle injuries alone. However, isolated straddle fractures are usually associated with some injury to the sacroiliac joint, either through a lateral or anteroposterior compressive force (Level 3) (49). What can be concluded from these studies is that PFUIs are essentially related to unstable pelvic fractures.

Although the classic signs of blood at the urethral meatus—inability to void and a distended bladder—should prompt investigations for a urethral injury, they are not always present. Blood at the meatus has been reported to be present in 20%–100% of cases (Level 3) (1,5,47,50–53). This disparity in reports may be related to time to presentation (< 1 hr after trauma) and degree of injury. Other signs and symptoms suggestive of a urethral injury include a scrotal/perineal hematoma and a highriding prostate on digital rectal examination (DRE).

Although often quoted as a sign of a urethral injury, the value of DRE in urethral injuries has been questioned (Level 3) (52,54,55) due to its low sensitivity. The high-riding prostate is a difficult sign, since the hematoma around the prostate may make the prostate difficult to palpate, and in most trauma centres the DRE is performed by non-urologists on the trauma team. The classic "butterfly" distribution of the hematoma is a result of the attachment of Colles' fascia of the perineum to the fascia lata of the thigh. Therefore, the diagnosis of a urethral injury relies on a high index of suspicion

and awareness that the classical signs of blood at the meatus and other clinical indicators may not be present. Pelvic fracture patterns on plain film radiography should be reviewed, and in those patients with high-risk fracture patterns (unstable pelvis), RUG should be considered.

Retrograde urethrography should be performed in all patients suspected of having a urethral injury. In the multisystem-traumatized patient, the timing of this investigation is sometimes difficult, but it is important. Hemodynamic stability is prioritized in Advanced Trauma Life Support protocols and RUG is not always possible in all situations. Computed tomography (CT) scanning of the abdomen is routinely performed in relatively hemodynamically stable patients. Pelvic arterial bleeding may be difficult to diagnose on abdominal CT scanning if the RUG or cystogram is performed prior to CT scanning. Extravasated dye from RUG may make arterial bleeding difficult to diagnose and cause unnecessary delay in treatment (Level 3) (56).

In those patients in whom time is available, RUG is readily performed, ideally with oblique views. To do this, the down-side leg is externally rotated and flexed at the knee and the patient should be helped to move to a 30° left anterior oblique position. Foam cushions may be placed under the patient to help maintain that position and to ensure that the urethra and BN are depicted in optimal profile. Radio-opaque dye (15–20 mL) is injected under fluoroscopic control; alternatively, a single pelvic x-ray is taken as the last few mL of dye is being injected.

In the presence of a pelvic fracture, the ability to position a patient to obtain oblique films may be limited. Similarly, in those patients whose spine must be stabilized on a backboard, the x-ray may be taken with the patient on the backboard. In these circumstances, good-quality oblique films may not be possible and only anteroposterior views are obtained. A useful maneuver is to tilt the tube 30° anterior to evaluate the BN. A subtle leak from the BN may not be visible unless the tube is tilted craniocaudally (Level 4) (44). This is very important because posterior urethral injuries have been classified according to contrast distribution patterns and whether or not contrast is present in the bladder on RUG. Extravasation patterns have also been found to be unreliable in differentiating a complete urethral disruption from partial injury based on RUG alone. Since most injuries occur at the bulbomembranous junction, distal to the external sphincter, spasm or voluntary contraction of the sphincter at the time of RUG could cause the contrast to extravasate into the perineum without any entering into the bladder. This would make a partial injury appear radiologically as a complete transection of the urethra (Level 3) (5,28).

In patients under "crash" protocols requiring emergent laparotomy, several alternatives are possible, depending on the stability of the patient. These include a single trial of gentle catheterization, acute flexible cystoscopy, and insertion of a suprapubic catheter percutaneously or at the time of laparotomy. Blind urethral catheterization has been banned for decades, due to the theoretical possibility of converting a partial injury into a complete injury. However, data to sustain this hypothesis have never been presented and no definite studies have been performed to show that a single gentle attempt will lead to increased morbidity (Level 3) (28). Flexible cystoscopy is used in attempts at primary realignment and has been used in lieu of RUG (Level 3) (57). Other urethral imaging modalities, including ultrasound and magnetic resonance imaging (MRI), have not been studied in the acute trauma setting. Ultrasonography may be used for percutaneous placement of a suprapubic catheter.

# 7.7 Acute Management

In patients with PFUI, there are two accepted methods of acute treatment. The first is early closed realignment over a catheter, using blind or endoscopic (endo-urologic) techniques. The second is placement of a suprapubic catheter cystostomy (SPC), and subsequent open perineal urethroplasty after the near inevitable (92%) urethral stricture forms. There is no consensus as to which of these two approaches is superior.

Immediate open retropubic urethroplasty or open catheter realignment was the procedure of choice for many decades, but the incontinence and impotence rates were noted to be higher than with the two other alternatives, so it was abandoned and is not indicated (Level 3) (4,37,58–60). However, in patients with a concomitant BN or rectal injury, immediate open primary repair of the BN or rectal injury and urethral catheter realignment is indicated to avoid subsequent urinary incontinence or pelvic sepsis (3,4,24,41,42).

# 7.7.1 Early catheter realignment

The benefits of early realignment over a catheter are potentially many. The procedure is generally simple, avoids the need for placement of an SPC and may decrease the overall impact of the urethral injury by promoting earlier return to spontaneous voiding. In one recent series, patients who underwent realignment had a significantly shorter time to spontaneous voiding than did those who had cystostomy (35 vs. 229 days) (61).

Most importantly, realignment appears to decrease the chance of subsequent urethral obliteration by about 30% over placement of a suprapubic tube alone (**Table 7**). In reports that directly compare the stricture rates between realignment and cystostomy, all had fewer strictures by a range of 8%–86% (**Figure 3**). It does not appear to increase the baseline 8% incontinence rate after PFUI (**Table 8**). In reports that directly compare incontinence rates between realignment and cystostomy, several showed no difference and several showed a decrease of up to 8% in the incontinence rate (**Figure 4**). The same can be appreciated with regard to ED, with an average of 13% reduction in the ED risk (**Table 9** and **Figure 5**).

Some authors have suggested, without evidence, that realignment also aligns the urethral ends so that any subsequent urethroplasty is technically easier and less likely to fail than those that occur after cystostomy (Level 4) (62). The evidence for this is that when strictures occur at centres that prefer to attempt dilation or urethrotomy before definitive urethroplasty, the percentage that respond to dilation/urethrotomy alone is five-fold higher in the realignment group (**Table 10**). All studies that directly compared this result among patients with realignment to cystostomy showed better results with realignment (**Figure 6**) (Level 3).

Note that Figures **3–6** represent the differences in percentage between the two options. For example, in **Figure 3** the negative percentages indicate less stricture after realignment compared to cystostomy.

FIGURE 3 Percentage of strictures after realignment compared to cystostomy



FIGURE 4

Percentage of incontinence after realignment vs. cystostomy



#### **FIGURE 5**

Percentage of erectile dysfunction after realignment vs. cystostomy



#### **FIGURE 6**

Percentage of realignment patients requiring urethroplasty instead of dilation



**TABLE 7** Stricture rate after cystostomy alone or realignment

Author	Year	Suprapubic Cystostomy (%)	Realignment (%)
DeWeerd (82)	1959		36
Mitchell (35)	1968		24
Gibson (83)	1974		62
Jackson (84)	1974		65
Jackson (84)	1974	88	75
Crassweller (85)	1977		32
Coffield (86)	1977	100	78
Cass (87)	1978		70
Morehouse (36)	1980	95	
McAninch (50)	1981	89	
Patterson (63)	1983		38
Al-Ali (77)	1983	100	100
Webster (37)	1983	100	92
Fowler (81)	1986		30
Gelbard (72)	1989		100
Barry (88)	1989		42
Rehman (67)	1989		66
Dhabuwala (89)	1990	100	

continued on page 167

#### **TABLE 7** Stricture rate after cystostomy alone or realignment, Cont'd

Author	Year	Suprapubic Cystostomy (%)	Realignment (%)
Husmann (90)	1990	95	94
Guille (68)	1991		75
Cohen (69)	1991		80
Follis (74)	1992	85	15
Herschorn (75)	1992	100	54
Quint (91)	1993		40
Kotkin (92)	1996		50
Koraitim (93)	1996	97	53
Londergan (76)	1997		50
Porter (73)	1997		50
Elliott (65)	1997		68
Podesta (73)	1997	100	100
Sahin (94)	1998		80
Jepson (95)	1999		50
Asci (64)	1999	83	45
Kielb (57)	2000		50
Moudouni (96)	2001		49
Ku (97)	2002	40	19
Tazi (98)	2003		36
Mouraviev (99)	2005	100	49
Salehipour (80)	2005		24
Healy (100)	2007		40
Hadjizacharia (61)	2008	100	14
Olapade-Olaopa (66)	2010		21
	Mean	92	61

#### TABLE 8 Incontinence rate after cystostomy alone or realignment

Author	Year	Suprapubic Cystostomy (%)	Realignment (%)
Cass (87)	1978		10
Patterson (63)	1983		3
Webster (37)	1983	14	7
Gelbard (72)	1989		0
Barry (88)	1989		8
Husmann (90)	1990	12	12
Guille (68)	1991		0
Cohen (69)	1991		20
Melekos (101)	1992		0
Herschorn (75)	1992	0	0
Follis (74)	1992	8	0
Quint (91)	1993		10
Kotkin (92)	1996		17
Koraitim (93)	1996	3	4
Porter (73)	1997		0
Elliott (65)	1997		4
Londergan (76)	1997		50
Rehman (67)	1998		17
Jepson (95)	1999		6
Asci (64)	1999	6	10
Moudouni (96)	2001		4
Tazi (98)	2003		0
Mouraviev (99)	2005	25	18
Salehipour (80)	2005		0
Healy (100)	2007		0
Olapade-Olaopa (66)	2010		0
	Mean	8	8

#### **TABLE 9** Erectile dysfunction rate after cystostomy alone or realignment

Author	Year	Suprapubic Cystostomy (%)	Realignment (%)
Cass (87)	1978		38
McAninch (50)	1981	17	
Patterson (63)	1983		15
Webster (37)	1983	36	52
Barry (88)	1989		0
Husmann (90)	1990	51	47
Guille (68)	1991		20
Cohen (69)	1991		60
Melekos (101)	1992		0
Herschorn (75)	1992	100	42
Follis (74)	1992	50	20
Quint (91)	1993		0
Kotkin (92)	1996		16
Koraitim (93)	1996	18	28
Porter (73)	1997		14
Elliott (65)	1997		8
Jepson (95)	1999		22
Asci (64)	1999	18	20
Moudouni (96)	2001		22
Tazi (98)	2003		19
Mouraviev (99)	2005	42	34
Selehipour (80)	2005		16
Healy (100)	2007		40
Olapade-Olaopa (66)	2010		0
	Mean	42	35

Author	Year	Suprapubic Cystostomy		Realignment	
		Urethroplasty (%)	Dilation/ Urethrotomy (%)	Urethroplasty (%)	Dilation/ Urethrotomy (%)
DeWeerd (82)	1959			38	62
Mitchell (35)	1968			50	50
Gibson (83)	1974			23	77
Jackson (84)	1974	71	29	57	43
Crassweller (85)	1977			100	0
Coffield (86)	1977	100	0	29	71
Cass (87)	1978			57	43
Morehouse (36)	1980	100	0		
McAninch (50)	1981	88	12		
Patterson (63)	1983			18	82
Fowler (81)	1986			29	61
Gelbard (72)	1989			50	50
Husmann (90)	1990	88	11	56	43
Herschorn (75)	1992	100	0	42	58
Londergan (76)	1997			0	100
Kielb (57)	2000			16	84
Balkan (71)	2005	100	38	17	16
Hadjizacharia (61)	2008	100	0	0	100
	Mean	93	11	34	55

#### TABLE 10 Stricture treatment after cystostomy alone or realignment

#### 7.7.1.1 **Methods**

There are several methods of placing a urethral catheter into the bladder across an injured urethra. Most experts start with a simple retrograde catheterization attempt (62–65). If this fails, most modern authors choose retrograde flexible cystoscopy next (57,61). Retrograde flexible or rigid urethroscopy through a suprapubic tube can be also attempted. This procedure is claimed to require only 5–10 minutes when successful (57,62), while retrograde rigid cystoscopy has been reported to require an average of 22 minutes (Level 3) (66). Other authors have used two cystoscopes: a rigid one placed anterograde and a flexible one placed retrograde to bridge the gap (Level 4) (67,68).

Other techniques involve using a guide wire placed anterograde or retrograde across the defect and then placing a Council tip Foley catheter over the wire (69,70) or using a feeding tube placed via the urethra into the bladder and grasped through a cystostomy (71). Direct placement of a Foley catheter

anterograde through a cystostomy (65) or urethroscopy towards a Goodwin sound placed through a cystostomy has also been described (72). Two blindly placed anterograde and retrograde catheters with strong magnets on the end have been used to safely traverse the defect, but unfortunately these catheters are not commercially available (73).

Older reports generally describe open techniques using Davis interlocking sounds (63,64) or a metal sound in the urethra guided by a finger in the BN (64,74), requiring a mean of 80 minutes to complete in one study (Level 3) (63). A technique using anterograde or retrograde placement of catheters required about 75 minutes (65).

#### 7.7.1.2 Success rates

The success rate of any realignment technique varies depending on the author, and ranges from 70%–87% (Level 3) (61,73–76). One series where authors gained experience in the technique over a 5-year period showed an increase in success rates from 80% up to 93% (Level 3) (66). Authors have suggested that after initial failure, realignment can be attempted again 2–3 days later with some success (Level 3) (61).

#### 7.7.1.3 **Duration of stenting**

The recommended duration of catheterization is highly variable, ranging from 3–6 weeks. While some authors suggest a period of catheterization as short as 3–4 weeks (Level 4) (61,63,64,71,72,77), many experts suggest 6 weeks of catheterization after realignment (Level 4) (69,73,78). Some recommend longer catheterization, up to 8 weeks (Level 4) (67,77).

### 7.7.1.4 Length of subsequent stricture

While some experts suggest that realignment may increase stricture length, it has only been studied in one report. In 10 children, the length of the subsequent stricture was no longer in those who failed endoscopic realignment vs. those who failed suprapubic diversion (Level 3) (78).

#### 7.7.1.5 **Avoidance of traction on urethral catheter**

It is a universal recommendation to not place the aligning catheter under tension (Level 4) (50); although it was only studied in one report. Traction resulted in distal urethral necrosis in 2/14 patients (14%) and BN incompetence in 1/14 patients (7%) (Level 3) (77).

#### 7.7.1.6 When to place the catheter

Most surgeons place the catheter as soon as practically possible (Level 4) (65,69) and this is generally achievable after a mean of 32 hours from injury (69). A single immediate blind placement of a Foley catheter is attempted at most centres soon after the injury is diagnosed (69). Some have delayed realignment for 7–19 days with good results (Level 3) (71). A single study comparing a small number of cases with early (72 hours) or more delayed realignment reported similar rates of subsequent stricture (Level 3) (67).

### 7.7.1.7 **Complications of alignment**

While most authors report good results with endoscopic realignment, some studies suggest that it decreases the success of any future urethroplasty. A study of seven patients reported that in those who required urethroplasty, it was half as successful (43% for the realigned group vs. 85% for the

non-realigned group). The authors hypothesized that endoscopic realignment causes inflammation and fibrosis of the torn ends of the urethra, although no proof for this was given (Level 3) (79). Displaced pubic bone directly in the path of urethral alignment has been reported to be associated with failure in one patient (Level 3) (69). The potential to form longer strictures must be weighed against the general tendency to cause far fewer strictures after realignment.

Direct complications from urethral realignment are uncommon and series that analyzed complications reported no significant complications from the procedure (65). Attempting and failing to achieve realignment with a catheter is not believed to harm the patient (Level 4) (74). One series reported pelvic abscess in 1/34 cases (3%) (Level 3) (63). A single urethroscrotal fistula appeared in a series of 14 realigned patients (7%) (Level 3) (69) and a perineal abscess developed in 1/6 and 1/4 patients (16% and 35%, respectively) in two other studies (Level 3) (80,81). Delayed realignment at a mean of 10 days caused septicemia in 15% of cases in one series (Level 3) (66).

#### 7.7.1.8 **Confounding issues in the data**

Almost all reports used different methods of achieving urethral alignment, making direct comparisons difficult. Early realignment reports often included pelvic exploration with removing the pelvic hematoma, cutting the puboprostatic ligaments, and using blind techniques. More up-to-date modern series used mostly endoscopic techniques with minimal manipulation of the injured area.

It is also possible that patients in whom realignment is possible may have less serious injuries than those in whom it fails. In some series, the patients managed with suprapubic cystostomy had previously failed alignment attempts, and these patients probably had more significant injuries and longer urethral distraction distances than those in whom alignment was successful. One study of 16 patients reported that partial urethral tears, as determined by urethrography, were present in 33% of those in whom realignment was not possible and in 46% of those in whom realignment was possible. Partial vs. total urethral disruption was much more common in the cystostomy group (7%) than in the alignment group (39%) (Level 3) (75).

# 7.7.2 **Suprapubic catheter cystostomy and delayed reconstruction**

Placement of an SPC can be the acute procedure of choice, or can be performed if an attempt at early catheterization fails. The advantages of the SPC are that it is a simple and straightforward procedure, is known to any urologist or general surgeon, effectively diverts the urine, allows for urine output monitoring, and avoids extravasation and sepsis.

By resolving the acute urethral and urinary problem, SPC allows focus to be placed on the treatment of other associated injuries. It can be performed at the time of emergency laparotomy, if surgery is needed for other injuries, or can be placed percutaneously under ultrasonographic guidance. The disadvantage is the almost inevitable development of a urethral stricture, which will require later reconstruction. Urethroplasty after PFUI is a highly specialized surgery, but the SPC allows time for the patient to be stabilized and—if necessary and under ideal local health care conditions—to be transferred to a specialized centre.

# 7.8 Urethral Stenosis/Obliteration: Reconstructive Options and Their Outcomes

The standard surgical approach to the treatment of PFUI stenosis or obliteration is an end-to-end anastomosis. For decades this procedure has been known as bulboprostatic anastomotic urethroplasty (BPA). This comes from the previous belief that the injury occurs at the prostatomembranous junction. However, current evidence shows that the injury is actually located at the bulbomembranous junction, so the procedure should be called bulbomembranous anastomosis (BMA). This operation is usually performed 3–6 months after the initial injury, as this allows the acute hematoma to settle down and be replaced by mature fibrotic tissue (Level 4) (8,41,42).

Prior to embarking on BMA for PFUI, a thorough assessment is necessary. This includes clinical examination to note the condition of the local tissues (penile skin, degree of perineal scarring, presence of cutaneous fistula), as this helps in treatment planning. Radiological staging is conventionally performed using RUG and voiding cystourethrography (VCUG). Besides assessment of the length of the urethral defect, this provides information on the length of healthy bulbar urethra available for repair and the status of the BN. Contrast MRI has been used recently to evaluate the length of the defect along with the degree of lateral prostatic displacement.

# 7.8.1 **Operative procedure: bulbomembranous anastomotic urethroplasty**

#### 7.8.1.1 **Pre-operative preparation**

Documentation of the presence or absence of ED, peri-operative antibiotics based on urine culture reports, good radiographic studies, and patient position for surgery are important details.

The standard lithotomy position is used for routine BMA. However, in many centres (102,103) an exaggerated lithotomy position is used, citing the advantage of better and more direct perineal exposure. However, the exaggerated lithotomy position has been associated with neuropraxic injury of the lower limbs, as well as rhabdomyolysis and acute renal failure (Level 3) (104–107). This is particularly important when the surgery lasts over 5 hours. This risk may be lower when a beanbag is not used, or if used, is padded throughout with a gel pad.

#### 7.8.1.2 **Incision**

A midline incision extending from the perineoscrotal junction superiorly to about 1 cm from the anal verge inferiorly is most commonly used. However, this is a matter of personal preference and some authorities use an inverted Y incision.

#### 7.8.1.3 Surgical steps

Following exposure of the bulbar urethra, the following procedures are performed in a step-wise fashion:

- 1. Bulbar urethral mobilization: Proximally, the bulbar urethra is dissected free from the perineal body up to the site of obliteration. Distally, the mobilization proceeds only as far as necessary, given that too much dissection distal to the penoscrotal junction may cause penile chordee.
- 2. Crural separation: The corpora cavernosa are separated in the midline using either sharp scissors or electrocautery. At this point, there is a virtual space that can be developed, separating the corpora. This allows the urethra to lie between the crura rather than on the surface of the crura and permits extra length.
- **3. Inferior pubectomy:** A wedge of the inferior pubic bone is excised if the prostatic apex is not reached after the first two maneuvers.
- 4. Supracrural rerouting: If inferior pubectomy does not provide for a tension-free anastomosis, some surgeons route the urethra supracrurally after creating a space between the left or right crus and the anterior surface of the pubic bone.

These steps were originally described by Marion (108), Paine and Coombes (109), and Waterhouse (110). Turner-Warwick then modified the approach and did it abdominoperineally (111). Finally, Webster and Ramon popularized the step-wise perineal approach for BMA (Level 3) (112). Use of the first two steps has been categorized as the simple perineal approach, whereas inclusion of steps three or four is known as the elaborated perineal approach (Level 3) (113).

In unusual circumstances, a trans-pubic (abdominoperineal) approach may be required for complex injuries, where adequate access to the prostatic apex cannot be provided by the first four steps (Level 3) (114).

# 7.8.2 **Staging investigations to predict the type of surgery required**

The literature is unclear as to whether the type of surgery required (simple perineal/elaborated perineal/abdominoperineal approach) can be predicted based on information obtained from staging investigations (RUG/VCUG/MRI/CT). Andrich *et al.* demonstrated that the bulbar urethral defect as visualized on conventional contrast studies (RUG and VCUG) may not predict the type of repair that is required. This is primarily because PFUI is associated with upward displacement of the bladder and prostate. The authors indicated that a surgeon dealing with such strictures should be well versed with all the described steps, as any of them may be required during the procedure (Level 3) (114). On the other hand, Koraitim suggested that for gaps of 2.5–3.0 cm in length, a simple perineal repair may suffice, whereas larger gaps would require an elaborated perineal repair (Level 3) (113,115).

The length of the bulbar urethral defect is an important parameter, which may predict the type of repair. Koraitim described the length of the urethral gap in relation to the length of the bulbar urethra (from the blind proximal end to the bulbopenile junction) as the gapometry/urethrometry index (GUI) (Level 3) (116). In his study, a GUI less than 0.35 required a simple perineal repair,

whereas a GUI greater than 0.35 required more complex surgery. The GUI, the urethral gap length, and the degree of lateral prostatic displacement were independent predictors of the type of repair required. A GUI cut-off of 0.35 provided a sensitivity, specificity, and accuracy of 90%, 91%, and 90%, respectively (Level 3) (117). However, this index has two important drawbacks: first, the length of the bulbar urethra can vary according to the position angle of the patient or the x-ray beam and second, the distal limit of the bulbar urethra located at the bulbopenile junction is highly uncertain in most cases.

In clinical practice, the vast majority of injuries are short (< 2 cm) and so most of them can be dealt with using the simple perineal approach.

# 7.8.3 Inferior pubectomy

The requirement of inferior pubectomy during BMA has varied from as low as 10% (Level 3) (102,103,118,119) to as high as 30%–64% (Level 3) (120–123) in different studies. This discrepancy may be related to the type of stricture, which in turn is influenced by the type of initial injury. In a recent study comparing outcomes in two different countries, inferior pubectomy was performed in 24% of Italian vs. 66% of Indian patients (Level 3) (124). This apparent difference was attributed to the fact that in India the mechanism of injury was largely due to pedestrian, bicycle, motorcycle, and agricultural injuries, whereas in Italy they primarily resulted from motor vehicle injuries, which presumably produce a less severe injury. The rate of primary urethral alignment, which results in simpler urethral strictures, was also higher among Italian patients.

#### 7.8.4 **The role of supracrural rerouting in bulbomembranous anastomotic urethroplasty**

Webster and Ramon highlighted the fact that supracrural rerouting may provide a further 2 cm length in bridging long urethral gaps that cannot be adequately bridged using the first three steps in the progressive perineal approach for BMA (bulbar urethral mobilization, crural separation, and inferior pubectomy) (Level 3) (112). However, other surgeons have found this step to be required very rarely (Level 3) (102). In a multicentre series with 145 patients undergoing posterior urethroplasty, supracrural rerouting was required in only four patients, three (75%) of whom developed recurrent stenosis (Level 3) (119). Similarly, Hosseini *et al.* performed supracrural rerouting in 11 of 200 patients (5.5%), 64% of whom failed. They concluded that supracrural rerouting should be used with caution, due to its high stricture recurrence rate (Level 3) (118,125).

### 7.8.5 **Outcomes of primary bulbomembranous anastomotic urethroplasty for pelvic fracture urethral injury**

Numerous studies have reported long-term success rates of 90%–98% for primary repair of PFUI (Level 3) (38,102,103,118,119,126).

### 7.8.6 **Reconstructive options for failed bulbomembranous anastomotic urethroplasty**

A failed BMA for PFUI is a formidable challenge and requires the surgeon to have mastery over a wide variety of techniques, since it may not be possible to predict which particular procedure will be required. In these cases, the surgeon's experience is crucial.

The type of procedure required will depend largely on the integrity of the bulbar urethra. In patients with too large a loss of the bulbar urethra due to ischemic necrosis, a single-stage repair may not be possible and the option for a staged urethroplasty should be kept in mind.

# 7.8.7 **Outcomes of re-do urethroplasty for pelvic fracture urethral injury**

Whereas success rates for primary BMA exceed 90% in most series, contradictory results have been reported for re-do urethroplasty. Culty *et al.* reported a 60% success rate for patients who underwent BMA after prior urethral manipulation, as compared to a success rate of 90% for patients undergoing primary repair (Level 3) (127,128). Similarly, Singh *et al.* reported a significantly poorer outcome for patients undergoing BMA after prior urethral surgery as compared to primary BMA (Level 3) (79). Contrary to these studies, others have reported success rates of 84%–92% for patients undergoing re-do urethroplasty after previous attempts at repair (Level 3) (129–131). These studies required the use of a trans-pubic approach in 30%–40% of patients, which is significantly higher than the requirement for this approach in primary BMA.

# 7.9 **Complex Scenarios and Complications of Pelvic Fracture Urethral Injury: Erectile Dysfunction, Incontinence, and Fistula**

Pelvic fracture urethral injury may result in complex morbidities, including erectile dysfunction, incontinence, and fistula formation. Erectile failure occurs due to neurovascular damage, whereas incontinence may be a result of bladder denervation or a direct injury of the bladder neck. Fistula may be formed due to the initial trauma scarring or iatrogenic causes. There is also growing concern as to whether the choice of initial PFUI management contributes to the development of these complications.

# 7.9.1 **Erectile dysfunction**

#### 7.9.1.1 Introduction

Erectile dysfunction is a well-known consequence of pelvic fracture. The incidence of ED after pelvic fracture without urethral injury is 5% (Level 3) (132). However, with posterior urethral rupture, the incidence of ED increases to 42% (the collected average in 580 patients from 14 series) (Level 3) (29,64,65,92,96,123,128,132–138). From another perspective, 80% of patients with ED after a pelvic fracture had rupture of the posterior urethra (Level 3) (132). Recent studies using more objective criteria to define ED reported a higher incidence. Shenfeld *et al.* found a 72% ED rate by using a strict 70% tip rigidity criterion for normal erections (Level 3) (138). Using the International Index of Erectile Function (IIEF) questionnaire, Anger *et al.* reported a 54% ED incidence rate after reconstruction of PFUI, which was severe in 31%; orgasmic and ejaculatory function were maintained (Level 3) (139).

Erectile dysfunction is clearly related to injuries of the anterior pubic arch and pelvic crush injuries. King found a 44% ED incidence after pelvic crush injuries, but only 6% after other, less severe, pelvic fractures (132). Erectile dysfunction is associated with bilateral rami fracture (135), disruption of the symphysis pubis (132), and pubic diastasis (134). Of 38 PFUIs reconstructed in one study, 47% of patients had ED and all suffered unstable pelvic fractures (64). Other risk factors include older age (24 vs. 40 years old), length of defect (2.5 vs. 4 cm), and proximal urethral injuries (29,135).

There is growing concern that ED is associated with the initial management of PFUI. In one review, the incidence of ED reported after immediate urethral realignment was 36%, while with initial suprapubic cystostomy and delayed repair, the incidence was 19% (Level 3) (93). However, in these studies primary urethral realignment has been performed using different techniques (such as sutured anastomosis) and different types of catheter traction. In cases treated with primary realignment without traction or sutures, the reported rates of ED were 17%–20% (Level 3) (64,92), similar to the result of delayed repair. It also appears that neurovascular damage to the cavernous nerves, which leads to ED, occurs at the time of the urethral injury itself, rather than as a result of the corrective urethroplasty (Level 3) (89,139). These findings indicate that ED seen after PFUI is due to the magnitude or nature of the trauma itself, rather than secondary to the initial repair.

Harwood *et al.* reviewed studies dated up to 2005 comparing the incidence of ED after primary realignment (PR) or delayed repair (DR), updating a previous meta-analysis performed by Koraitim in 1995 (133). After DR, the average ED incidence was 29% in 15 series with 759 patients; however, considering only the 354 patients reported after 1990, it was 43%. After PR, the average ED incidence was 29% in 23 series with 525 patients, but considering only the 221 reported after 1990, it was 22.2% (p = < 0.0001). These series are difficult to compare, since they are non-randomized and non-contemporary. Instead of the open realignment employed in the past, most recent series of PR use endoscopic/endo-urologic realignment techniques, which are less likely to cause tissue or neuro-vascular damage. Potency evaluation is also not uniform; in recent series, stricter and more objective evaluation instruments were used and patients with partial loss of erectile capability were included. Moreover, less severely injured patients are more likely to receive PR and in many series, failed PR patients were also included in the DR group.

#### 7.9.1.2 **Etiology**

There is a wide discrepancy in the etiology of ED after PFUI (mainly depending on the study methodology), reported as vasculogenic in 28%–96%, neurogenic in 20%–89% and psychogenic in 4%–38% of cases (Level 3) (133,135,138,140–143).

Armenakas *et al.* evaluated PFUI patients with ED before reconstruction using pelvic MRI and duplex ultrasound, and showed that in 80% of cases the ED was vasculogenic in origin. They also reported prostatic displacement with fibrosis in 87% and injuries to the corpora cavernosa in 80% of the patients (Level 3) (140).

The investigation of ED by intracorporeal papaverine injections has indirectly shown that erectile failure after pelvic fracture is more often (89% of the time) the result of neural and not vascular damage (Level 3) (135). Similarly, in a study using nocturnal penile tumescence (NPT) followed with penile duplex ultrasonography, Shenfeld *et al.* discovered that after PFUI, 72% of ED is neurogenic (Level 3) (138). These findings can be explained anatomically, as the nervi erigentes are located close to the sub-prostatic urethra and are partly tethered within the fibrotic perineal body, therefore sub-prostatic dislocations may disrupt the cavernous nerves with sparing of arterial inflow (Level 3) (64) (Level 3) (144). The findings that neurogenic ED in PFUI may heal spontaneously over time and that the majority responded well to sildenafil therapy imply that neurogenic ED is not caused by complete disruption of the neurovascular bundles, but most probably due to neuropraxis with potential recovery over time (Level 3) (138).

Psychogenic factors can also be involved, since about 10% of survivors of severe motor vehicle accidents develop post-traumatic stress disorder and up to 80% of them report sexual dysfunction (133), so mixed organic and psychogenic etiologies are highly relevant.

There is agreement that surgery for PFUI does not cause ED. In a comparative study, Kotkin found no difference in potency in patients treated by realignment (76% potency) vs. catheterization alone (70% potency) (Level 3) (92). In another study, seven patients (27%) remained potent after the injury and after urethroplasty (Level 3) (89). Corriere *et al.* found no change in potency after urethral reconstruction in his patients, but a further 32% reported de novo ED at 1 year (Level 3) (128).

#### 7.9.1.3 **Diagnosis**

Erectile dysfunction is common among PFUI patients. Erectile function should be assessed and documented before attempting urethroplasty. Shenfeld *et al.* proposed that patients with ED, as documented by IIEF questionnaire, should undergo NPT testing, and if abnormal, penile duplex ultrasound with intracavernous injection should be performed. Patients with normal vascular function on duplex ultrasound are diagnosed as neurogenic ED. Patients with abnormal arterial function on duplex ultrasound may undergo arteriography. It should be done before planned urethral reconstruction to determine the exact site of vascular occlusion and to aid in selecting vessels for revascularization if indicated (Level 3) (138).

#### 7.9.1.4 Management

Erectile function is impaired in over half of men with PFUI. Realistic expectations should be discussed with patients as soon as possible after their injury. Patients with ED after PFUI represent a target population for early penile rehabilitation, which includes the various pharmacological interventions discussed below (Level 3) (139)

#### Sildenafil

Shenfeld *et al.* studied patients with ED due to PFUI. Almost half (47%) responded well to sildenafil, with patients reporting erections sufficient for satisfactory intercourse. Patients with neurogenic ED were more likely to respond to sildenafil (60%) than were those with vasculogenic ED (20%). Favourable response to sildenafil may predict spontaneous resumption of normal erectile function over time.

Similar to the positive effects of sildenafil in radical prostatectomy patients, there is a possibility that sildenafil treatment may have a protective or therapeutic role in ED after PFUI, improving the chance for later recovery of erectile function by preserving erectile tissue integrity following surgery (Level 3) (145).

#### Intracavernosal Injections

The mainstay treatment for neurogenic ED in PFUI is intracavernous injection therapy. The combination of papaverine with phentolamine injection is highly efficacious (89%) in neurogenic ED (135). Some authors also use prostaglandin E1, alone or in combination. Patients who did not respond to sildenafil (usually with neurogenic ED) responded well to intracavernous injection therapy (138).

Intracavernous injections can be started within a few weeks of completion of urethral reconstruction to avoid cavernous fibrosis. Penile and perineal pain after injection may discourage patients, however this problem usually resolves with time (138).

#### Surgery

Patients with arteriogenic or mixed etiology ED do not respond well to sildenafil or intracavernous injections. In cases of arterial damage, penile revascularization using the inferior epigastric to dorsal penile artery anastomotic technique significantly improved erectile function in patients with proven penile arterial insufficiency who did not respond to sildenafil and injections (Level 3) (138).

Penile revascularization has been suggested before any attempt at urethral reconstruction to avoid ischemic necrosis and atrophy with stricture formation in the bulbar urethra (Level 4) (146,147). Penile prosthesis may be offered electively if all else fails (Level 3) (135).

#### Spontaneous Recovery of Erectile Function

Spontaneous recovery of erections after PFUI is well documented. In 1975, King reported one incidental patient who recovered erectile function after 2 years. Dhabuwala *et al.* reported that four patients (15%) regained potency after urethroplasty (89). Six patients (7%) regained potency after urethroplasty in another report (135) and Majeed reported recovery in 8 of 21 (38%) patients (six full and two partial) 3–30 months after injury (136). Shenfeld showed that 33% of men with ED responding to sildenafil had spontaneous resolution. Pelvic fracture urethral injury patients are thus a suitable group for penile rehabilitation protocols (139,145).

### 7.9.2 Incontinence

Continence in the male is maintained by the proximal and distal sphincter mechanisms (see the previous section Urinary Continence and Sphincteric Mechanism). In PFUI, the distal sphincter components may be damaged, and continence is based mainly on the BN function; incontinence manifests if the BN is injured and rendered incompetent (Level 3) (117,148–150). The incidence of BN injury and incontinence following PFUI varies from 0%–50%, with the majority of studies reporting a 4%–5% incidence rate (38,148,151).

#### 7.9.2.1 Pathogenesis

Bladder neck injury may involve the BN musculature or nerve supply, either as a direct impact of the trauma or subsequent to a hematoma-fibrosis retraction of the BN (151,152). The risk of incontinence in PFUI is also influenced by the type of pelvic fracture and the patient's age (38,153).

According to Mundy and Andrich, the "typical" BN injuries (80% of all cases) are found in lateral compression or open-book pelvic fractures, in which the intact puboprostatic ligaments are pulled apart, resulting in a longitudinal anterior rupture of the BN. "Atypical" injuries, such as transverse BN transection or "blow-out" BN injury involving the prostate, rarely occur (153).

Koraitim reported that BN injuries occur more commonly in pelvic fractures involving both superior and inferior pubic rami of the same side, and the anterior aspect of the BN is usually torn by sharp edges of the fractured bones. Children younger than 15 years are more often affected (67% of all cases), possibly due to their smaller-sized prostates offering less protection against bone fragments (38).

Although Koraitim reported a higher incidence of incontinence in the immediate primary realignment group (21%) compared to delayed repair cases (5%) (Level 3) (24), this observation needs to be interpreted with caution, since there are various methods of primary realignment. A higher incidence of incontinence may occur when Foley catheter traction is used in the realignment, causing ischemic damage and BN incompetence (Level 3) (50,77). Otherwise, the higher incidence of incontinence in some studies was probably a reflection of the injury severity itself rather than a result of the primary realignment (Level 4) (92,144).

In our analysis of the acute management outcome in 26 studies, primary realignment does not appear to increase the baseline incontinence rate compared to cystostomy (see the previous section Early Catheter Realignment).

#### 7.9.2.2 Evaluation

Incontinence following PFUI is caused by BN dysfunction. This may be secondary to BN injury or to neurogenic dysfunction in cases of associated damage to the pelvic plexus. This can occur in fractures of the sacrum with injury to the sacral roots. Injury to the BN should be identified during the initial assessment and operated on as soon as possible, to control urinary extravasation and perform primary BN anatomic repair, thus avoiding scarred healing that may lead to incontinence. However, BN injuries frequently remain unnoticed, so evaluation of BN function should be performed before definitive urethroplasty.

Assessment of the BN function can be performed by a combination of antegrade cystoscopy and a standard "up and down" cystourethrogram (Level 3) (38). The initial cystogram should be taken at a low bladder volume (100 mL) while the detrusor is at rest, then filling the bladder gradually in order to avoid overfilling. Care should be taken not to confuse BN injury with radiological BN incompetence, which may occur if the bladder is overfilled or if the detrusor contracts in the presence of a suprapubic catheter, because they exert a non-physiological pressure on the BN, causing it to appear open (Level 3) (152).

A closed BN appearance on cystogram means that the BN is competent. However, if the cystogram reveals opening of the BN, further evaluation using antegrade (suprapubic) cystoscopy is required to assess its competency. Open BN is still regarded as functional (competent) if the cystogram shows a triangular funnel-shaped BN with a length of  $\leq 1$  cm, and on cystoscopy the BN appears closed with no scarring or distortion. On the other hand, the BN opening is considered dysfunctional (incompetent) if the shape on cystogram is rectangular with length of > 1 cm, and on cystoscopy there is the presence of quadrant scarring, distortion, and gaping (Level 3) (38,148). Neurogenic BN dysfunction appears as a fixed open BN in patients with other evidence of sacral root injury (perineal anesthesia or hypoesthesia, hypotonic anal sphincter) and usually in the presence of fractures of the sacral foramina.

Management of BN incompetence should be conservative, since spontaneous resolution after catheter removal can occur, without incontinence. Treatment of neurogenic BN dysfunction is also conservative, since patients will not necessarily be incontinent and may recover some neurologic function in time, whereas post-traumatic BN dysfunction requires surgery. For this reason, a careful assessment is important for the correct diagnosis of BN dysfunction. The algorithm in **Figure 7** can be used for evaluation of suspected BN injury following PFUI.



#### 7.9.2.3 Management

Post-traumatic dysfunctional BN requires surgical reconstruction. On the other hand, if the BN is still functional or if the diagnostic results are doubtful, BN surgery may be deferred in favour of conservative management, since these patients do not necessarily become incontinent (Level 3) (148,152). The timing of BN reconstruction in PFUI remains controversial. Some authors prefer a sequential approach, dealing with BN injury after urethral reconstruction, while others recommend concurrent BN and urethral surgery to reduce operative morbidities (Level 3) (38,148,153).

Numerous techniques of BN reconstruction have been described in the literature. This includes BN scar excision and re-approximation, construction of a neo-BN by various tubing techniques, and BN reinforcement using mechanical occlusion procedures such as implantation of artificial urinary sphincters, slings, and collagen injections (38,148,151,153). The outcomes of these BN procedures are summarized in **Table 11**.

Author	Year	Bladder Neck Procedure	n	Outcome
MacDiarmid	1995	Conservative	4	100% continent
		Artificial urinary sphincter (AUS)	1	100% minor urge leakage
Iselin & Webster	1999	Collagen implant	1	100% leakage, 2 pads daily
		Scar excision & BN approximation	6	83% continent 17% leakage, 1 pad daily
Al Rifaei	2004	Anterior bladder tube	10	40% continent 30% partial continence 30% incontinent (2 fistulas, 1 false route)
17 - 13	2010	Tanahago bladder tube	2	50% continent
Koraitim		Young-Dees-Leadbetter procedure	7	86% continent
		Mitrofanoff procedure	1	100% continent
	2010	Bladder flap	1	100% continent
Mundy & Andrich		Scar excision & BN approximation	12	33% continent 67% incontinent – weak sphincter (7/8 patients → continent after AUS implantation)

#### TABLE 11 Procedures and outcomes of delayed BN reconstruction in PFUI

Delayed BN reconstruction after PFUI remains a challenge. Neither scar excision nor BN approximation and neo-BN construction techniques have shown consistent, reliable results. This emphasizes the importance of early diagnosis and repair of these injuries. The artificial urinary sphincter is probably the best option (153).

### 7.9.3 **Fistula**

Fistula may occur as a late complication of PFUI and poses a major surgical challenge (154). The incidence of urethrorectal fistula (URF) ranges from 1.5%–5.8%, depending on the type and location of the urethral injury (130). The etiology varies from initial trauma scarring to iatrogenic causes including repeated surgical procedures or false endoscopic tracts. These factors contribute to the development of fistulous cavities by chronic inflammatory process, impaired vascular bed, fibrosis, and infection (155,156). However, in the vast majority of cases, they are associated with direct anorectal trauma.

#### 7.9.3.1 Clinical presentation and evaluation

Common clinical presentations of URF are pneumaturia and fecaluria, which may be noticed in the catheter after urethral reconstruction, or may manifest as a late complication on catheter removal. Some patients may experience passage of urine through the rectum, rectal pain, suprapubic pain, and recurrent cystitis (155).

Evaluation of the exact fistula location and size may be obtained from a barium enema or cystogram. Cystourethroscopy with simultaneous digital rectal examination is useful to describe the fistula relationship with the ureteral orifices and to rule out urethral obstruction (155). Sigmoidoscopy may be helpful to locate the rectal entry of the fistula, to determine the anal sphincter integrity, and to confirm the absence of other rectal pathology. This information will aid in determining the optimal time for repair, the surgical approach, and the type of diversion needed (157).

#### 7.9.3.2 Management

The surgical objectives in the management of URFs are permanent separation of the urinary and fecal streams, prevention of urethral injury, and preservation of urinary and fecal continence (156). These goals can be achieved by adhering to the principles of fistula repair, which include adequate surgical exposure, complete excision of fistulous tracts and separation of adjacent tissues, tension-free sutures, and interposition of vascularized tissue (Level 3) (155).

Interposition of healthy tissue helps to reduce post-operative complications, supports the urethral anastomosis, promotes tissue healing, and prevents infection and fistula recurrence (151,154). Various types of flaps are available for repair of URF. A combination of bulbospongiosus muscle and subcutaneous dartos pedicled flap can be mobilized to form a tension-free interposition flap in the posterior urethral region (Level 3) (154). Studies have also successfully used the omental or gracilis muscle flap (Level 3) (130,154,158).

#### Diversion

Diversion of the feces or urine is not a necessary routine in the management of all fistulas. However, diversion is required in patients with complex fistulas, previously failed attempts at closure, poor general condition, severe infection, urinary and fecal incontinence, or extensive trauma. Most studies favour both fecal and urinary diversion for a successful fistula repair (Level 3) (154–156).

Fecal diversion may be accomplished at the time of fistula repair, or performed earlier in more urgent conditions such as uncontrollable infection, rectal pain, and fecal incontinence. The approach involves making a colostomy prior to fistula repair, followed by closure of the colostomy after confirmation of fistula healing (155). Spontaneous closures of fistulas following fecal and urinary diversion have also been reported in several studies. However, such success is not easily replicated, making surgery the only effective treatment (155,156).

#### Surgical Approach

The surgical approach in fistula repair should be individualized depending on the fistula location and etiology, the familiarity of the approach, the history of previous repairs, and associated problems such as urethral or anal strictures. The ideal approach should provide adequate surgical exposure, allow smooth movement of the instruments, and result in a relatively small operative wound, with fewer post-operative complications (Level 3 (154,155,156). A variety of surgical approaches for URF repair have been proposed, including (but not limited to) the trans-perineal approach, the transpubic approach, and the trans-perineal–inferior pubectomy approach.

The trans-perineal approach is familiar to urologists and pediatric urologists. This approach is suitable in pediatric patients, for low-lying fistulas near the anus, and for shorter lengths (< 2.5 cm) of posterior urethral stenosis (Level 3) (154,156). Mobilization of the distal urethra is also feasible through this approach, providing ease of repair of any associated urethral pathology (156). However, the trans-perineal approach is not suitable for patients with severe pelvic injury, because the urethral stenosis is usually longer and the fistula tends to be located relatively farther from the anus (154).

The trans-pubic approach involves symphysiectomy, which allows excellent exposure to the base of the bladder or rectum. This approach is suitable for repair of complex posterior urethral strictures and fistulas located far from the anus. This technique also allows for omental interposition and may work well in cases where there is excessive perineal scar tissue or a prior perineal procedure was unsuccessful (130,154).

The trans-perineal–inferior pubic approach fully exposes the space behind the pubis and does not lead to pelvic instability. In cases of a high-lying prostate where the anastomosis may remain under tension, urethral lengthening can be achieved through this approach by separating the proximal corporeal bodies at the level of the crus. Xu *et al.* reported a reproducible success rate with this approach in 16 out of 18 URF cases. The trans-perineal–inferior pubic approach may be associated with fewer post-operative complications and is suitable as a first-line procedure in URF cases with complex posterior urethral stenosis (Level 3) (154).

In practice, the vast majority of these fistulas are easily addressed trans-perineally, since they are usually low fistulas and may be dealt with at the time of urethral repair. It is only with unusual injuries that a higher or complex fistula requires an abdominoperineal approach.

# 7.10 Recommendations

The following recommendations were made based on review of the available literature and expert opinion.

# 7.10.1 Anatomy, mechanisms of injury, and classification

- 1. The dual urinary sphincter mechanism (internal and external) is highly advantageous, because each sphincteric unit may independently maintain continence if the other has been injured. Assessment of possible damage of both components should always be performed (A).
- 2. Although the abbreviation PFUDD (for pelvic fracture urethral distraction defect) has been traditionally used to describe pelvic fracture–related urethral injuries, its use should be discontinued, since a large percentage are partial injuries and even complete ruptures do not always present as a separation of the urethral ends; therefore, many times there is neither distraction nor defect. The term should be replaced by PFUI (pelvic fracture urethral injury) (A).
- 3. Having a useful classification of PFUI is desirable for management decisions and outcome evaluation. However, none of the existing classifications is ideal and each of them has limitations precluding their widespread clinical application. Therefore, no recommendation is possible at this time and new classification systems are needed (D).

# 7.10.2 **Clinical presentation, diagnosis, imaging: associated injuries**

- 1. Urethral injuries should be suspected and ruled out in all patients with pelvic fractures (A).
- Urethral injuries should be highly suspected with pelvic fracture patterns that include pelvic ring disruption causing unstable injuries (either rotationally, vertically, or both), particularly in the absence of more obvious physical signs (blood at the meatus) (A).
- 3. Although still often quoted as a diagnostic tool for PFUI, DRE is not reliable and should not be used for this purpose. However, DRE retains its value in diagnosing associated rectal injuries (B).
- 4. Retrograde urethrography is at present the best technique for establishing the site and nature of urethral injury. It should be performed by an experienced operator, with diagnostic and staging intention. Well-performed RUG should visualize the whole urethra, including the BN when possible, indicating the location and degree of the injury (A).
- 5. If conditions allow, a single gentle attempt at catheter passage can be performed under fluoroscopic guidance at the time of RUG (B).

### 7.10.3 Acute management

- 1. Due to a high morbidity rate, early open retropubic primary suture repair or open retropubic catheter realignment is not recommended (A).
- 2. In patients with concomitant bladder, BN, or rectal injuries, immediate open primary repair of these injuries and urethral catheter realignment is indicated, to avoid subsequent urinary incontinence or pelvic sepsis (A).
- 3. Early endoscopic/endo-urologic catheter realignment performed by a urologist should be considered, provided the patient is stable and the proper instruments and equipment are available (B).
- 4. Realignment can be obtained by gentle simple retrograde catheterization or with a variety of procedures that include use of a flexible cystoscope and retrograde passage of a guide wire or a combination of flexible and rigid cystoscopes passed antegrade or retrograde through a suprapubic tract (B).
- 5. If successful, urethral catheterization should be maintained for 3 to 6 weeks (B).
- 6. Placement of an SPC, either as the acute management of choice or after an attempt at early catheterization fails, is the other accepted alternative. Placement can be performed at the time of emergency laparotomy if surgery is needed for other injuries, or done percutaneously under ultrasonographic guidance (A).
# 7.10.4 **Urethral stenosis/obliteration: reconstructive options and their outcomes**

- 1. Whenever possible, this surgery should be performed by an experienced surgeon skilled in all technical alternatives that may be necessary, since it may not be possible to anticipate the type of repair required (B).
- 2. For delayed reconstruction, the perineal midline progressive surgical approach is recommended (B).
- 3. The standard or extended lithotomy position can be used. However, the extended lithotomy position should be restricted to 5 hours, to avoid lower limb complications (B).
- Indicators of the need for an elaborated perineal/trans-pubic repair include a GUI (length of defect/length of bulbar urethra) > 0.35, a urethral gap length < 2.5 cm, and lateral prostatic displacement. In such cases, the surgeon needs to be prepared for a complex procedure (B).
- 5. Inferior pubectomy remains an important adjunct to BMA and surgeons should be proficient in this step prior to attempting BMA for any type of PFUI (B).
- 6. Supracrural rerouting in BMA is of value in some rare cases when extra urethral length is required (B).
- 7. A widely open BN with rectangular margins on cystography and with visible scarring on antegrade cystoscopy indicates possible internal sphincter damage, therefore the patient should be informed about the likelihood of post-operative incontinence (B).
- 8. When urethroplasty is successfully accomplished via the perineum, BN reconstruction (if necessary) may be postponed for a subsequent session. In perineo-abdominal procedures, BN reconstruction may be performed during the same session (C).
- 9. For failed BMA, re-do BMA is recommended if an adequate length of bulbar urethra is available. In the absence of sufficient bulbar urethral length, penile skin flap (tubed) urethroplasty or staged urethroplasty using a perineal or abdominoperineal approach are the alternatives (B).

#### 7.10.5 **Complex scenarios and complications**

- 1. Management of post-traumatic incontinence should be individualized. Bladder neck repair/reconstruction, the artificial urinary sphincter, and a continent diversion are the recommended alternatives (B).
- 2. There is some evidence that early use of phosphodiesterase type 5 enzyme (PDE5) inhibitors may improve erectile function after urethral injury (C).
- Management of post-traumatic urethral fistula should be individualized. The surgical approach should provide for ample exposure of the fistula, the fistulous tract should be excised completely, and a well-vascularized interposition flap should be applied (B).

#### 7.10.6 Future research

- 1. Current classification systems are limited and not clinically useful. Validated new proposals are required.
- The ideal timing of urethroplasty after injury is unknown (standard 3–6 months). The safety/efficacy of earlier repair protocols (3–4 weeks) needs to be established.
- 3. Prospective studies comparing catheter realignment vs. SPC and DR should be conducted.
- 4. The vascular significance of post-traumatic erectile dysfunction should be studied, as should the role of microvascular penile revascularization before BMA to avoid bulbar necrosis after urethroplasty.
- 5. The efficacy of penile rehabilitation protocols using PDE5 inhibitors should be evaluated.

# 7.11 References

- 1. Lowe MA, Mason JT, Luna GK, *et al.* Risk factors for urethral injuries in men with traumatic pelvic fractures. J Urol. 1988;140(3):506-507.
- 2. Palmer JK, Benson GS, Corriere JN Jr. Diagnosis and initial management of urological injuries associated with 200 consecutive pelvic fractures. J Urol. 1983;130(4):712-714.
- 3. Antoci J, Schiff M Jr. Bladder and urethral Injuries in patients with pelvic fractures. J Urol. 1982;128(1):25-26.
- 4. Koraitim MM. Pelvic fracture urethral injuries: The unresolved controversy. J Urol. 1999;161(5):1433-1441.
- Andrich DE, Day A, Mundy AR. Proposed mechanisms of lower urinary tract injury in fractures of the pelvic ring. BJU Int. 2007;100(3):567-573.
- Turner-Warwick RT. Principles of urethral reconstruction. In: Webster GD, Kirby RS, King L, et al., editors. Reconstructive urology. Oxford: Blackwell Scientific Publications; 1993. p. 609-642.
- 7. Federative Committee on Anatomical Terminology (FCAT). Terminologica anatomica: International anatomical terminology. Stuttgart: Georg Thieme Verlag; 1998. p. 70.
- 8. Chapple C, Barbagli G, Jordan G, et al. Consensus statement on urethral trauma. BJU Int. 2004;93(9):1195-1202.
- 9. Rosenstein DI, Alsikafi NF. Diagnosis and classification of urethral injuries. Urol Clin North Am. 2006;33(1):73-85.
- 10. Mundy AR, Glass J. Bladder, prostate and urethra. In: Standring S, editor. Gray's anatomy. 39th ed. Philadelphia: Elsevier Churchill Livingstone; 2005.
- 11. Jordan GH. Management of membranous urethral distraction injuries via the perineal approach. In: McAninch JW, Jordan GH, Carroll PR, editors. Traumatic and reconstructive urology. Philadelphia:W.B. Saunders; 1996. p. 393.
- 12. Clegg EJ. The musculature of the human prostatic urethra. J Anat. 1957;91(3):345-351.
- 13. MacDiarmid SA, Chapple CR. Surgical management of injuries to the bladder neck. In: McAninch JW, Jordan GH, Carroll PR, editors. Traumatic and reconstructive urology. Philadelphia: WB Saunders; 1996. p. 533-540.
- 14. Brooks JD, Chao WM, Kerr J. Male pelvic anatomy reconstructed from the visible human data set. J Urol. 1998;159(3):868-872.
- 15. Oelrich TM. The urethral sphincter muscle in the male. Am J Anat. 1980;158(2):229-246.
- 16. Karam I, Droupy S, Abd-Alsamad I, *et al.* Innervation of the female human urethral sphincter: 3D reconstruction of immunohistochemical studies in the fetus. Eur Urol. 2005;47(5):627-634.
- 17. Wallner C, Dabhoiwala NF, DeRuiter MC, et al. The anatomical components of urinary continence. Eur Urol. 2009;55(4):932-944.
- Dalpiaz O, Mitterberger M, Kerschbaummer A, et al. Anatomical approach for surgery of the male posterior urethra. BJU Int. 2008;102(10):1448-1451.
- 19. Turner-Warwick RT. Complex traumatic posterior urethral strictures. J Urol. 1977;118(4):564-574.
- 20. Colapinto SM, McCallum RM. Injury to the male posterior urethra in fractured pelvis: A new classification. J Urol. 1977;118(4):575 -580.
- 21. McCallum RW. The adult male urethra: Normal anatomy, pathology, and method of urethrography. Radiol Clin North Am. 1979; 17(2):227-244.
- 22. Pokorny M, Pontes JE, Pierce JM Jr. Urological injuries associated with pelvic trauma. J Urol. 1979;121(4):455-457.
- 23. Mouraviev VB, Santucci RA. Cadaveric anatomy of pelvic fracture urethral distraction injury: Most injuries are distal to the external urinary sphincter. J Urol. 2005;173(3):869-872.
- Koraitim MM, Marzouk ME, Atta MA, et al. Risk factors and mechanism of urethral injury in pelvic fractures. Br J Urol. 1996;77(6), 876-880.
- 25. Andrich DE, Mundy AR. The nature of urethral injury in cases of pelvic fracture urethral trauma. J Urol. 2001;165(5):1492-1495.

- Whitson JM, McAninch JW, Tanagho EA, et al. Mechanism of continence after repair of posterior urethral disruption: Evidence of rhabdosphincter activity. J Urol. 2008;179(3):1035-1039.
- 27. Tile M. Pelvic ring fractures: Should they be fixed? J Bone Joint Surg Br. 1988;70(1):1-12.
- Aihara R, Blansfield JS, Millham FH, et al. Fracture locations influence the likelihood of rectal and lower urinary tract injuries in patients sustaining pelvic fractures. J Trauma. 2002;52(2):205-208.
- 29. Boone TB, Wilson WT, Husmann DA. Postpubertal genitourinary function following posterior urethral disruptions in children. J Urol. 1992;148(4):1232-1234.
- Sandler CM, Harris JH Jr, Corriere JN Jr, et al. Posterior urethral injuries after pelvic fracture. AJR Am J Roentgenol. 1981; 137(6):1233-1237.
- Goldman SM, Sandler CM, Corriere JN Jr, *et al.* Blunt urethral trauma: A unified, anatomical mechanical classification. J Urol. 1997;157(1):85-89.
- Al Rifaei M, Eid NI, Al Rifaei A. Urethral injury secondary to pelvic fracture: Anatomical and functional classification. Scand J Urol Nephrol. 2001;35(3):205-211.
- 33. Moore EE, Cogbill TH, Malagoni MA, et al. Organ injury scaling. Surg Clin North Am. 1995;75(2):293-303.
- Ennemoser O, Colleselli K, Reissigl A, et al. Posttraumatic posterior urethral stricture repair: Anatomy, surgical approach and long-term results. J Urol. 1997;157(2):499-505.
- 35. Mitchell JP. Injuries to the urethra. Br J Urol. 1968;40(6):649-670.
- Morehouse DD, Mackinnon KJ. Management of prostatomembranous urethral disruption: 13-year experience. J Urol. 1980; 123(2):173-174.
- Webster GD, Mathes GL, Selli C. Prostatomembranous urethral injuries: A review of the literature and a rational approach to their management. J Urol. 1983;130(5):898-902.
- 38. Koraitim MM. Assessment and management of an open bladder neck at posterior urethroplasty. Urology. 2010;76(2):476-479.
- Devine C, Jordan GH, Devine PC. Primary realignment of the disrupted prostatomembranous urethra. Urol Clin North Am. 1989; 16(2):291-295.
- Onen A, Subasi M, Arslan H, *et al.* Long-term urologic, orthopedic, and psychological outcome of posterior urethral rupture in children. Urology. 2005;66(1):174-179.
- 41. Lynch TH, Martínez-Piñeiro L, Plas E, et al. EAU guidelines on urological trauma. Eur Urol. 2005;47(1):1-15.
- 42. Martinez-Piñeiro L, Djakovic N, Plas E, et al. EAU guidelines on urethral trauma. Eur Urol. 2010;57(5):791-803.
- 43. Patel U. Lower urinary tract trauma. In: Patel U, Rickards D, editors. Imaging and urodynamics of the lower urinary tract. London, England: Taylor & Francis; 2005. p. 115-121.
- 44. Ingram MD, Watson SG, Skippage PL, *et al.* Urethral injuries after pelvic trauma: Evaluation with urethrography. Radiographics. 2008; 28(6):1631-1643.
- Demetriades D, Karaiskakis M, Toutouzas K, et al. Pelvic fractures: Epidemiology and predictors of associated abdominal injuries and outcomes. J Am Coll Surg. 2002;195(1):1-10.
- 46. Bjurlin MA, Fantus RJ, Mellett MM, *et al.* Genitourinary injuries in pelvic fracture morbidity and mortality using the National Trauma Data Bank. J Trauma. 2009;67(5):1033-1039.
- 47. Lückhoff C, Mitra B, Cameron PA, et al. The diagnosis of acute urethral trauma. Injury. 2011;42(9):913-916.
- Basta AM, Blackmore CC, Wessells H. Predicting urethral injury from pelvic fracture patterns in male patients with blunt trauma. J Urol. 2007;177(2):571-575.
- Young, WR, Burgess AR, Brumback RJ, et al. Pelvic fractures: Value of plain radiography in early assessment and management. Radiology. 1986;160(2):445-451.
- 50. McAninch J. Traumatic injuries to the urethra. J Trauma. 1981;21(4):291-297.

- 51. Chan L, Nade S, Brooks A, *et al.* Experience with lower urinary tract disruptions associated with pelvic fractures: Implications for emergency room management. Aust N Z J Surg. 1994;64(6):395-399.
- 52. Ball C, Jafri SM, Kirkpatrick AW, *et al.* Traumatic urethral injuries: Does the digital rectal examination really help us? Injury. 2009;40(9):984-986.
- 53. Ziran BH, Chamberlin E, Shuler FD, *et al.* Delays and difficulties in the diagnosis of lower urologic injuries in the context of pelvic fractures. J Trauma. 2005;58(3):533-537.
- 54. Esposito TJ, Ingraham A, Luchette F, *et al.* Reasons to omit digital rectal exam in trauma patients: No fingers, no rectum, no useful additional information. J Trauma. 2005;59(6):1314-1319.
- 55. Shlamovitz GZ, Mower WR, Bergman J, *et al.* Poor test characteristics for the digital rectal examination in trauma patients. Ann Emerg Med. 2007;50(1):25-33.
- 56. Spencer Netto FA, Hamilton P, Kodama R, *et al.* Retrograde urethrocystography impairs computed tomography diagnosis of pelvic arterial hemorrhage in the presence of a lower urologic tract injury. J Am Coll Surg. 2008;206(2):322-327.
- 57. Kielb S, Voeltz Z, Wolf JS. Evaluation and management of traumatic posterior urethral disruption with flexible cystourethroscopy. J Trauma. 2001;50(1) 36-40.
- 58. Morehouse DD, Belitsky P, Mackinnon K. Rupture of the posterior urethra. J Urol. 1972;107(2):255-258.
- 59. Weems WL. Management of genitourinary injuries in patients with pelvic fractures. Ann Surg. 1979;189(6):717-723.
- 60. Muhlbauer S, Bard RH. Early definitive urological management of patient with crush pelvic trauma and deep perineal laceration. Urology. 1980;15(1):56-59.
- 61. Hadjizacharia P, Inaba K, Teixeira PG, *et al.* Evaluation of immediate endoscopic realignment as a treatment modality for traumatic urethral injuries. J Trauma. 2008;64(6):1443-1449.
- 62. Gheiler EL, Frontera JR. Immediate primary realignment of prostatomembranous urethral disruptions using endourologic techniques. Urology. 1997;49(4):596-599.
- 63. Patterson DE, Barrett DM, Myers RP, et al. Primary realignment of posterior urethral injuries. J Urol. 1983;129(3):513-516.
- Asci R, Sarikaya S, Büyükalpelli R, *et al.* Voiding and sexual dysfunctions after pelvic fracture urethral injuries treated with either initial cystostomy and delayed urethroplasty or immediate primary urethral realignment. Scand J Urol Nephrol. 1999; 33(4):228-233.
- 65. Elliott DS, Barrett DM. Long-term followup and evaluation of primary realignment of posterior urethral disruptions. J Urol. 1997; 157(3):814-816.
- 66. Olapade-Olaopa EO, Atalabi OM, Adekanye AO, *et al.* Early endoscopic realignment of traumatic anterior and posterior urethral disruptions under caudal anaesthesia A 5-year review. Int J Clin Pract. 2010;64(1):6-12.
- 67. Rehman J, Samadi D, Ricciardi R Jr, *et al.* Early endoscopic realignment as primary therapy for complete posterior urethral disruptions. J Endourol. 1998;12(3):283-289.
- Guille F, Cipolla B, Leveque JM, et al. Early endoscopic realignment of complete traumatic rupture of the posterior urethra. Br J Urol. 1991;68(2):178-180.
- 69. Cohen JK, Berg G, Carl GH, *et al.* Primary endoscopic realignment following posterior urethral disruption. J Urol. 1991; 146(6):1548-1550.
- 70. Fishman IJ, Hirsch IH, Toombs BD. Endourological reconstruction of posterior urethral disruption. J Urol. 1987;137(2):283-286.
- 71. Balkan E, Kilic N, Dogruyol H. The effectiveness of early primary realignment in children with posterior urethral injury. Int J Urol. 2005;12(1):62-66.
- 72. Gelbard MK, Heyman AM, Weintraub P. A technique for immediate realignment and catheterization of the disrupted prostatomembranous urethra. J Urol. 1989;142(1):52-55.
- 73. Porter JR, Takayama TK, Defalco AJ. Traumatic posterior urethral injury and early realignment using magnetic urethral catheters. J Urol. 1997;158(2):425-430.

- 74. Follis HW, Koch MO, McDougal WS. Immediate management of prostatomembranous urethral disruptions. J Urol. 1992; 147(5):1259-1262.
- 75. Herschorn S, Thijssen A, Radomski SB. The value of immediate or early catheterization of the traumatized posterior urethra. J Urol. 1992;148(5):1428-1431.
- 76. Londergan TA, Gundersen LH, van Every MJ. Early fluoroscopic realignment for traumatic urethral injuries. Urology. 1997;49(1):101-103.
- 77. Al-Ali IH, Husain I. Disrupting injuries of the membranous urethra The case for early surgery and catheter splinting. Br J Urol. 1983; 55(6):716-720.
- 78. Podestá ML, Medel R, Castera R, *et al.* Immediate management of posterior urethral disruptions due to pelvic fracture: Therapeutic alternatives. J Urol. 1997;157(4):1444-1448.
- 79. Singh BP, Andankar MG, Swain SK, *et al.* Impact of prior urethral manipulation on outcome of anastomotic urethroplasty for post-traumatic urethral stricture. Urology. 2010;75(1):179-182.
- 80. Salehipour M, Khezri A, Askari R, et al. Primary realignment of posterior urethral rupture. Urol J. 2005;2(4):211-215.
- 81. Fowler JW, Watson G, Smith MF, et al. Diagnosis and treatment of posterior urethral injury. Br J Urol. 1986;58(2):167-173.
- 82. Deweerd JH. Management of injuries to the bladder, urethra and genitalia. Surg Clin North Am. 1959;39(4):973-987.
- 83. Gibson GR. Urological management and complications of fractured pelvis and ruptured urethra. J Urol. 1974;111(3):353-355.
- 84. Jackson DH, Williams JL. Urethral injury: A retrospective study. Br J Urol. 1974;46(6):665-676.
- 85. Crassweller PO, Farrow GA, Robson CJ, et al. Traumatic rupture of the supramembranous urethra. J Urol. 1977;118(5):770-771.
- Coffield KS, Weems WL. Experience with management of posterior urethral injury associated with pelvic fracture. J Urol. 1977; 117(6):722-724.
- 87. Cass AS, Godec CJ. Urethral injury due to external trauma. Urology. 1978;11(6):607-611.
- 88. Barry, JM. Visual urethrotomy in the management of the obliterated membranous urethra. Urol Clin North Am. 1989;16(2):319-324.
- Dhabuwala CB, Hamid S, Katsikas DM, et al. Impotence following delayed repair of prostatomembranous urethral disruption. J Urol. 1990;144(3):677-678.
- 90. Husmann DA, Wilson WT, Boone TB, *et al.* Prostatomembranous urethral disruptions: Management by suprapubic cystostomy and delayed urethroplasty. J Urol. 1990;144(1):76-78.
- Quint HJ, Stanisic TH. Above and below delayed endoscopic treatment of traumatic posterior urethral disruptions. J Urol. 1993; 149(3):484-487.
- Kotkin L, Koch MO. Impotence and incontinence after immediate realignment of posterior urethral trauma: Result of injury or management? J Urol. 1996;155(5):1600-1603.
- 93. Koraitim MM. Pelvic fracture urethral injuries: Evaluation of various methods of management. J Urol. 1996;156(4):1288-1291.
- 94. Sahin H, Bircan MK, Akay AF, *et al.* Endoscopic treatment of complete posterior urethral obliteration. Acta Urol Belg. 1998; 66(4):21-24.
- 95. Jepson BR, Boullier JA, Moore RG, *et al.* Traumatic posterior urethral injury and early primary endoscopic realignment: Evaluation of long-term follow-up. Urology. 1999;53(6):1205-1210.
- Moudouni SM, Patard JJ, Manunta A, et al. Early endoscopic realignment of post-traumatic posterior urethral disruption. Urology. 2001;57(4):628-632.
- 97. Ku JH, Kim ME, Jeon YS, *et al.* Management of bulbous urethral disruption by blunt external trauma: The sooner, the better? Urology. 2002;60(4):579-583.
- Tazi H, Ouali M, Lrhorfi MH, et al. Endoscopic realignment for post-traumatic rupture of posterior urethra [Article in French]. Prog Urol. 2003;13(6):1345-1350.
- Mouraviev VB, Coburn M, Santucci RA. The treatment of posterior urethral disruption associated with pelvic fractures: Comparative experience of early realignment versus delayed urethroplasty. J Urol. 2005;173(3):873-876.

- Healy CE, Leonard DS, Cahill R, et al. Primary endourologic realignment of complete posterior urethral disruption. Ir Med J. 2007; 100(6):488-489.
- Melekos MD, Pantazakos A, Daouaher H, et al. Primary endourologic re-establishment of urethral continuity after disruption of prostatomembranous urethra. Urology. 1992;39(2):135-138.
- 102. Morey AF, McAninch JW. Reconstruction of posterior urethral disruption injuries: Outcome analysis in 82 patients. J Urol. 1997; 157(2):506-510.
- Cooperberg MR, McAninch JW, Alsifaki NF, et al. Urethral reconstruction for traumatic posterior urethral disruption: Outcomes of a 25-year experience. J Urol. 2007;178(5):2006-2010.
- 104. Biswas S, Gnanasekaran I, Ivatury RR, et al. Exaggerated lithotomy position-related rhabdomyolysis. Am Surg. 1997;63(4):361-364.
- 105. Bocca G, van Moorselaar JA, Feitz WF, *et al.* Compartment syndrome, rhabdomyolysis and risk of acute renal failure as complications of the lithotomy position. J Nephrol. 2002;15(2):183-185.
- 106. Gabrielli A, Caruso L. Postoperative acute renal failure secondary to rhabdomyolysis from exaggerated lithotomy position. J Clin Anesth. 1999;11(3):257-263.
- 107. Bildsten SA, Dmochowski RR, Spindel MR, *et al.* The risk of rhabdomyolysis and acute renal failure with the patient in the exaggerated lithotomy position. J Urol. 1994;152(6 Pt 1):1970-1972.
- 108. Marion G. De la reconstitution de l'urètre par urétrorrhaphie circulaire avec dérivation de l'urine [Article in French]. J Urol Med Chir. 1912;1:523-528.
- 109. Paine D, Coombes W. Transpubic reconstruction of the urethra. Br J Urol. 1968;40(1):78-84.
- 110. Waterhouse K, Laungani G, Patil U. The surgical repair of membranous urethral strictures: Experience with 105 consecutive cases. J Urol. 1980;123(4):500-505.
- 111. Turner-Warwick RT. A technique for posterior urethroplasty. J Urol. 1960;83:416-419.
- 112. Webster GD, Ramon J. Repair of pelvic fracture posterior urethral defects using an elaborated perineal approach: Experience with 74 cases. J Urol. 1991;145(4):744-748.
- 113. Koraitim MM. Post-traumatic posterior urethral strictures: Preoperative decision making. Urology. 2004;64(2):228-231.
- 114. Andrich DE, O'Malley J, Summerton DJ, *et al.* The type of urethroplasty for a pelvic fracture urethral distraction defect cannot be predicted preoperatively. J Urol. 2003;170(2 Pt 1):464-467.
- 115. Koraitim MM. On the art of anastomotic posterior urethroplasty: A 27-year experience. J Urol. 2005;173(1):135-139.
- 116. Koraitim MM. Predictors of surgical approach to repair pelvic fracture urethral distraction defects. J Urol. 2009;182(4):1435-1439.
- 117. Koraitim MM. Gapometry and anterior urethrometry in the repair of posterior urethral defects. J Urol. 2008;179(5):1879-1881.
- 118. Javanmard B, Hosseinee J, Rezaei A, *et al.* MP-10.11: Evaluation of supracrural rerouting success rate as a technique for resolution of posterior urethral disruption defects. Urology. 2009;74(4):S90-S91.
- Kizer WS, Armenakas NA, Brandes SB, et al. Simplified reconstruction of posterior urethral disruption defects: Limited role of supracrural rerouting. J Urol. 2007;177(4):1378-1381.
- 120. Flynn BJ, Delvecchio FC, Webster GD. Perineal repair of pelvic fracture urethral distraction defects: Experience in 120 patients during the last 10 years. J Urol. 2003;170(5):1877-1880.
- 121. Corriere JN. 1-stage delayed bulboprostatic anastomotic repair of posterior urethral rupture: 60 patients with 1-year followup. J Urol. 2001;165:404-407.
- 122. Fu Q, Zhang J, Sa YL, *et al.* Transperineal bulboprostatic anastomosis in patients with simple traumatic posterior urethral strictures: A retrospective study from a referral urethral center. Urology. 2009;74(5):1132-1136.
- 123. Tunc HM, Tefekli AH, Kaplancan T, *et al.* Delayed repair of post-traumatic posterior urethral distraction injuries: Long-term results. Urology. 2000;55(6):837-841.
- 124. Kulkarni SB, Barbagli G, Kulkarni JS, *et al.* Posterior urethral stricture after pelvic fracture urethral distraction defects in developing and developed countries, and choice of surgical technique. J Urol. 2010;183(3):1049-1054.

- 125. Hosseini SJ, Rezaei A, Mohammadhosseini M, *et al.* Supracrural rerouting as a technique for resolution of posterior urethral disruption defects. Urol J. 2009;6(3):204-207.
- 126. Lumen N, Hoebeke P, Troyer BD, et al. Perineal anastomotic urethroplasty for posttraumatic urethral stricture with or without previous urethral manipulations: A review of 61 cases with long-term followup. J Urol. 2009;181(3):1196-1200.
- Culty T, Boccon-Gibod L. Anastomotic urethroplasty for posttraumatic urethral stricture: Previous urethral manipulation has a negative impact on the final outcome. J Urol. 2007;177(4):1374-1377.
- 128. Corriere JN Jr, Rudy DC, Benson GS. Voiding and erectile function after delayed one-stage repair of posterior urethral disruptions in 50 men with a fractured pelvis. J Trauma. 1994;37(4):587-589.
- 129. Bhagat SK, Gopalakrishnan G, Kumar S, *et al.* Redo-urethroplasty in pelvic fracture urethral distraction defect: An audit. World J Urol. 2011;29(1):97-101.
- 130. Wadhwa SN, Chahal R, Hemal AK, *et al.* Management of obliterative posttraumatic posterior urethral strictures after failed initial urethroplasty. J Urol. 1998;159(6):1898-1902.
- 131. Shenfeld OZ, Gofrit ON, Gdor Y, *et al.* Anastomotic urethroplasty for failed previously treated membranous urethral rupture. Urology. 2004;63(5):837-840.
- 132. King J. Impotence after fractures of the pelvis. J Bone Joint Surg Am. 1975;57(8):1107-1109.
- 133. Harwood PJ, Grotz M, Eardley I, et al. Erectile dysfunction after fracture of the pelvis. J Bone Joint Surg Br. 2005;87(3):281-290.
- Malavaud B, Mouzin N, Tricoire JL, et al. Evaluation of male sexual function after pelvic trauma by the International Index of Erectile Function. Urology. 2000;55(6):842-846.
- Mark SD, Keane TE, Vandemark RM, et al. Impotence following pelvic fracture urethral injury: Incidence, aetiology and management. Br J Urol. 1995;75(1):62-64.
- 136. Majeed SA. Neurologic deficits in major pelvic injuries. Clin Orthop Relat Res. 1992;282:222-228.
- Routt ML, Simonian PT, Defalco AJ, et al. Internal fixation in pelvic fractures and primary repairs of associated genitourinary disruptions: A team approach. J Trauma. 1996;40(5):784-790.
- Shenfeld OZ, Kiselgorf D, Gofrit ON, et al. The incidence and causes of erectile dysfunction after pelvic fractures associated with posterior urethral disruption. J Urol. 2003;169(6):2173-2176.
- 139. Anger JT, Sherman ND, Dielubanza E, *et al.* Erectile function after posterior urethroplasty for pelvic fracture-urethral distraction defect injuries. BJU Int. 2009;104(8):1126-1129.
- Armenakas NA, McAninch JW, Lue TF, et al. Posttraumatic impotence: Magnetic resonance imaging and duplex ultrasound in diagnosis and management. J Urol. 1993;149(5 Pt 2):1272-1275.
- Robinson LQ, Woodcock JP, Stephenson TP. Results of investigation of impotence in patients with overt or probable neuropathy. Br J Urol. 1987;60(6):583-587.
- 142. Ellison M, Timberlake GA, Kerstein MD. Impotence following pelvic fracture. J Trauma. 1988;28(5):695-696.
- Munarriz RM, Yan OR, Nehra A, et al. Blunt trauma: The pathophysiology of hemodynamic injury leading to erectile dysfunction. J Urol. 1995;153(6):1831-1840.
- 144. Chapple CR. Urethral injury. BJU Int. 2000;86(3):318-326.
- Shenfeld OZ, Gofrit ON, Gdor Y, et al. The role of sildenafil in the treatment of erectile dysfunction in patients with pelvic fracture urethral disruption. J Urol. 2004;172(6 Pt 1):2350-2352.
- 146. Jordan GH. Editorial comment on: Shenfeld OZ, Kiselgorf D, Gofrit ON, *et al.* The incidence and causes of erectile dysfunction after pelvic fractures associated with posterior urethral disruption. J Urol. 2003;169(6):2173-2176.
- McAninch JW. Editorial comment on: Shenfeld OZ, Kiselgorf D, Gofrit ON, *et al.* The incidence and causes of erectile dysfunction after pelvic fractures associated with posterior urethral disruption. J Urol. 2003;169(6):2173-2176.
- Iselin CE, Webster GD. The significance of the open bladder neck associated with pelvic fracture urethral defects. J Urol. 1999; 162(2):347-351.

- Koraitim MM, Atta MA, Fattah GA, et al. Mechanism of continence after repair of post-traumatic posterior urethral strictures. Urology. 2003;61(2):287-290.
- 150. Koraitim MM. The male urethral sphincter complex revisited: An anatomical concept and its physiological correlate. J Urol. 2008; 179(5):1683-1689.
- 151. Al-Rifaei MA, Al-Rifaei AM, Al-Angabawy A. Management of urinary incontinence after bulboprostatic anastomotic urethroplasty for posterior urethral obstruction secondary to pelvic fracture. Scand J Urol Nephrol. 2004;38(1):42-46.
- 152. MacDiarmid SA, Rosario D, Chapple CR. The importance of accurate assessment and conservative management of the open bladder neck in patients with post-pelvic fracture membranous urethral distraction defects. Br J Urol. 1995;75(1):65-67.
- 153. Mundy AR, Andrich DE. Pelvic fracture-related injuries of the bladder neck and prostate: Their nature, cause and management. BJU Int. 2010;105(9):1302-1308.
- 154. Xu YM, Sa YL, Fu Q, *et al.* Surgical treatment of 31 complex traumatic posterior urethral strictures associated with urethrorectal fistulas. Eur Urol. 2010;57(3):514-520.
- 155. Dorairajan LN, Hemal AK. Lower urinary tract fistula: The minimally invasive approach. Curr Opin Urol. 2009;19(6):556-562.
- 156. Helmy TE, Sarhan OM, Dawaba ME, *et al.* Urethrorectal fistula repair in children: Urologic perspective. J Trauma. 2010;69(5): 1300-1303.
- 157. Zinman L. The management of the complex recto-urethral fistula. BJU Int. 2004;94(9):1212-1213.
- 158. Gupta NP, Mishra S, Dogra PN, *et al.* Does a previous end-to-end urethroplasty alter the results of redo end-to-end urethroplasty in patients with traumatic posterior urethral strictures? Int J Urol. 2008;15(10):885-888.

#### Acknowledgement

Dr. Abdel Wahab El-Kassaby would like to express his gratitude to Dr. Mohamed Kotb Tolba, Urologist at Ain Shams University, for his help in collecting data, editing and finalizing this work.

# Committee

# **C**8

# Posterior Urethral Stenosis After Treatment for Prostate Cancer

#### **CHAIRS**

Sender Herschorn, Canada Sean Elliott, United States

#### MEMBERS

Michael Coburn, United States Hunter Wessells, United States Leonard Zinman, United States Committee

# CONTENTS

8

#### Posterior Urethral Stenosis After Treatment for Prostate Cancer

8.1	Introduction	201					
8.2	Materials and Methods2						
8.3	Epidemiology and Risk Factors	204					
	8.3.1 Radical prostatectomy	204					
	8.3.2 Radiation	207					
	8.3.3 Cryotherapy	218					
	8.3.4 High-intensity focused ultrasound	219					
	8.3.5 Post-trans-urethral prostatectomy (Trans-urethral resection of the prostate)	220					
8.4	Evaluation and Pre-Operative Management	221					

# Committee

8.5	Treatmen	t	223
	8.5.1	Treatment approach after radiotherapy	223
	8.5.2	Treatment after trans-urethral resection of the prostate	225
	8.5.3	Management of post-radical prostatectomy vesico-urethral anastomotic strictures	226
8.6	Recomm	endations	231
	8.6.1	Future research	232
8.7	Referenc	es	233



# 8.1 Introduction

According to data published for 2010 by the American Cancer Society, prostate cancer affects 217,730 men annually and the median age at diagnosis is 68 years (1). The 5-year relative survival for localized disease is 99.1% and only one in six men diagnosed with prostate cancer will die of prostate cancer.

Treatment choices are numerous and local recurrence is common, leading to retreatment in many. According to statistics from the 2007 Surveillance Epidemiology and End Results (SEER) database, among men newly diagnosed with prostate cancer, radical prostatectomy (RP) is selected as initial therapy in 36%, external beam radiotherapy (EBRT) in 20%, brachytherapy (BT) in 10%, and BT + EBRT in 4% (2).

Cryotherapy and thermal ablation were used less commonly. As these data only follow patients through 6 months, it is difficult to calculate how many in the modern era go on to receive additional therapy. Treatment trends in the management of low-risk prostate cancer also vary over time, as reflected in the CaPSURE (Cancer of the Prostate Strategic Urologic Research Endeavor) database report (**Figure 1**) (3).



The *p* values for significant trends are as follows: External beam radiotherapy (EBRT): p = 0.0005; brachytherapy (Brachy): p = 0.0001; primary androgen deprivation therapy (PADT): p = 0.0492; watchful waiting (WW): p = 0.0048; The trend for radical prostatectomy (RP) is not significant: p = 0.96 (3). Because the male urethra courses through the prostate, it is susceptible to injury during prostate cancer treatment. Stenosis of the posterior urethra can lead to recurring problems of urinary retention, dysuria, urinary frequency, and incontinence. All have a significant negative impact on quality of life. Since the probability of long-term survival after prostate cancer treatment is high, quality of life issues are paramount. For these reasons, it is important for practitioners to understand the

Author	Year	Modality	Design	N
Borboroglu (5)	2000	RP	Retrospective cohort	467
Kao (6)	2000	RP	Retrospective questionnaire	1,069
Potosky (7)	2002	RP		337
Hu (8)	2003	RP		2,292
Yildirim (9)	2008	RP		136
Augustin (10)	2002	RP	Retrospective cohort	368
Ruiz-Deya (11)	2001	RPP	Retrospective cohort	250
Poon (12)	2000	RRP	Retrospective cohort	220
Park (13)	2001	RRP	Retrospective cohort	753
Begg (14)	2002	RRP	Retrospective cohort	11,522
Erickson (15)	2009	RRP	Retrospective cohort	4,132
Carlsson (16)	2010	ORRP vs. LARRP	Retrospective cohort	1,738 (485 open vs. 1,253 robotic)
Breyer (17)	2010	ORRP vs. LARRP	Retrospective cohort	998 (695 open vs. 293 robotic)
Gillitzer (18)	2010	RPP vs. RRP	Retrospective cohort	2,918 (866 RPP vs. 2,052 RRP)

**TABLE 1** Incidence of posterior urethral stenosis after radical prostatectomy

BN: bladder neck; CAD: coronary artery disease; EBL: estimated blood loss; LARRP: laparoscopically assisted robotic radical prostatectomy; MV: multivariate; MVLR: multivariate logistic regression model; OR: odds ratio; ORRP: open radical retropubic radical prostatectomy;

frequency with which posterior urethral stenosis (PUS) occurs after prostate cancer treatment, in order to properly counsel patients about the implications of their treatment choice. It is also critical that we work to better define the comparative effectiveness of treatment options to manage therapy-related PUS.

Rate (%)	Follow-Up	Accrual	Comments
11	> 12 months	91–99	Risk factors: current smoking, CAD, and EBL in MVLR model; Univariate: also diabetes mellitus, operation time; Obesity was not recorded
20.5 crude			Only 2.8% "persistent"
15	12 months		
22–28	< 2 years		Depends on surgeon volume
29	40 months		
10.6	38 months (mean)		
3 crude	30 months (mean)		
10	20, 37, 16 months (mean)		5% BN preservation, 10% in tennis racket, and 18% in anterior bladder tube
4.8 crude		94–99	Mean time to development: 4 (1–15) months; Predictor = maximum scar width (crude OR = 8)
17	1 year	92-96	Better outcomes with very high-volume hospitals and surgeons
2.5	44 months	83-00	MV predictors: year of surgery and non-nerve-sparing approach
4.5 vs. 0.2 crude		02-07	No risk factors discussed
2.2 (2.6 vs. 1.4) crude	> 12 months	02–08	Cox model: earlier year of surgery, older age, higher PSA but only in open group; No variation in robotic group
3.8 vs. 5.5	52 months (median)	97—07	Multivariate logistic regression risk factors: Gleason score, TURP, prostate volume, tumour stage and grade, transfusions, acute urinary retention treated with suprapubic tube, surgical technique

PSA: prostate-specific antigen; RP: radical prostatectomy; RPP: radical perineal prostatectomy; RRP: radical retropubic prostatectomy; TURP: trans-urethral resection of the prostate.

# 8.2 Materials and Methods

The committee was charged with the responsibility of assessing and reviewing the epidemiology, evaluation, and management of PUS following localized treatment for prostate cancer. Articles from peer-reviewed journals, abstracts from scientific meetings, and literature searches by hand and electronically formed the basis of this review. The search terms used included *prostate cancer, radical prostatectomy, radiation, brachytherapy, cryotherapy*, and *high-intensity focused ultrasound* (HIFU). The articles were analyzed, summarized, and included in the chapter under the various headings. Due to the dynamic nature of prostate cancer management, most of the references used are from the past 15 years.

As a general term, PUS can be subdivided into bladder neck stenosis, vesico-urethral anastomotic stenosis, prostatic urethral stenosis, membranous stenosis, prostatomembranous stenosis, and bulbomembranous stenosis. Obliterative lesions can be seen for virtually all of the aforementioned entities. The literature does not always differentiate between the various anatomic locations for the stenosis. However, post-RP stenosis is usually located at the vesico-urethral anastomosis and in the sections on radical prostatectomy, it is referred to as such.

Specific recommendations and grades of recommendations were made on the basis of published results and determined by the Levels of Evidence (4). Consensus of the committee determined the recommendations, which are found at the end of the chapter. Recommendations for future research are also included.

# 8.3 Epidemiology and Risk Factors

#### 8.3.1 Radical prostatectomy

Posterior urethral stenosis after RP manifests as a narrowing of the anastomosis between the bladder neck and the membranous urethra, commonly called bladder neck contracture (BNC), which occurs in 1.4%–29% of patients after RP (**Table 1**) (5-18). The number of radical prostatectomies performed in the US exceeded 80,000 in 2001, and continues to remain constant despite concerns about the public health benefit of prostate-specific antigen (PSA) screening. Using conservative estimates from the literature, it is calculated that over 5,000 men will require treatment each year for post-prostatectomy strictures of the posterior urethra and bladder neck. Thus, further investigations are needed to understand the pathogenesis of post-prostatectomy stricture so that preventive measures can be introduced.

Clinical risk factors include urinary extravasation, increased blood loss, current cigarette smoking, older age, and obesity (5–19). These factors may reflect poor wound healing and/or poor visualization during the vesico-urethral anastomosis, impairing epithelial-to-epithelial apposition. Surgeon experience also appears to be a significant factor. Indeed, surgical experience may correlate with improved

epithelial-to-epithelial apposition but may also reflect case selection. Both temporal reports of single surgeon experience and cross-sectional reports of Medicare data have shown contracture rates to be lower with increased case volume.

A 25-year catalogue of a single surgeon's open radical retropubic prostatectomy cohort demonstrated a reduction in BNC rates from 17% in 1983 to 1% in 2007 (15). Hu *et al.*, in a review of Medicare data, demonstrated BNC rates to vary from 28% among low-volume surgeons operating at low-volume hospitals to 18% among high-volume surgeons practicing at high-volume hospitals (8).

Better visualization for accomplishing an epithelial-to-epithelial anastomosis may also explain why BNC rates are lower with a perineal or robotic rather than an open retropubic approach (11,16,17,20,21). Whereas BNC rates after open RP can be as high as 29%, BNC rates after perineal prostatectomy are consistently around 3% (22–24). In another review of Medicare data, Hu *et al.* demonstrated the BNC rate after minimally invasive prostatectomy to be 6% whereas the rate after open prostatectomy was 14%. The risk of complications is much higher after salvage RP (following radiotherapy) than after primary RP, and PUS can occur in 42% of such patients. It has been well documented that most PUS after RP occurs within 2 years of surgery (15,19).

Overall, the likelihood of BNC after RP ranges from 1.4%–29%. Most contemporary series report BNC rates of 5%–10% (5,25). In one large multi-institutional series, 28% of patients self-reported BNC after radical retropubic prostatectomy (RRP), but only 2.8% of the cases were persistent (25). Robotic laparoscopic prostatectomy has been heralded as a technique associated with earlier continence and lower complication rates; publications to date suggest that BNC rates of 1%–3% are common, but longer follow-up is needed to confirm these results (16,17,26).

Vesico-urethral anastomotic strictures (VUAS) after RP result from fibrotic narrowing of the reconfigured/spared bladder neck (15,27). Proposed mechanisms include anastomotic tension, inflammation from urinary extravasation, poor tissue handling, and ischemia. Risk factors identified in case series and large prospective studies can be divided into pre-operative, intra-operative, and post-operative categories, and include excessive blood loss, type of bladder neck dissection, postoperative urinary leakage, adjuvant radiotherapy, and prior trans-urethral resection of the prostate (TURP) (5,25,28). Treating acute post-operative urinary retention with a suprapubic rather than a trans-urethral catheter has been mentioned as another risk factor (18). It is likely that multiple factors contribute to the development of BNC post-RRP (29–35). We have listed the major identified risk factors in **Table 2**.

# **TABLE 2** Risk factors for vesico-urethral anastomotic stenosis (defined as requiring intervention) after radical prostatectomy

Author	Risk Factor	N	VAUS rate (%)				
	Pre-Operative						
Sano (29) Thiel (36)	Age	48	Higher with age				
Borboroglu (5)	Comorbidity	467					
Borboroglu (5)	Smoking	467					
	Intra-Operative						
Rabbani (21)	Open vs. MIS	4,592	Lower with MIS				
Hu (20)		8,837					
Thiel (36)	Blood loss	246					
Huang (30)		708					
Borboroglu (5)		467	Higher with more estimated blood loss				
Kostakopoulos (31)		294					
Gillitzer (18)		2,918					
Gallo (32)	Anastomosis	90	No difference				
Sano (29)	Suture type	48	No unrerence				
lgel (33) Levy (23)	Vest sutures	91 143	Worse with vest sutures				
Srougi (34)	BN eversion	100	No difference				
Erickson (15)	Surgeon volume	4,132	Lower with high volume				
	Post-Operative						
Surya (27)	Extravasation	156	Conflicting				
Levy (23)		143	Connicting				
Ozu (35)	Catheter removal	55	No difference				
Gillitzer (18)	Acute retention	2,918	Higher if treated with suprapubic vs. Foley catheter				
BN: bladder neck; MIS: minimally invasive surgery.							

#### 8.3.2 Radiation

Radiotherapy can be delivered via an external beam source or intracavitary brachytherapy seeds. Brachytherapy can be delivered as short-acting, non-permanent seeds (high dose rate brachytherapy—HDR-BT) or longer half-life seeds that are permanently implanted (low dose rate brachytherapy—LDR-BT).

Radiation causes its therapeutic effect by damaging the DNA of actively dividing cells. The long-term effect is via the persistent effect of oxidative stress. Adverse effects such as PUS are secondary to chronic fibrosis and progressive endarteritis in poorly oxygenated submucosal and muscular tissues, with eventual tissue scarring (37,38).

Because toxicity to surrounding organs limits the radiotherapy dose, advances in radiotherapy delivery such as BT, multimodality therapy (BT + EBRT), three-dimensional conformal radiotherapy (3DCRT), and intensity-modulated radiotherapy (IMRT) have been designed to focus the radiation on the prostate, allowing dose escalation to the tumour site while minimizing adjacent organ damage. This has occurred with acceptable acute toxicity (< 90 days post-radiotherapy) and short-term adverse effects (90 days–5 years); however, the long-term adverse effects have been poorly documented. Whereas surgical PUS occurs primarily within the first 2 years of treatment (15,19), PUS due to radiotherapy continues to accumulate over the long term. In light of the high prevalence of people living long term after pelvic radiotherapy and the accumulation of urinary radiotherapy adverse effects over an extended time horizon, it is imperative that we better understand the delayed urinary adverse effects of pelvic radiotherapy, including PUS.

#### 8.3.2.1 Overview of brachytherapy

Studies have shown that local control in radiotherapy is largely dependent on the dose delivered. Zietman *et al.* demonstrated that men with low-risk prostate cancer have a lower risk of biochemical failure with a higher dose of radiotherapy (39). Similar findings were seen in other studies. Zelefsky *et al.* demonstrated that there is a dose-dependent reduction in post-treatment positive biopsy rate (40). Pollack *et al.* reported similar findings (41). As a result, the general consensus is that patients with localized prostate cancer should receive at least 74 Gy (42).

In order to deliver high doses of radiation without affecting surrounding tissue, thereby minimizing adverse side effects, three main treatment modalities exist:

- Three-dimensional conformal radiotherapy (3DCRT)
- Intensity-modulated radiotherapy (IMRT)
- Brachytherapy (BT)

Brachytherapy allows for delivery of a highly conformal radiation dose to the prostate through direct placement of radioactive seeds. A high dose is administered to the prostate itself, with rapid dose fall-off beyond the gland. This not only serves to focus the dose to the prostate gland itself, but also protects surrounding adjacent tissue, including the urethra. Two variations exist: For low-risk cancer, permanent seed BT is more commonly used, either with iodine-125 or palladium-103. The radiation dose from a permanent seed implant is delivered over months as the isotope decays. For iodine-125, with a half-life of 60 days, this results in a maximal dose rate of about 10 cGy/h.

For higher-risk disease, HDR-BT is combined with EBRT. This is called high-dose-rate brachytherapy boost (HDRBB). Given the degree of fall-off, the additional radiation is thought to treat any potential extra-capsular extension. The HDR-BT dose rate is about 1,000-fold higher (about 100 Gy/h), which is similar to the dose rate delivered by a linear accelerator. However, BT offers a combination of optimized dosimetry and retraction, or distancing, of normal tissues away from the source, limiting damage to surrounding tissues while selectively damaging tissues sensitive to large radiation fraction sizes (e.g. late-responding normal tissue). The greatest advantage is optimizing dose distribution by varying source dwell times along the catheters. High-dose-rate brachytherapy boost is most commonly delivered in two or more fractions of 8–10 Gy combined with 40–50 Gy ERBT.

#### How Often Is Brachytherapy Used?

The use of BT has increased over recent years. In a 2004 study evaluating the treatment choices for low-risk prostate cancer using the CaPSURE database, there has been a sharp increase in the use of BT (from 3.1% to 12.0%) and androgen deprivation monotherapy (from 3.1% to 21.7%), from 1989 to 2001 (**Figure 1**). In contrast, the rates of RP, EBRT, and active surveillance (AS) have fallen (from 63.8%, 16.1%, and 13.8%, to 51.6%, 6.8%, and 7.9%, respectively) (3).

Similar trends were noted in a 2010 study evaluating patients with low-risk disease in the British Association of Urological Surgeons Cancer Registry (43). Brachytherapy as initial management went from 0% in 2000 to 2% of cases in 2006, and AS increased from 0% in 2000 to 39% in 2006, while the proportion of patients opting for RP (27% in 2000 to 15% in 2006) and radical radiotherapy declined (23% in 2000 to 9% in 2006).

In this chapter, we will evaluate the current literature to assess the incidence, timing, nature, and outcome of urethral stricture in men receiving  $BT \pm EBRT$  for treatment of their prostate cancer.

Radiation causes its therapeutic effect by damaging the DNA of actively dividing cells. Adverse effects such as PUS are secondary to chronic fibrosis and progressive endarteritis in poorly oxygenated submucosal and muscular tissues, with eventual tissue scarring (37,38).

#### Incidence with Brachytherapy

Numerous reports have shown that urethral stenosis is the most common late complication reported in patients after BT (44–46). The incidence of urethral stenosis following HDR-BT in the literature varies from 0%-14% (46–54), with the majority of series reporting rates of 4%-9% at 5 years (**Table 3**) (43,44,55–59). Pellizzon *et al.* report a 13.8% 5-year actuarial rate of late urinary retention due to stenosis, of which age was the only independent predictor (59). Deger *et al.* studied 442 patients who had received a combination of 3DCRT and BT (HDRBB) (55). After a median follow-up of 5 years, they reported a 9% rate of urethral stenosis development. **Table 4** shows the incidence of stenosis after HDRBB (60–67).

Author	Year	Modality	Design	N	Rate	Follow- Up	Accrual	Comments
Zelefsky (47)	2000	BT		248	10% actuarial at 5 years	48 months	89–96	All grade 3 strictures, all treated with trans-urethral resection
Allen (48)	2005	BT		186	0 stricture 1.1% TURP	46 months		Urethral dose does not matter in the resolution of IPSS; stricture was irrelevant because so low
Herstein (49)	2005	BT		352	2%–3% TURP	>2 years		AUASS had returned within one patient of baseline by 2 years on average but 50% on alpha-blockers
Kollmeier (50)	2005	BT	Retrospective cohort	2,050	2% underwent TURP post-BT	38 months	90-04	
Zelefsky (51)	2007	BT		367	4% crude	63 months (median)	98–02	Also 19% chronic urethritis
Mabjeesh (52)	2007	BT	Retrospective cohort	665	2% required TURP	45 months	98–06	
Anderson (53)	2009	BT		263	1.5%	≥ 1 year		
Luo (54)	2009	BT	Retrospective cohort	138	6% if prior TURP; 2% if no prior TURP	23 months		

#### **TABLE 3** Incidence of posterior urethral stenosis after brachytherapy

AUASS: American Urologic Association Symptom Score; BT: brachytherapy; IPSS: International Prostate Symptom Score; TURP: trans-urethral resection of the prostate.

# **TABLE 4** Incidence of posterior urethral stenosis after brachytherapy boost with external beam radiotherapy

Author	Year	Modality	N	Rate	Follow- Up	Accrual	Comments
Albert (60)	2003	BT (25% + EBRT)	201	0%	2.8 years	97–02	Two-thirds had "same or improved" erectile function
Wehle (61)	2004	BT (39% + EBRT)	105	11% crude	24 months (median)	98–00	Pre-radiotherapy flow rate was a predictor of post-radiotherapy probabilities
Sarosdy (62)	2004	BT (44% + EBRT)	158	5.2% (BT) vs. 14.8% TURP (BT + EBRT)		98–00	10% had prior TURP (evenly split between groups); urinary diversion 1.3% overall
Merrick (63)	2006	BT (53% BT + EBRT)	1,186	3.6% 9-year actuarial; plus 1.4% crude underwent TURP without stricture	4.3 years (median)		Minimum urethral dose to BM urethra (HR 1.01 but continuous variable) and EBRT (HR 4.1) were predictors in MV model; All at BM urethra
Chen (64)	2006	BT (60% BT + EBRT)	5,621	10%	>2 years		No difference with EBRT; urinary competence: 33% no prior TURP (n = 5,256) vs. 46% prior TURP (n = 365)
Chen (65)	2007	HDR + EBRT	85	3.5%	49 months		
Nohara (66)	2010	HDR + EBRT		1%	31.5 months (median)		
Sullivan (67)	2009	HDR + EBRT in 90% (10% HDR only)	474	12% 6-year actuarial (8% crude)	41 months (mean)		92% occurred at BM urethra; risk factors in MV model: prior TURP (HR 2.8); hypertension, dose per fraction; all strictures were initially managed with either dilation (n = 15) or optical urethrotomy (n = 20); second-line therapy was required in 17 cases (49%), third-line in three cases (9%), and one patient required open urethroplasty (grade 3 toxicity); located at BN in two, prostate in one and BM urethra in 35

BM: bulbomembranous; BN: bladder neck; BT: brachytherapy; EBRT: external beam radiotherapy; HDR: high-dose-rate brachytherapy; HR: hazard ratio; MV: multivariate; TURP: trans-urethral resection of the prostate.

In a more recent study, Sullivan reported a crude stenosis rate of 8%, corresponding to an actuarial risk of stenosis development of 12% at 6 years, at a median follow-up of 41 months after HDR-BT (67). This rate was seemingly higher in monotherapy patients (15% at 3 years) compared to HDR-BT boost for EBRT (HDRBB) patients (11% at 6 years); there was a higher rate of stenosis as well as a shorter median latency period in monotherapy patients. The overall actuarial rate of grade 2 or higher bulbomembranous (BM) urethral stricture was estimated at 10.8% (95% CI: 7.0–14.9), with a median time to diagnosis of 22 months (range: 10–68 months) in those where stricture had already arisen. The actuarial rate of development of BM stricture is shown in **Figure 2**.



In the Merrick *et al.* study, 29 out of 1,186 patients developed a urethral stricture a mean of  $2.6 \pm 1.3$  years after BT (median: 2.4; range: 0.5 to 6.0) (63). All strictures involved the BM urethra. The 9-year actuarial risk of BM urethral stricture disease was 3.6% (**Figure 3**).



It is important to recognize that the rates of urethral strictures reported in the radiotherapy literature generally include only strictures resulting in symptoms and may therefore be underestimating the true rate of urethral stricture development.

#### Incidence with External Beam Radiotherapy

Urethral stenosis occurs after 3DCRT in 1%–13% of patients, and the risk is increased with long-term follow-up: < 7% with < 5 years of follow-up and 10%–18% with 5–10 years of follow-up (**Table 5**) (68–74). As with BT, the risk of stenosis is increased in those with a history of TURP prior to EBRT (70).

Interestingly, whereas IMRT has successfully reduced rectal toxicity through improved targeting of radiotherapy beams, urinary symptoms can actually be worse with IMRT than with 3DCRT. A randomized trial of 3DCRT and IMRT revealed a higher incidence of urinary urgency, frequency, and incontinence (20%) among those receiving 81 Gy of IMRT than among those receiving 3DCRT at lower doses (12%) (74). Urethral stenosis occurred in 3% of both groups. The increased specificity of radiation with IMRT may spare the rectum, but the dose escalation may in fact put the urethra at higher risk (74).

The incidence of PUS following adjuvant or salvage EBRT ranges from 3%–8.5% (75–78). Salvage prostatectomy after EBRT is associated with a PUS rate of 42% (**Table 6**) (79).

Author	Year	Modality	N	Rate	Follow- Up	Accrual	Comments
Lawton (69)	1991	EBRT	1,020	4.6% stricture	>7 years		
Chism (71)	2003	EBRT	156	< 1% stricture	26 months	92–99	
Lawton (68)	2008	EBRT	2,922	9% grade 3 at 8 years by Kaplan-Meier	10.3 years		Does not break down grade 3 into type; sounds like mostly hematuria
Gardner (70)	2002	EBRT 77 Gy CRT	39 with > 10- year follow- up	7.7% crude (13% including the grade 1–2 strictures)	13 years	76–92	1/3 strictures had prior TURP
Zietman (39)	2005	EBRT 3D (proton beam)	393	20% ≥ grade 2 genito- urinary toxicity morbidity but complications not specified	5.5 years (median)	96–99	
Al- Mamgani (72)	2009	EBRT with boost vs. IMRT	78	Urinary obstruction requiring treatment: 18% vs. 10%	76/56 months		Decreased rectal symptoms but increased urinary
Zelefsky (74)	2008	EBRT/IMRT (66–81 Gy)	1,571	3% crude grade 3 = stricture in all	8 years	88–00	Cl of late genito-urinary toxicity grade $\geq$ 2 was 15%; 35% in those with acute symptoms vs. 12% in those without; acute (37% vs. 22%), and chronic (20% vs. 12%) were higher in IMRT at 81 Gy than 3DCRT at lower doses. Cox model predictors: 3DCRT (HR 0.44) and acute toxicity (HR 6.95)

#### **TABLE 5** Incidence of posterior urethral stenosis after external beam radiotherapy (EBRT)

3DCRT: three-dimensional conformal radiotherapy; CI: confidence interval; CRT: conformal radiotherapy; EBRT: external beam radiotherapy; HR: hazard ratio; IMRT: intensity-modulated radiotherapy; TURP: trans-urethral resection of the prostate.

# **TABLE 6**Incidence of posterior urethral stenosis after adjuvant or external beam<br/>radiotherapy (EBRT) and salvage radical prostatectomy

Author	Year	Modality	Design	N	Rate	Follow- Up	Accrual	Comments
Ost (75)	2009	RP + adjuvant IMRT		104	6%	36 months (median)		
Macdonald (76)	2007	RP + adjuvant RT		65	3%	5 years (median)		
Cozzarini (77)	2008	RP + hypo- fractionated		50	8.50%	25 months		
De Meerleer (78)	2008	RP + IMRT		63	6%	30 months		
Gotto (79)	2010	RP vs. salvage RP	Retrospective cohort	3,458 primary and 98 salvage	5% vs. 42% salvage RP crude	46 & 35 months (median)	99–07	BT: 14% EBRT: 47% BT + EBRT: 62%

BT: brachytherapy; EBRT: external beam radiotherapy; IMRT: intensity-modulated radiotherapy; RP: radical prostatectomy; RT: radiotherapy.

#### Urethral Stricture Due to Brachytherapy

#### Pathophysiology

Urethral obstruction immediately after BT implant is due to therapy-induced inflammation of the prostate. Although the problem is common, it is generally self-limited (80). Urethral stenosis is the most common long-term serious urinary adverse effect of BT, occurring in 1%–12% of men (19,47,48,51,53,62,63,81–83).

Because toxicity to surrounding organs limits the radiotherapy dose, advances in radiotherapy delivery such as BT, multimodality therapy (BT + EBRT), 3DCRT, and IMRT have been designed to focus the radiation on the prostate, allowing dose escalation to the tumour site while minimizing adjacent organ damage. This has occurred with acceptable acute toxicity (< 90 days post-radiotherapy) and short-term adverse effects (90 days–5 years); however, the long-term adverse effects have been poorly documented. Whereas surgical PUS occurs primarily within the first 2 years of treatment (15,19), PUS due to radiotherapy continues to accumulate over the long term. In light of the high prevalence of people living long term after pelvic radiotherapy and the accumulation of urinary radiotherapy adverse effects over an extended time horizon, it is imperative that we better understand the delayed urinary adverse effects of pelvic radiotherapy, including PUS.

#### Time Frame (Brachytherapy)

An examination of SEER-Medicare data showed that within 2 years of BT, 30% of patients were listed with a diagnosis of urinary obstruction and 10% had a claim for a procedure performed for obstruction, most often dilation of urethral stricture (64). The William Beaumont Hospital group reported on 65 patients who received HDR-BT monotherapy, and found a urethral stricture rate of 8% with 36 months' follow-up. The median time to development of strictures was also short, at 16.5 months (range: 4–29 months) (84). This compares to median latency periods of 24–36 months in the HDRBB population (44,45,56).

#### **Stricture Location (Brachytherapy)**

The relatively specific sensitivity of the BM urethra to radiotherapy damage appears paradoxical, as this area, lying approximately 20 mm distal to the prostatic apex (81), should theoretically receive a far lower radiation dose than the prostatic urethra, which rarely undergoes stenosis (44,46,59,63,85). In the Sullivan *et al.* study, the stricture location was the BM urethra in 92.1% of cases (67). The overall actuarial rate of grade 2 or higher BM urethral stricture was estimated at 10.8% (95% CI: 7.0–14.9), with a median time to diagnosis of 22 months (range: 10–68 months). In the Merrick *et al.* study, 29 of 1,186 patients developed urethral strictures and all were in the BM urethra (63).

#### **Risk Factors (Brachytherapy)**

Risk factors for urethral stricture after BT included older age, non-white race, low income, more comorbidities, combination therapy with EBRT or hormonal therapy, and history of prior TURP. Older age was not found to be a significant risk factor in the series of Pellizon *et al.* (59). Several other series have confirmed that the risk of urethral stricture after BT is increased by combination therapy with EBRT. For example, one single-institution series reported that the risk of undergoing TURP was 5.2% after BT but increased to 14.8% after BT + EBRT (62). Similarly, a review of the CaPSURE multi-institutional registry revealed a crude risk of treatment for urethral stricture of 1.8% after BT and 5.2% after BT + EBRT, with a median follow-up of 2.7 years.

Most strictures occur at the membranous urethra, and early investigators noted the risk to be related to the dose delivered to the apex of the prostate (63,81,82). Others have countered that apical dose does not matter; however, a close read of more recent series demonstrates their apical dose to be much lower than in earlier series (48,51). Fewer series of HDR-BT evaluated the long-term risk of stricture development; however, the risk appears to be similar to that with LDR-BT (1%–12%) (65–67).

Stricture development with LDR-BT usually occurs in the bulbar urethra, and is more commonly seen with the use of midline needles, the irradiation of a long length of urethra, previous TURP, previous urethral pathology, and older age. The risk can be reduced with careful attention to technique and urethral dose, as well as patient selection.

Of the suggested clinical predictive factors for urethral strictures following prostate BT, previous TURP is consistently a risk factor for late genito-urinary (GU) toxicity in patients receiving either HDR-BT or LDR-BT (**Figure 4**) (67,86–89). Even in the absence of radiotherapy, TURP alone is associated with a urethral stricture rate of between 1.5% and 4% (90,91). Galalae *et al.* reported

incontinence in 9 out of 144 patients (92). All but one had a history of TURP shortly before or after radiation. Of 16 patients who underwent TURP within 5 months of radiation, 8 became incontinent, 4 developed urethral stricture, and 4 developed bladder sphincter sclerosis.



Retrospective data suggest that EBRT or LDR-BT for prostate carcinoma in those with a history of prior TURP resulted in a 15% chance of developing a urethral stricture or BNC, which was significantly greater than the 6% rate in those without a history of TURP (89). In another series, of over 400 patients receiving HDR-BT, all patients with late grade 3 and 4 GU complications (including 7.4% with urethral strictures) had undergone either TURP or urethrotomy within 1 year pre- or post-BT (55).

Previous TURP, and particularly multiple previous TURPs, should be considered a relative contraindication to HDR-BT, and these patients should be counseled as to their increased risk of urethral stricture formation when considering BT.

A history of hypertension was also a significant predictive factor for stricture formation (**Figure 4**) (67), and this is a plausible finding based on toxicity studies from other tumour sites, where hypertension has been shown to increase late severe toxicity, especially in conjunction with diabetes mellitus

(93). Urethral damage may be exacerbated by poor circulation (as may happen with hypertensioninduced microvasculature changes), and previous TURP can also reduce the urethral blood flow (94), making vascular endothelium a likely target (95).

It seems prudent to manage vascular risk factors aggressively in patients who are to undergo HDR-BT.

#### **Dosimetry (Brachytherapy)**

The dose per fraction of HDRBB prescribed to the target volume was significantly related to the formation of strictures, suggesting that the damage resulting in BM urethral stricture has a low a:b ratio; analogous to many normal tissue responses in classical radiobiology terms. The a value is related to unrepairable damage in cells, while the b value is related to repairable damage. The ratio gives a measure of the repair potential of cells.

A low a:b ratio implies more radioresistance, but this does not directly explain the site of the stricture being substantially inferior to the high-radiation dose area. One explanation for this may be needle slippage, with some centres reporting up to 20 mm of caudal movement of catheters between fractions (46,96–98). Mate *et al.* did not have verification of needle position at every fraction, and hence the potential for inadvertent dose inferior to the apex is unknown (44). Countering this is the fact that their stricture rate is remarkably similar to that of those who do perform positional verification prior to each fraction (56) as well as those performing separate implants and planning for each fraction (45,54). This suggests that the extension of the dose inferiorly may not be the only explanation. Detailed dosimetric investigations, particularly subdividing the dose to the apex and peri-apical tissues, as well as updated data from cases with needle positional verification, may contribute further to our understanding of stricture etiology.

In the Merrick *et al.* study, differences in BM urethral dose profiles were stratified by distance from the prostatic apex in patients with and without strictures (63). The difference between the two curves was statistically significant ( $p \le 0.001$ ) (**Figure 5**).



#### 8.3.2.2 Combination with external beam

#### Type of External Beam Radiotherapy

Urethral strictures seem to occur less frequently as a complication following LDR-BT and conformal EBRT than following HDRBB. Modern LDR-BT series report incidences varying from 0%–5.5% (48,63,84). Contemporary 3DCRT, however, is associated with rates of 1%–4% (94). High-dose IMRT, to 81 Gy for example, has reported stricture development rates of 3% (99).

#### 8.3.3 Cryotherapy

Cryotherapy involves the ablation of tissue by local induction of extremely low temperatures, and is used as a therapeutic modality for prostate cancer. In 1996, the American Urological Association (AUA) recognized cryotherapy as a therapeutic option for prostate cancer and removed the "investigational" label from this procedure. Improvements in the technology of cryotherapy have allowed for more efficient freezing of the prostate gland, while reducing damage to surrounding tissues, notably the urethra, external urinary sphincter, and rectum. This modality offers a minimally invasive treatment with low morbidity, minimal blood loss, short hospital stay, and high rates of negative post-treatment biopsies (100–107).

Cryotherapy principles, including the mechanisms of cell injury and cell death, have been well studied (108,109). The main mechanism of cytotoxicity that cryotherapy produces is the induction of targeted areas of coagulative necrosis in the prostate gland. The freezing injury comprises direct mechanical shock, osmotic shock, and cellular hypoxia. Mechanisms of action include protein denaturation via dehydration; transfer of water from the intracellular space to the extracellular space; rupture of cell membranes from ice crystal expansion; toxic concentration of cellular constituents; and thermal shock from rapid super-cooling, slow thawing, vascular stasis, and increased apoptosis (100,110).

One of the most important recent advances in cryotherapy has been real-time ultrasound-guided placement of the cryoprobes and continuous visualization of freezing. Biplanar trans-rectal ultrasound (TRUS) allows for transverse and longitudinal views of the prostate as well as the frozen area. The views are interchangeable during the procedure. Frozen tissue is different from unfrozen tissue in sound impedance, resulting in strong echo reflection at the interface of normal and frozen tissue (100).

In order to protect the urethra and the external urinary sphincter and to minimize urethral sloughing and prevent urinary incontinence, a urethral warming device is used during prostate cryotherapy (100).

#### 8.3.3.1 **Urethral sloughing and/or urethral stricture (cryotherapy)**

Tissue sloughing has been reported to occur in 3.8%–23% of cases (101,106,111–114). With the current refinement of the freezing technique, however, symptomatic sloughing is a minor and infrequent event, occurring in less than 3% of patients. Treatment consists of antibiotics and adequate drainage of urine. Intermittent self-catheterization may lead to spontaneous tissue dislodgment. Transurethral resection or removal of the necrotic tissue may be required if the condition persists (100).

Urethral stricture rarely forms after cryotherapy if an effective urethral warming device is used (100). However, if extensive tissue sloughing takes place, stricture at the bladder neck or the middle of the prostatic urethra can occur. In those cases of stenosis, trans-urethral incision or balloon dilation is usually successful. Calcification of the stricture may also occur, necessitating trans-urethral resection. The use of an effective urethral warming catheter is essential to minimize the risk of tissue sloughing (100,115,116).

Recto-urethral fistula has been reported to occur in 0%–3% of patients (103,106,116–118). It is most commonly seen in patients who were previously treated with radiation. In recent series, the rate is 0%, owing to the high accuracy of TRUS and temperature monitoring of the rectal wall (100).

#### 8.3.4 High-intensity focused ultrasound

High-intensity focused ultrasound is a new technology, and with time the incidence of urethral stricture may decrease as it did with the introduction of BT and cryotherapy; however, with present technology, PUS is reported to occur in 7%–30% of those undergoing HIFU as first-line treatment (119,120) and in 20% of salvage HIFU cases (121,122).

#### 8.3.4.1 Epidemiology and risk factors (high-intensity focused ultrasound)

High-intensity focused ultrasound is a minimally invasive alternative technique for the management of both benign prostatic hyperplasia (BPH) and localized primary or recurrent prostatic cancer (123). It was originally introduced in 1992 as a thermo-ablation treatment option for BPH. The target effect is achieved by the emission of a high-energy ultrasound beam, which is focused on the prostate through a trans-rectal probe imaging the lesion by simultaneous ultrasonography, while delivering a generated temperature in the range of 100°C, leading to immediate coagulative necrosis (124). This results in tissue destruction attributable to coagulation necrosis, cavitation, and temperature rise starting at the centre of the treated volume of prostate, followed by a peripheral spread.

The most common adverse advent with HIFU is the development of bladder outlet obstruction due to edema and sloughing of necrotic tissue. The first clinical application in BPH treatment in 1994 revealed a significant reduction in obstructive symptoms (125). In 2000, the same group demonstrated less desirable outcome in a long-term study, with 44% of the patients requiring a secondary TURP within 4 years of the initial procedure (124).

Subsequent report by Uchida *et al.* noted a 27% rate of bladder outlet obstruction requiring urethrotomy, TURP, or bladder neck incision (126). Most of the peri-operative episodes of urinary retention were caused by edema requiring catheterization for up to 40 days (127). To reduce the incidence of urinary retention, the concept of combined TURP and HIFU in one session was introduced (126,127). This reduced the catheterization time to 7 days, with subsequent reports with similar findings, revealing a decrease of 2%–8% in the rate of bladder outlet obstruction by adding an initial TURP to HIFU therapy. Long-term follow-up, however, may demonstrate delay in the appearance of bladder outlet obstruction, since many cases do not develop obstructive disease for 15 months to 9 years (128). There was a trend toward lower rates of bladder outlet obstruction (12.5%) when a longer interval between TURP and HIFU was used, especially if a large amount of tissue was resected. The long-term effect of HIFU on the prostate is increased fibrosis, which leads to 80%–100% of bladder neck scarring in patients with multiple prior episodes of recurrent obstruction.

Older age is the only single factor that clearly predicts a greater rate of single episodes of obstruction after HIFU; however, sloughing of prostatic tissue seems to be the major problem, with an incidence of bladder neck obstruction occurrence of 2%–55% (129,130).

#### 8.3.4.2 High-intensity focused ultrasound summary

Bladder outlet obstruction occurred in 25% of patients after the first HIFU thermal ablation of localized prostatic cancer, while 5% had obstruction from multiple episodes. Necrotic tissue accounted for most first episodes. Trans-urethral resection of the prostate performed 3 months after HIFU had a marked decrease in bladder outlet obstruction (12.5% vs. 30%). The presence of late post-HIFU BNC varies from 3.6% to 4.8% irrespective of the addition of TURP to the original HIFU. These are classic vesical neck stenoses requiring the conventional remedies of cold-knife or laser urethrotomy.

#### 8.3.5 **Post-trans-urethral prostatectomy** (Trans-urethral resection of the prostate)

Bladder neck contracture is a disappointing, but consistently occurring complication of all forms of prostatic surgery (131). The etiology is not well understood, but is undoubtedly related to the type of procedure used (surgical, endoscopic, or ablative), the size of the prostate, extravasation of urine, the length of catheterization, and a history of prior prostatic surgery. Bladder neck contracture can develop as late as 15–19 months post-TURP, but most develop within 2–8 months and are usually identified by the development or persistence of voiding or storage symptoms after an initial improvement (132).

In the presence of continued bladder over-activity or a large post-void residual (PVR) urine volume, bladder dysfunction should first be distinguished from an obstructing BNC (133). A meta-analysis of randomized controlled trials of various forms of surgical techniques used for BPH report an overall rate of 2%–4% (134,135).

The occurrence of BNC following TURP has changed over the past two decades, from 15% reported in a randomized prospective trial in 1995 (136) to the significant decrease of 3.4% reported in 2004 (136,137). This study also confirmed the observation that prostatic volume had a significant impact on the incidence of this complication. Patients with low prostate resection weight (average  $11 \pm 3.7$  g) are predisposed to bladder neck stenosis. This occurred in 29 of 846 patients undergoing surgery. The remaining patients, with an average resection weight of 28 g, were free of BNC. The development of BNC had no correlation with surgeon experience or time of resection. The one most consistent observation is the development of BNC in small prostates. The mechanism leading to this complication after TURP is still unclear, but the key factors proposed are extensive resection and fulguration at the bladder neck, undermining the bladder neck, a large resection loop that generates excessive heat, and the presence of a small intra-urethral adenoma (91,138). One study also revealed that patients with BPH and associated intravesical calculi had an unexplained significantly lower incidence of BNC than did patients without vesical stones (3.2% vs. 13.1%) (132).

Trans-urethral incision of the prostate (TUIP), introduced by Orandi in 1973 as an alternative to TURP (139), has been used primarily in patients with BPH if the gland does not exceed 30 g (140). Lee *et al.*, in a study of 1,470 patients compared the effectiveness of combining the two procedures in preventing the development of BNC. This study showed that TURP plus TUIP could completely prevent the incidence of BNC if the resected adenoma weight was a greater than 30 g, while the incidence of BNC was 7.7% if the resected weight was less than 30 g (132,137).

# 8.4 Evaluation and Pre-Operative Management

Men who develop PUS after treatment for prostate cancer may present with lower urinary tract symptoms (LUTS), both storage and voiding. The usual timing of onset of the stenosis depends on the type of treatment that has been administered. With radiation (both EBRT and BT) it usually occurs within a few years. After RP ( $\pm$  EBRT), TURP, or interventions such as HIFU and cryotherapy that result in tissue sloughing, the symptoms of obstructed voiding may occur immediately after catheter removal or more likely within the first year.

There is as yet no evidence-based recommended work-up for new or persistent LUTS after treatment for prostate cancer. The following recommendations are based on the recommendations for evaluation for LUTS in older men, from the sixth International Consultation on New Developments in Prostate Cancer and Prostate Diseases (141). These recommendations were also incorporated into the updated AUA Clinical Guidelines in the Management of BPH (142). Additional recommendations represent the consensus of the committee.

The workup for LUTS after treatment for prostate cancer is determined by the onset and severity of the symptoms. Development of PUS is usually associated with *de novo*, recurrent, or persistent LUTS. The main complaint may relate to an obstructed voiding pattern, such as a reduced force of stream, although other voiding and/or storage symptoms may predominate. Careful evaluation prior to initiation of intervention should be undertaken. The timing of the intervention is determined by the severity of the symptoms and findings. As an example, acute urinary retention after Foley catheter removal following RRP may merit immediate cystoscopy and re-catheterization.

In general, evaluation of suspected PUS after treatment for prostate cancer (summarized in **Table 7**) includes:

- History: LUTS, validated question naires, voiding diary; see Chapter 2 Evaluation and Follow-Up.
- Physical examination: general, abdominal, genital, perineal, rectal, and neurological as required
- Laboratory investigations:
  - Urinalysis: the presence of hematuria may indicate additional pathology such as bladder tumour or complications of bladder outlet obstruction with a bladder calculus
  - Urine culture and sensitivity (or leukocyte esterase screening test): this is necessary prior to instrumentation; infection may represent or contribute to the underlying cause of the voiding symptoms
- PSA: to rule out persistent or recurrent cancer
- Renal function tests (creatinine, blood urea nitrogen) if clinically indicated

- Uroflowmetry and PVR measurement
- **Cystoscopy:** allows lower urinary tract evaluation to assess for anterior urethral pathology, sphincteric integrity, foreign bodies, calculi, recurrent cancer, and other areas of stenosis/stricture
  - Consider antegrade endoscopy to assess anatomy proximal to stenosis
- Imaging
  - Retrograde urethrography (RUG) and possibly voiding cysto-urethrography (VCUG) if unable to delineate length, location, severity, and complexity of stenosis, depending on complexity. In general, imaging is reserved for cases where complete cysto-urethroscopy cannot be performed due to various reasons (multiple strictures encountered, complete urethral obliteration, patient unwilling to undergo procedure in ambulatory setting). Performed separately, each provides useful information in evaluating the level of the stricture, but both done simultaneously may allow evaluation of the whole urinary tract proximal and distal to the level of stricture
- Renal/ureteral ultrasound if clinically indicated
- Prostate imaging (TRUS) if necessary to exclude abscess, calcification, cancer recurrence
- Other (computed tomography/magnetic resonance imaging): if disease is felt to be more extensive, e.g., cancer, abscess, prostatic calcification, fistula

• **Urodynamic evaluation** is reserved for specific cases, to evaluate all types of voiding dysfunction as needed

### **TABLE 7** Suggested work-up for posterior urethral stenosis after treatment for prostate cancer

#### 1. History

2. Physical exam: general, abdominal, genital, perineal, rectal, and neurological as required

- 3. Laboratory:
  - a. Urinalysis ± urine culture
  - b. PSA to rule out persistent or recurrent cancer
  - c. Renal function tests (creatinine, blood urea nitrogen) if clinically indicated
- 4. Uroflowmetry and PVR measurement
- 5. Cystoscopy: retrograde and antegrade (if necessary)
- 6. Imaging:
  - a. RUG and possibly VCUG if unable to delineate length, location, severity, and complexity of stenosis
  - b. Renal/ureteral ultrasound if indicated
  - c. Prostate imaging (TRUS) if necessary
  - d. Other (computed tomography/magnetic resonance imaging) if disease is felt to be outside urinary tract (e.g., cancer, abscess, prostatic calcification, fistula)

7. Urodynamic evaluation if necessary

# 8.5 **Treatment**

#### 8.5.1 **Treatment approach after radiotherapy**

A proposed algorithm for the management of strictures following forms of radiation is in Figure 6.


Endoscopic urethrotomy and/or dilation of urethral strictures is associated with recurrence rates of approximately 60% for bulbar strictures, regardless of etiology (143,144). Whatever the mechanism, a primary concern with any intervention for BM strictures is their relationship to the continence mechanism of the external sphincter lying either within or adjacent to the stenotic area.

Sullivan *et al.* reported that from their series of 474 patients, 38 (8%) were diagnosed with a urethral stricture, with a median follow-up of 4 months (67). Once diagnosed, these strictures were initially treated with either dilation (n = 15) or optical urethrotomy (n = 20). The follow-up beyond the time of stricture occurrence was between 2 and 48 months (median: 16 months). Second-line therapy was required in 17 patients (49%), which consisted of: repeated dilation (n = 4), repeated optical urethrotomy (n = 3), intermittent self-catheterization (n = 5), optical urethrotomy (n = 2), and dilation (n = 3). Three cases (9%) had third-line therapy in the form of intermittent self-catheterization (n = 2) or urethroplasty (n = 1). Of those patients diagnosed and treated for a urethral stricture, four patients (10.5% of the stricture cases) developed urinary incontinence severe enough to require daily pad use.

Of the 32 cases of stenosis that were referred to a urologist following prostate cancer therapy, five occurred after BT, five occurred after EBRT, and four occurred after BT + EBRT (145). Membranous urethral stenoses resulting from BT, EBRT, and BT + EBRT in which the prostate was still *in situ* were managed successfully by excision and anastomotic urethroplasty. Urethral stents fared less well, with urethral stenosis recurring at either end of the stent.

Of the five with stenosis after BT, two patients had a short stenosis (< 2 cm) in the anterior urethra, which were both successfully treated with anastomotic urethroplasty; three patients had PUS, one of which was successfully treated with anastomotic urethroplasty, and two were treated with a urethral stent, only one of which was successful. Of the four with stenosis after BT + EBRT, one patient had a long stricture (> 2 cm) in the anterior urethra, which was successfully treated with perineal urethrostomy; three patients had PUS, one of which was successfully treated with anastomotic urethroplasty and two were treated with a urethral stent, only one of which was successfully treated with anastomotic urethroplasty and two were treated with a urethral stent, only one of which was successful.

Of the 16 cases of fistula after prostate cancer therapy, one occurred after BT, zero occurred after EBRT, and three occurred after BT + EBRT (145). All were treated successfully. The case occurring after BT was managed successfully with a rectal bladder. Of the three occurring after BT + EBRT, one was managed successfully with inferior pubectomy, prostatectomy, and bladder neck to bulbar urethra anastomotic urethroplasty; one was managed successfully with a colon conduit urostomy; and one was managed successfully as a urethral transection and ligation, as the patient still had some urine via urethra to manage as a rectal bladder.

External beam radiotherapy was identified as a risk factor for failure after repair of stenosis (145). Of the anterior and posterior urethral stenosis groups combined, two of five patients (40%) treated with prior EBRT monotherapy achieved success, accounting for three of three anterior urethral reconstruction failures. EBRT in combination therapy was associated with success in 9 of 16 patients (56%). Patients who had received EBRT as monotherapy or combination therapy accounted for seven of the nine failures (78%).

In the study by Gómez-Iturriaga Piña *et al.*, grade 3 GU toxicity, manifesting as a urethral stricture, was observed in 3/96 patients (3.1%) (146). These were corrected with urethral dilation or transurethral resection. One of these men presented with urinary retention 7 months after the implant and was initially treated with alpha-blockers and clean intermittent catheterization. As there was no resolution, a trans-urethral resection was performed 33 months after BT. The second patient presented 18 months after BT, with difficulty in initiating voiding. Cystoscopy and bladder neck incision were performed. The third patient had acute urinary retention 42 months after his implant. Cystoscopy demonstrated a significant urethral stenosis that was dilated. All three men showed satisfactory improvement after treatment. None had an enlarged prostate before their BT; volumes ranged from 30–37 cm<sup>3</sup> and only one had presented with an elevated International Prostate Symptom Score (IPSS), of 18/35.

#### 8.5.2 **Treatment after trans-urethral resection of the prostate**

The management of BNC may vary from simple dilation to an open formidable reconstruction. Simple intermittent urethral dilation may prove successful for VUAS after RP but is rarely successful after TURP (147). Bladder neck contracture following TURP or any of the newer minimally invasive therapies is most consistently resolved by bladder neck incision, which is the most preferred method (147,148). Vanni *et al.* reported on using a tri-radial incision in the bladder neck at 9-, 12-, and 3-o'clock, preceded and followed by 0.4 mg of mitomycin C as an antiproliferative agent to prevent recurrence (149). A full-thickness incision with a cold knife through the fibrotic ring into the periprostatic fat is then followed by 10 days of an indwelling catheter. This approach has a success rate of 84% in the refractory BNC that has failed prior direct vision internal urethrotomy (DVIU).

Bladder neck contracture following TURP appears to have no correlation with surgeon experience, but is more likely to appear as a sequel to trans-urethral resection of small-volume prostates due to aggressive overzealous resection of the bladder neck, a complication that can be decreased by the addition of a trans-urethral incision of the vesical neck (150). Bladder neck contracture with complete obliteration of the lumen is a rare but challenging complication of TURP that requires suprapubic cystostomy followed by Seldinger needle access endoscopically, guide wire placement through the stenotic diaphragm, dilation, and subsequent direct visual tri-radial urethrotomy to maintain potency (151).

To reduce the morbidity of traditional monopolar TURP, bipolar resection with various devices has been developed, using normal saline as the irrigant. Several randomized studies have prospectively compared the two techniques without any evidence of a change in the incidence of BNC (125).

### 8.5.3 Management of post–radical prostatectomy vesico-urethral anastomotic strictures

A proposed algorithm for the management of VUAS is shown in Figure 7.



CIC: clean intermittent catheterization.

The definitive management of PUS generally requires endo-urological or open surgical interventions. Conservative interventions such as urethral catheterization or suprapubic cystostomy can temporize until definitive treatment is possible.

Local urethral dilation using male urethral sounds or other forms of radial expansion, such a filiforms and followers, insertion of straight Amplatz (152) or S-shaped (153) co-axial dilators over a guide wire, balloon dilators (154), or an endoscopic dilator system (155,156), may facilitate placement of a urethral drainage catheter or allow initiation of an intermittent self-catheterization protocol. A critical consideration in the treatment of VUAS is the risk of urinary incontinence. Formal electrosurgical incision of BNC after RRP may cause urinary incontinence. As a result, treatment algorithms reserve this intervention for refractory cases or incontinent patients (**Figure 7**).

#### 8.5.3.1 Surgical management – endo-urological

Interruption of the scarred bladder neck fibres is the central premise of endo-urological procedures for VUAS. After radical prostatectomy, a step-wise approach with the goal of preserving urinary continence is advocated. **Table 8** contains reported series of patients managed with endo-urological techniques.

Treatment	Authors	N	Success (%)	Level of Evidence
Dilation	Ramchandani (1994) (157) Geary (1995) (158) Thiel (2006) (36) Park (2001) (13) Herschorn (2007) (153)	27 80 43 26 18	59 38 100 92.3	3
DVIU	Surya (1990) (27) Dalkin (1996) (28) Borboroglu (2000) (5) Gonzalgo (2005) (26)	18 17 52	62 88 58	3 3 3
Trans-urethral resection	Popken (1998) (159)	24	100	3
Holmium:YAG laser	Hayashi (2005) (160) Lagerveld (2005) (161) Eltahawy (2008) (162)	3 10 24	100 100 83	4 4 3
UroLume®	Meulen (1999) (163) Zivan (2001) (164) Elliott (2002) (165) Magera (2009) (166)	2 1 9 25	100 100 88 52	4
Endo-urethroplasty	Chiou (1996) (167) Kuyumcuoglu (2010) (168)	2 11	100 55	4 3

#### **TABLE 8** Endo-urological management of vesico-urethral anastomotic stenosis

Most anastomotic strictures after RRP occur within 6 months. Many investigators differentiate between early, "immature," strictures, which occur days to weeks after catheter removal, and "mature" scar (28). For early post-operative BNC, urethral dilation with sounds, co-axial dilators, balloon dilators, or filiforms and followers is indicated. In all such cases, cystoscopic placement of a guide wire with straight or curved co-axial dilators (13,153) or long filiform reduces the risk of false passage or disruption of a recent anastomosis. Dilation allows for spontaneous voiding while the scarred region stabilizes. The success of dilation in these circumstances is variable, although some series report long-term favourable outcomes with this approach (13,36,157,158). For strictures that fail initial dilation or occur more than 6 weeks after RP, a low-energy incision has been recommended: either cold-knife DVIU or holmium:YAG laser of the VUAS (160–162). Dalkin described deep incisions at the 4- and 8-o'clock positions with a cold-knife direct vision urethrotomy from the proximal area of the contracture to its distal extent (28). Care must be taken to avoid injury to the normal striated sphincter muscle fibres. The incisions were carried down to bleeding tissue; a monopolar cautery electrode was used if hemostasis was required. Catheter drainage was used for 72 hours. In a subsequent publication, Yurkanin and Dalkin reported that voiding, urinary bother, continence, and quality of life were no different in men after DVIU for VUAS when compared to a control group of asymptomatic men post-RRP (169).

Trans-urethral electrosurgical incision has been used when other interventions have failed, including dilation, DVIU, and a course of intermittent self-catheterization. In such circumstances, the much higher risk of incontinence is considered against the likelihood of long-term urethral patency (170). Highly symptomatic patients may be generally willing to accept the risks of incontinence and the necessity of subsequent artificial urinary sphincter (AUS) or male sling surgery.

Numerous cases series and case reports document successful treatment of post-RP VUAS. Coldknife DVIU is advocated most often, and success rates vary from 58%–92% in small retrospective case series (5,26–28,159). Failure of repeated DVIU for VUAS is an extremely challenging problem. Because most open reconstructive techniques compromise continence (170,171), alternatives such as endo-urethroplasty (167,168) and stenting have been proposed as adjuncts to DVIU. Another proposed intervention for recurrent VUAS includes the endoscopic injection of 0.3–0.4 mg/mL of mitomycin C into each incision site at the time of tri- or quadrant DVIU. Vanni *et al.* reported that with this technique, at a median follow-up of 12 months, 13 of 18 patients (72%) had a patent bladder neck after one procedure, as did three (17%) after two procedures, and one after four procedures (149). Seventeen patients had undergone radical prostatectomies, including two with radiation and one post-TURP.

The permanent metallic UroLume stent (AMS; Minnetonka, MN) is used sparingly due to challenges with tissue re-growth and intrusion and migration into the bladder. In selected cases of refractory VUAS, several authors have described successful UroLume implantation (163–166). Although the UroLume has usually been described in conjunction with immediate or subsequent anti-incontinence surgery, use of the shortest possible UroLume stent may preserve sphincteric function.

#### 8.5.3.2 Surgical management – open

In cases of the most severe post-RRP anastomotic stenoses, an aggressive reconstructive approach may be considered. Temporarily diverting suprapubic catheter drainage allows planning for reconstruction or diversion. In selected patients, suprapubic drainage may be the best long-term strategy when faced with severe medical comorbidities, stenosis requiring urinary diversion, or recurrent advanced prostate carcinoma. The literature outlining surgical reconstruction consists of case series, summarized in **Table 9**.

Treatment	Authors	N	Success (%)	Approach	Level of Evidence
	Schlossberg (1995) (172)	2	100	Abdominoperineal	4
	Wessells (1998) (171)	4	100	Abdominoperineal or perineal	4
Urethro- plasty	Theodoros (2000) (173)	6	83	Abdominoperineal	4
	Elliott (2006) (145)	10	70	Abdominoperineal	3
	Simonato (2007) (174)	3	100	Abdominoperineal	4
	Herschorn (2007) (175)	5	100	Abdominal or abdominoperineal	4

#### TABLE 9 Open surgical management of vesico-urethral anastomotic stenosis

Schlossberg *et al.* reported on two patients with obliterative strictures successfully treated with an abdominal and perineal approach, partial pubectomy, omental wrapping, and repeat vesico-urethral anastomosis (172). The patients were dry and voiding at 7 and 18 months post-treatment.

Wessells *et al.* described re-anastomoses in four patients with severe obliterative stenoses (171). One patient underwent excision and end-to-end anastomosis through a combined abdominal and perineal approach. Two patients had a trans-pubic approach with an onlay penile skin graft and rectus muscle flap for one and re-anastomosis with a bladder tube for the other. Both were wrapped with omentum. The fourth patient had a perineal approach with an onlay urethroplasty to the bladder neck with a 7 cm penile fasciocutaneous flap. All were patent at 17–54 months after surgery and all were incontinent. Two underwent AUS implants.

Theodoros *et al.* reported on six men with complex BNC following repeated unsuccessful transurethral resections (173). All underwent abdomino-perineal excision of the stenosis and end-to-end anastomosis with simultaneous AUS implant. Three had simultaneous clam ileocystoplasty for intractable detrusor over-activity. After a mean of 24 months, all were patent, five were continent, and one was improved.

Elliott *et al.* reported a 70% success rate in 10 patients with vesico-urethral re-anastomoses for intractable stenosis following RP in their series of severe urethral complications after prostate cancer therapy (145). Of the four with EBRT, two were unsuccessful, including one who required a fasciocutaneous flap. Six of the patients needed partial or total pubectomy to accomplish the urethroplasty. Incontinence was managed with AUS implant.

Simonato *et al.* reported on three patients with intractable BNC after RP who underwent anterior perineal mobilization of the bulbar urethra, stricture excision, and vesico-urethral re-anastomosis through a perineal incision (174). All were patent but incontinent at 6 months and underwent AUS implant. The mean follow-up for the whole group, including an additional three men with complications of treatment for BPH, was 38 months.

Herschorn reported on five patients with complete occlusion of the vesico-urethral anastomosis who underwent re-anastomoses (175). Three were done via the abdomen alone and two required abdominal and anterior perineal mobilization. All were patent after a mean of 26 months. The three patients with the abdominal-only approach had mild or no incontinence and the other two had moderate to severe incontinence.

Selection of the appropriate procedure requires consideration of surgical exposure, amount of scar to be excised, and sources of healthy vascularized tissue for transfer into the diseased bladder neck region. Patient age, prior surgery or radiotherapy, cancer stage, and life expectancy must all be assessed before intervention. Men with VUAS after RRP can undergo successful excision of the stenosis and re-anastomosis. The types of reconstruction and approach are variable and may depend on the length of stenosis, degree of peri-urethral and pelvic fibrosis, previous radiation, and experience of the surgeon.

Longer stenosis lengths require more perineal and penile urethral mobilization. While this approach is feasible in relatively short stenoses, long defects may require more extensive mobilization of the distal urethra. The primary goal is patency, with many men requiring insertion of an AUS at a later date (171). Catheterization for 3–4 weeks, followed by voiding cysto-urethrography, ensures complete urethral healing prior to catheter removal.

Urinary diversion with the bladder *in situ* has been reported for patients with radiation necrosis, severe neurogenic bladder dysfunction, complex fistulas, and other factors that make reconstruction of the urethra impractical or impossible (176,177).

Ullrich and Wessells reported on cephalad mobilization of the bladder base after resection of the vesico-urethral anastomosis (or prostate if present after TURP or radiation) (176). They incorporated an intestinal segment into the bladder neck and created a cutaneous stoma, and no attempt was made to close the distal urethra. Intestinal tissue was anastomosed to the bladder neck without any tension using a single-layer closure with 2-0 polyglycolic acid suture. The appendix or tapered ileum can be used according to the Mitrofanoff principle for continent catheterizable diversion. A continence mechanism based on the ileocecal valve can also be used (178).

### 8.6 **Recommendations**

- Risk factors for development of VUAS identified in case series and large prospective RP studies can be divided into preoperative, intra-operative, and post-operative categories, and include excessive blood loss, type of bladder neck dissection, post-operative urinary leakage, adjuvant radiotherapy, prior TURP, smoking, older age, obesity, and surgeon experience (Level 2–3). Other risk factors may include open versus minimally invasive surgery (Level 2–3) and acute post-operative retention treated with suprapubic tube (Level 3).
- 2. Following BT, stenosis is the most common long-term serious urinary adverse effect (Level 2–3), and most stenoses that develop within 2–5 years are in the BM region (Level 2–3). Risk factors included older age, non-white race, low income, more comorbidities, combination therapy with EBRT or hormonal therapy, and history of prior TURP (Level 2–3).
- 3. Urethral stenosis after EBRT also increases with long-term follow-up (Level 2–3). Salvage RP is associated with the highest stenosis rate (Level 3).
- 4. Following cryotherapy, prostatic obstruction may occur with tissue sloughing (Level 3). Urethral warming is used to minimize sloughing and prevent stricture occurrence (Level 3).
- 5. Following HIFU, necrotic sloughing of the prostate may occur, necessitating TURP (Level 3). Pre- or post-HIFU TURP may decrease the development of bladder outflow obstruction (Level 3). Long-term BNC may still occur (Level 3).
- 6. Patients with low prostatic resection weights (at TURP for BPH) are predisposed to BNC (Level 2–3).
- 7. Prior to surgery, a basic patient evaluation should consist of a history, physical examination, urinalysis, and PVR urine measurement (Level 1–2; A). Urine (urinalysis, culture, and sensitivity/leukocyte esterase screening test) and blood testing (blood urea nitrogen, creatinine, glucose, PSA) is recommended. Cystoscopy and appropriate imaging of the urinary tract are helpful in guiding therapy (Level 2–3; B). Urodynamics may be helpful to evaluate voiding dysfunction/incontinence (Level 3; C).
- 8. Following radiation, a graded approach to management beginning with endo-urological procedures is recommended (Figure 6). This may be combined with self-dilation. Failures of management may necessitate more invasive approaches, including stents, open reconstruction, or diversion (Level 3; C).
- 9. For VUAS following RP, a graded approach to management beginning with endo-urologic procedures is recommended (Figure 7). This may be combined with self-dilation. Failures of management may necessitate more invasive approaches, including stents, open reconstruction, or diversion (Level 3; C). Concomitant or resultant urinary incontinence may require additional evaluation and surgery (Level 3; C).

#### 8.6.1 Future research

- 1. Continue to document risk factors and associations with localized treatment for prostate cancer.
- 2. Standardization is needed in reporting complications from all sources, including surgeons and radiation oncologists.
- 3. Anatomic classification systems are needed in defining the location of PUS. Classification can also include description of incremental anatomic severity. Higher-grade lesions should be associated with greater morbidity, warrant more complex treatment, and may have worse prognoses. No accepted grading system exists yet for VUAS.
- 4. Identify intra-operative techniques of RP that are associated with lower risk of VUAS.
- 5. Standardization is needed in work-up for accurate delineation of the stenosis and its morbidity.
- 6. Registry of surgical cases of stenoses after RP and radiation to create larger cohorts is needed.
- 7. Randomized trials of interventional techniques, both endo-urological and open, are needed.

### 8.7 References

- 1. American Cancer Society. Cancer facts & figures 2010. 2010. p. 23-37. Available: http://www.cancer.org/acs/groups/content/@ nho/document/acspc-024113.pdf; Accessed: March 30, 2012.
- 2. Elliott SP, Jarosek SL, Virnig BA. Unpublished analysis of SEER public use file 1992–2006. Personal Communication.
- Cooperberg MR, Lubeck DP, Meng MV, et al. The changing face of low-risk prostate cancer: Trends in clinical presentation and primary management. J Clin Oncol. 2004;22(1):2141-2149.
- 4. Levels of evidence. BJU Int. 2008;101:1333.
- Borboroglu PG, Sands JP, Roberts JL, et al. Risk factors for vesicourethral anastomotic stricture after radical prostatectomy. Urology. 2000;56(1):96-100.
- Kao TC, Cruess DF, Garner D, et al. Multicenter patient self-reporting questionnaire on impotence, incontinence and stricture after radical prostatectomy. J Urol. 2000;163(3):858-864.
- Potosky AL, Warren JL, Riedel ER, et al. Measuring complications of cancer treatment using the SEER-Medicare data. Med Care. 2002;40(8 Suppl):IV-62-68.
- 8. Hu JC, Gold KF, Pashos CL, et al. Role of surgeon volume in radical prostatectomy outcomes. J Clin Oncol. 2003;21(3):401-405.
- 9. Yildirim A, Basok EK, Ilhan AI, *et al.* The impact of urinary drainage on the development of anastomotic stricture after radical retropubic prostatectomy. Int Urol Nephrol. 2008;40(3):667-673.
- 10. Augustin H, Pummer K, Daghofer F, *et al.* Patient self-reporting questionnaire on urological morbidity and bother after radical retropubic prostatectomy. Eur Urol. 2002;42(2):112-117.
- 11. Ruiz-Deya G, Davis R, Srivastav SK, et al. Outpatient radical prostatectomy: Impact of standard perineal approach on patient outcome. J Urol. 2001;166(2):581-586.
- 12. Poon M, Ruckle H, Bamshad BR, *et al.* Radical retropubic prostatectomy: Bladder neck preservation versus reconstruction. J Urol. 2000;163(1):194-198.
- 13. Park R, Martin S, Goldberg JD, *et al.* Anastomotic strictures following radical prostatectomy: Insights into incidence, effectiveness of intervention, effect on continence, and factors predisposing to occurrence. Urology. 2001;57(4):742-746.
- 14. Begg CB, Riedel ER, Bach PB, et al. Variations in morbidity after radical prostatectomy. N Engl J Med. 2002;346(15):1138-1144.
- Erickson BA, Meeks JJ, Roehl KA, et al. Bladder neck contracture after retropubic radical prostatectomy: Incidence and risk factors from a large single-surgeon experience. BJU Int. 2009;104(11):1615-1619.
- 16. Carlsson S, Nilsson AE, Schumacher MC, *et al.* Surgery-related complications in 1253 robot-assisted and 485 open retropubic radical prostatectomies at the Karolinska University Hospital, Sweden. Urology. 2010;75(5):1092-1097.
- 17. Breyer BN, Davis CB, Cowan JE, *et al.* Incidence of bladder neck contracture after robot-assisted laparoscopic and open radical prostatectomy. BJU Int. 2010;106(11):1734-1738.
- 18. Gillitzer R, Thomas C, Wiesner C, *et al.* Single center comparison of anastomotic strictures after radical perineal and radical retropubic prostatectomy. Urology. 2010;76(2):417-422.
- Elliott SP, Meng MV, Elkin EP, et al. Incidence of urethral stricture after primary treatment for prostate cancer: Data from CaPSURE. J Urol. 2007;178(2):529-534.
- Hu JC, Gu X, Lipsitz SR, et al. Comparative effectiveness of minimally invasive vs open radical prostatectomy. JAMA. 2009;302(14):1557-1564.
- 21. Rabbani F, Yunis LH, Pinochet R, *et al.* Comprehensive standardized report of complications of retropubic and laparoscopic radical prostatectomy. Eur Urol. 2010;57(3):371-386.
- Frazier HA, Robertson JE, Paulson DF. Radical prostatectomy: The pros and cons of the perineal versus retropubic approach. J Urol. 1992;147(3 Pt 2):888-890.

- 23. Levy JB, Ramchandani P, Berlin JW, et al. Vesicourethral healing following radical prostatectomy: Is it related to surgical approach? Urology. 1994;44(6):888-892.
- 24. Gillitzer R, Melchior SW, Hampel C, *et al.* Specific complications of radical perineal prostatectomy: A single institution study of more than 600 cases. J Urol. 2004;172(1):124-128.
- 25. Besarani D, Amoroso P, Kirby R. Bladder neck contracture after radical retropubic prostatectomy. BJU Int. 2004;94(9):1245-1247.
- 26. Gonzalgo ML, Pavlovich CP, Trock BJ, *et al.* Classification and trends of perioperative morbidities following laparoscopic radical prostatectomy. J Urol. 2005;174(1):135-139.
- Surya BV, Provet J, Johanson KE, et al. Anastomotic strictures following radical prostatectomy: Risk factors and management. J Urol. 1990;143(4):755-758.
- 28. Dalkin BL. Endoscopic evaluation and treatment of anastomotic strictures after radical retropubic prostatectomy. J Urol. 1996;155(1):206-208.
- 29. Sano T, Iguchi R, Asaki S, *et al.* Relationship between type of suture and anastomotic stricture after radical prostatectomy [Article in Japanese]. Hinyokika Kiyo. 2010;56(2):95-98.
- 30. Huang G, Lepor H. Factors predisposing to the development of anastomotic strictures in a single-surgeon series of radical retropubic prostatectomies. BJU Int. 2006;97(2):255-258.
- 31. Kostakopoulos A, Argiropoulos V, Protogerou V, *et al.* Vesicourethral anastomotic strictures after radical retropubic prostatectomy: The experience of a single institution. Urol Int. 2004;72(1):17-20.
- Gallo L, Perdonà S, Autorino R, et al. Vesicourethral anastomosis during radical retropubic prostatectomy: Does the number of sutures matter? Urology. 2007;69(3):547-551.
- Igel TC, Wehle MJ. Vesicourethral reconstruction in radical retropubic prostatectomy: An alternative technique. J Urol. 1999;161(3):844-846.
- 34. Srougi M, Paranhos M, Leite KM, *et al.* The influence of bladder neck mucosal eversion and early urinary extravasation on patient outcome after radical retropubic prostatectomy: A prospective controlled trial. BJU Int. 2005;95(6):757-760.
- Ozu C, Hagiuda J, Nakagami Y, et al. Radical retropubic prostatectomy with running vesicourethral anastomosis and early catheter removal: Our experience. Int J Urol. 2009;16(5):487-492.
- 36. Thiel DD, Igel TC, Brisson TE, *et al.* Outcomes with an alternative anastomotic technique after radical retropubic prostatectomy: 10-year experience. Urology. 2006;68(1):132-136.
- 37. Crew JP, Jephcott CR, Reynard JM. Radiation-induced haemorrhagic cystitis. Eur Urol. 2001;40(2):111-123.
- 38. deVries CR, Freiha FS. Hemorrhagic cystitis: A review. J Urol. 1990;143(1):1-9.
- Zietman AL, DeSilvio ML, Slater JD, et al. Comparison of conventional-dose vs high-dose conformal radiation therapy in clinically localized adenocarcinoma of the prostate: A randomized controlled trial. JAMA. 2005;294(10):1233-1239.
- 40. Zelefsky MJ, Fuks Z, Hunt M, *et al.* High dose radiation delivered by intensity modulated conformal radiotherapy improves the outcome of localized prostate cancer. J Urol. 2001;166(3):876-881.
- 41. Pollack A, Zagars GK, Starkschall G, *et al.* Prostate cancer radiation dose response: Results of the M. D. Anderson phase III randomized trial. Int J Radiat Oncol Biol Phys. 2002;53(5):1097-1105.
- 42. Lukka H, Warde P, Pickles T, *et al.* Controversies in prostate cancer radiotherapy: Consensus development. Can J Urol. 2001;8(4):1314-1322.
- 43. McVey GP, McPhail S, Fowler S, *et al.* Initial management of low-risk localized prostate cancer in the UK: Analysis of the British Association of Urological Surgeons Cancer Registry. BJU Int. 2010;106(8):1161-1164.
- Mate TP, Gottesman JE, Hatton J, *et al.* High dose-rate afterloading 1921ridium prostate brachytherapy: Feasibility report. Int J Radiat Oncol Biol Phys. 1998;41(3):525-533.
- 45. Aström L, Pedersen D, Mercke C, *et al.* Long-term outcome of high dose rate brachytherapy in radiotherapy of localised prostate cancer. Radiother Oncol. 2005;74(2):157-161.
- 46. Morton GC. The emerging role of high-dose-rate brachytherapy for prostate cancer. Clin Oncol (R Coll Radiol). 2005;17(4):219-227.

- 47. Zelefsky MJ, Hollister T, Raben A, *et al.* Five-year biochemical outcome and toxicity with transperineal CT-planned permanent I-125 prostate implantation for patients with localized prostate cancer. Int J Radiat Oncol Biol Phys. 2000;47(5):1261-1266.
- Allen ZA, Merrick GS, Butler WM, et al. Detailed urethral dosimetry in the evaluation of prostate brachytherapy-related urinary morbidity. Int J Radiat Oncol Biol Phys. 2005;62(4):981-987.
- 49. Herstein A, Wallner K, Merrick G, et al. I-125 versus Pd-103 for low-risk prostate cancer: Long-term morbidity outcomes from a prospective randomized multicenter controlled trial. Cancer J. 2005;11(5):385-389.
- 50. Kollmeier MA, Stock RG, Cesaretti J, *et al.* Urinary morbidity and incontinence following transurethral resection of the prostate after brachytherapy. J Urol. 2005;173(3):808-812.
- 51. Zelefsky MJ, Yamada Y, Cohen GN, *et al.* Five-year outcome of intraoperative conformal permanent I-125 interstitial implantation for patients with clinically localized prostate cancer. Int J Radiat Oncol Biol Phys. 2007;67(1):65-70.
- 52. Mabjeesh NJ, Chen J, Stenger A, *et al.* Preimplant predictive factors of urinary retention after iodine 125 prostate brachytherapy. Urology. 2007;70(3):548-553.
- 53. Anderson JF, Swanson DA, Levy LB, *et al.* Urinary side effects and complications after permanent prostate brachytherapy: The MD Anderson Cancer Center experience. Urology. 2009;74(3):601-605.
- Luo HL, Fang FM, Chuang YC, et al. Previous transurethral resection of the prostate is not a contraindication to high-dose rate brachytherapy for prostate cancer. BJU Int. 2009;104(11):1620-1623.
- 55. Deger S, Boehmer D, Roigas J, *et al.* High dose rate (HDR) brachytherapy with conformal radiation therapy for localized prostate cancer. Eur Urol. 2005;47(4):441-448.
- 56. Martinez A, Gonzalez J, Spencer W, *et al.* Conformal high dose rate brachytherapy improves biochemical control and cause specific survival in patients with prostate cancer and poor prognostic factors. J Urol. 2003;169(3):974-979.
- 57. Phan TP, Syed AM, Puthawala A, *et al.* High dose rate brachytherapy as a boost for the treatment of localized prostate cancer. J Urol. 2007;177(1):123-127.
- 58. Vicini FA, Kestin LL, Martinez AA. Use of conformal high-dose rate brachytherapy for management of patients with prostate cancer: Optimizing dose escalation. Tech Urol. 2000;6(2):135-145.
- 59. Pellizzon AC, Salvajoli JV, Maia MA, *et al.* Late urinary morbidity with high dose prostate brachytherapy as a boost to conventional external beam radiation therapy for local and locally advanced prostate cancer. J Urol. 2004;171(3):1105-1108.
- 60. Albert M, Tempany CM, Schultz D, et al. Late genitourinary and gastrointestinal toxicity after magnetic resonance image-guided prostate brachytherapy with or without neoadjuvant external beam radiation therapy. Cancer. 2003;98(5):949-954.
- 61. Wehle MJ, Lisson SW, Buskirk SJ, *et al.* Prediction of genitourinary tract morbidity after brachytherapy for prostate adenocarcinoma. Mayo Clin Proc. 2004;79(3):314-317.
- 62. Sarosdy MF. Urinary and rectal complications of contemporary permanent transperineal brachytherapy for prostate carcinoma with or without external beam radiation therapy. Cancer. 2004;101(4):754-760.
- 63. Merrick GS, Butler WM, Wallner KE, *et al.* Risk factors for the development of prostate brachytherapy related urethral strictures. J Urol. 2006;175(4):1376-1380.
- Chen AB, D'Amico AV, Neville BA, et al. Patient and treatment factors associated with complications after prostate brachytherapy. J Clin Oncol. 2006;24(33):5298-3504.
- 65. Chen YC, Chuang CK, Hsieh ML, et al. High-dose-rate brachytherapy plus external beam radiotherapy for T1 to T3 prostate cancer: An experience in Taiwan. Urology. 2007;70(1):101-105.
- 66. Nohara T, Mizokami A, Kumano T, *et al.* Clinical results of iridium-192 high dose rate brachytherapy with external beam radiotherapy. Jpn J Clin Oncol. 2010;40(7):677-683.
- 67. Sullivan L, Williams SG, Tai KH, *et al.* Urethral stricture following high dose rate brachytherapy for prostate cancer. Radiother Oncol. 2009;91(2):232-236.
- Lawton CA, Bae K, Pilepich M, et al. Long-term treatment sequelae after external beam irradiation with or without hormonal manipulation for adenocarcinoma of the prostate: Analysis of radiation therapy oncology group studies 85-31, 86-10, and 92-02. Int J Radiat Oncol Biol Phys. 2008;70(2):437-441.

- 69. Lawton CA, Won M, Pilepich MV, *et al.* Long-term treatment sequelae following external beam irradiation for adenocarcinoma of the prostate: Analysis of RTOG studies 7506 and 7706. Int J Radiat Oncol Biol Phys. 1991;21(4):935-939.
- 70. Gardner BG, Zietman AL, Shipley WU, *et al.* Late normal tissue sequelae in the second decade after high dose radiation therapy with combined photons and conformal protons for locally advanced prostate cancer. J Urol. 2002;167(1):123-126.
- 71. Chism DB, Horwitz EM, Hanlon AL, *et al.* Late morbidity profiles in prostate cancer patients treated to 79-84 Gy by a simple four-field coplanar beam arrangement. Int J Radiat Oncol Biol Phys. 2003;55(1):71-77.
- 72. Al-Mamgani A, Heemsbergen WD, Peeters ST, *et al.* Role of intensity-modulated radiotherapy in reducing toxicity in dose escalation for localized prostate cancer. Int J Radiat Oncol Biol Phys. 2009;73(3):685-691.
- 73. Chen MJ, Weltman E, Hanriot RM, *et al.* Intensity modulated radiotherapy for localized prostate cancer: Rigid compliance to dose-volume constraints as a warranty of acceptable toxicity? Radiat Oncol. 2007;2:6.
- 74. Zelefsky MJ, Levin EJ, Hunt M, *et al.* Incidence of late rectal and urinary toxicities after three-dimensional conformal radiotherapy and intensity-modulated radiotherapy for localized prostate cancer. Int J Radiat Oncol Biol Phys. 2008;70(4):1124-1129.
- 75. Ost P, Fonteyne V, Villeirs G, *et al.* Adjuvant high-dose intensity-modulated radiotherapy after radical prostatectomy for prostate cancer: Clinical results in 104 patients. Eur Urol. 2009;56(4):669-675.
- 76. Macdonald OK, Lee RJ, Snow G, *et al.* Prostate-specific antigen control with low-dose adjuvant radiotherapy for high-risk prostate cancer. Urology. 2007;69(2):295-299.
- 77. Cozzarini C, Fiorino C, Di Muzio N, *et al.* Hypofractionated adjuvant radiotherapy with helical tomotherapy after radical prostatectomy: Planning data and toxicity results of a phase I-II study. Radiother Oncol. 2008;88(1):26-33.
- 78. De Meerleer G, Fonteyne V, Meersschout S, *et al.* Salvage intensity-modulated radiotherapy for rising PSA after radical prostatectomy. Radiother Oncol. 2008;89(2):205-213.
- 79. Gotto GT, Yunis LH, Vora K, *et al.* Impact of prior prostate radiation on complications after radical prostatectomy. J Urol. 2010;184(1):136-142.
- Merrick GS, Butler WM, Lief JH, et al. Temporal resolution of urinary morbidity following prostate brachytherapy. Int J Radiat Oncol Biol Phys. 2000;47(1):121-128.
- 81. Merrick GS, Butler WM, Tollenaar BG, *et al.* The dosimetry of prostate brachytherapy-induced urethral strictures. Int J Radiat Oncol Biol Phys. 2002;52(2):461-468.
- Wallner K, Roy J, Harrison L. Tumor control and morbidity following transperineal iodine 125 implantation for stage T1/T2 prostatic carcinoma. J Clin Oncol. 1996;14(2):449-453.
- Zelefsky MJ, Wallner KE, Ling CC, *et al.* Comparison of the 5-year outcome and morbidity of three-dimensional conformal radiotherapy versus transperineal permanent iodine-125 implantation for early-stage prostatic cancer. J Clin Oncol. 1999;17(2):517-522.
- 84. Grills IS, Martinez AA, Hollander M, *et al.* High dose rate brachytherapy as prostate cancer monotherapy reduces toxicity compared to low dose rate palladium seeds. J Urol. 2004;171(3):1098-1104.
- Ragde H, Blasko JC, Grimm PD, et al. Interstitial iodine-125 radiation without adjuvant therapy in the treatment of clinically localized prostate carcinoma. Cancer. 1997;80(3):442-453.
- 86. Moreira SG Jr, Seigne JD, Ordorica RC, *et al.* Devastating complications after brachytherapy in the treatment of prostate adenocarcinoma. BJU Int. 2004;93(1):31-35.
- 87. Deger S, Boehmer D, Turk I, et al. High dose rate brachytherapy of localized prostate cancer. Eur Urol. 2002;41(4):420-426.
- Marks LB, Carroll PR, Dugan TC, *et al*. The response of the urinary bladder, urethra, and ureter to radiation and chemotherapy. Int J Radiat Oncol Biol Phys. 1995;31(5):1257-1280.
- 89. Seymore CH, el-Mahdi AM, Schellhammer PF. The effect of prior transurethral resection of the prostate on post radiation urethral strictures and bladder neck contractures. Int J Radiat Oncol Biol Phys. 1986;12(9):1597-1600.
- 90. Madersbacher S, Marberger M. Is transurethral resection of the prostate still justified? BJU Int. 1999;83(3):227-237.
- 91. Varkarakis J, Bartsch G, Horninger W. Long-term morbidity and mortality of transurethral prostatectomy: A 10-year follow-up. Prostate. 2004;58(3):248-251.

- Galalae RM, Kovács G, Schultze J, et al. Long-term outcome after elective irradiation of the pelvic lymphatics and local dose escalation using high-dose-rate brachytherapy for locally advanced prostate cancer. Int J Radiat Oncol Biol Phys. 2002;52(1):81-90.
- 93. Chon BH, Loeffler JS. The effect of nonmalignant systemic disease on tolerance to radiation therapy. Oncologist. 2002;7(2):136-143.
- 94. Sandhu AS, Zelefsky MJ, Lee HJ, *et al.* Long-term urinary toxicity after 3-dimensional conformal radiotherapy for prostate cancer in patients with prior history of transurethral resection. Int J Radiat Oncol Biol Phys. 2000;48(3):643-647.
- Zaider M, Zelefsky MJ, Cohen GN, et al. Methodology for biologically-based treatment planning for combined low-doserate (permanent implant) and high-dose-rate (fractionated) treatment of prostate cancer. Int J Radiat Oncol Biol Phys. 2005;61(3):702-713.
- 96. Damore SJ, Syed AM, Puthawala AA, *et al.* Needle displacement during HDR brachytherapy in the treatment of prostate cancer. Int J Radiat Oncol Biol Phys. 2000;46(5):1205-1211.
- 97. Hoskin PJ, Bownes PJ, Ostler P, *et al.* High dose rate afterloading brachytherapy for prostate cancer: Catheter and gland movement between fractions. Radiother Oncol. 2003;68(3):285-288.
- Martinez AA, Pataki I, Edmundson G, *et al.* Phase II prospective study of the use of conformal high-dose-rate brachytherapy as monotherapy for the treatment of favorable stage prostate cancer: A feasibility report. Int J Radiat Oncol Biol Phys. 2001;49(1):61-69.
- 99. Zelefsky MJ, Chan H, Hunt M, *et al.* Long-term outcome of high dose intensity modulated radiation therapy for patients with clinically localized prostate cancer. J Urol. 2006;176(4 Pt 1):1415-1419.
- 100. Lam JS, Pisters LL, Belldegrun AS. Cryotherapy for prostate cancer. In: Wein AJ, Kavoussi LR, Novick AC, *et al.*, editors. Campbell-Walsh urology. 9th ed. Philadelphia (PA): Saunders Elsevier; 2007. p. 3032-3052.
- 101. Shinohara K, Connolly JA, Presti JC Jr, *et al.* Cryosurgical treatment of localized prostate cancer (stages T1 to T4): Preliminary results. J Urol. 1996;156(1):115-120.
- 102. Koppie TM, Grossfeld GD, Miller D, et al. Patterns of treatment of patients with prostate cancer initially managed with surveillance: Results from the CaPSURE database. Cancer of the Prostate Strategic Urological Research Endeavor. J Urol. 2000;164(1):81-88.
- 103. Long JP, Bahn D, Lee F, *et al.* Five-year retrospective, multi-institutional pooled analysis of cancer-related outcomes after cryosurgical ablation of the prostate. Urology. 2001;57(3):518-523.
- 104. Bahn DK, Lee F, Badalament R, et al. Targeted cryoablation of the prostate: 7-year outcomes in the primary treatment of prostate cancer. Urology. 2002;60(2 Suppl 1):3-11.
- 105. Donnelly BJ, Saliken JC, Ernst DS, *et al.* Prospective trial of cryosurgical ablation of the prostate: Five-year results. Urology. 2002;60(4):645-649.
- Han KR, Cohen JK, Miller RJ, et al. Treatment of organ confined prostate cancer with third generation cryosurgery: Preliminary multicenter experience. J Urol. 2003;170(4 Pt 1):1126-1130.
- 107. Prepelica KL, Okeke Z, Murphy A, *et al.* Cryosurgical ablation of the prostate: High risk patient outcomes. Cancer. 2005;103(8):1625-1630.
- 108. Gonder MJ, Soanes WA, Smith V. Experimental prostate cryosurgery. Invest Urol. 1964;1:610-619.
- 109. Gage AA, Baust J. Mechanisms of tissue injury in cryosurgery. Cryobiology. 1998;37(3):171-186.
- 110. Cooper IS, Hirose T. Application of cryogenic surgery to resection of parenchymal organs. N Engl J Med. 1966;274(1):15-18.
- 111. Coogan CL, McKiel CF. Percutaneous cryoablation of the prostate: Preliminary results after 95 procedures. J Urol. 1995;154(5):1813-1817.
- 112. Wieder J, Schmidt JD, Casola G, *et al.* Transrectal ultrasound-guided transperineal cryoablation in the treatment of prostate carcinoma: Preliminary results. J Urol. 1995;154(2 Pt 1):435-441.
- 113. Cohen JK, Miller RJ, Rooker GM, *et al.* Cryosurgical ablation of the prostate: Two-year prostate-specific antigen and biopsy results. Urology. 1996;47(3):395-401.

- 114. Long JP, Fallick ML, LaRock DR, et al. Preliminary outcomes following cryosurgical ablation of the prostate in patients with clinically localized prostate carcinoma. J Urol. 1998;159(2):477-484.
- 115. Pisters LL. Cryotherapy for prostate cancer: Ready for prime time? Curr Opin Urol. 2010;20(3):218-222.
- 116. Izawa JI, Ajam K, McGuire E, *et al.* Major surgery to manage definitively severe complications of salvage cryotherapy for prostate cancer. J Urol. 2000;164(6):1978-1981.
- 117. Ghafar MA, Johnson CW, De La Taille A, *et al.* Salvage cryotherapy using an argon based system for locally recurrent prostate cancer after radiation therapy: The Columbia experience. J Urol. 2001;166(4):1333-1337.
- 118. Cox RL, Crawford ED. Complications of cryosurgical ablation of the prostate to treat localized adenocarcinoma of the prostate. Urology. 1995;45(6):932-935.
- 119. Ahmed HU, Ishaq A, Zacharakis E, *et al.* Rectal fistulae after salvage high-intensity focused ultrasound for recurrent prostate cancer after combined brachytherapy and external beam radiotherapy. BJU Int. 2009;103(3):321-323.
- 120. Challacombe BJ, Murphy DG, Zakri R, *et al.* High-intensity focused ultrasound for localized prostate cancer: Initial experience with a 2-year follow-up. BJU Int. 2009;104(2):200-204.
- Murat FJ, Poissonnier L, Rabilloud M, et al. Mid-term results demonstrate salvage high-intensity focused ultrasound (HIFU) as an effective and acceptably morbid salvage treatment option for locally radiorecurrent prostate cancer. Eur Urol. 2009;55(3):640-647.
- 122. Chalasani V, Martinez CH, Lim D, *et al.* Salvage HIFU for recurrent prostate cancer after radiotherapy. Prostate Cancer Prostatic Dis. 2009;12(2):124-129.
- 123. Chaussy C, Thüroff S. High-intensity focused ultrasound in the management of prostate cancer. Expert Rev Med Devices. 2010;7(2):209-217.
- 124. Thüroff S, Chaussy C, Vallancien G, *et al.* High-intensity focused ultrasound and localized prostate cancer: Efficacy results from the European multicentric study. J Endourol. 2003;17(8):673-677.
- 125. Iori F, Franco G, Leonardo C, *et al.* Bipolar transurethral resection of prostate: Clinical and urodynamic evaluation. Urology. 2008;71(2):252-255.
- 126. Uchida T, Ohkusa H, Nagata Y, *et al.* Treatment of localized prostate cancer using high-intensity focused ultrasound. BJU Int. 2006;97(1):56-61.
- 127. Madersbacher S, Schatzl G, Djavan B, *et al.* Long-term outcome of transrectal high-intensity focused ultrasound therapy for benign prostatic hyperplasia. Eur Urol. 2000;37(6):687-694.
- 128. Chaussy C, Thüroff S. The status of high-intensity focused ultrasound in the treatment of localized prostate cancer and the impact of a combined resection. Curr Urol Rep. 2003;4(3):248-252.
- 129. Vallancien G, Prapotnich D, Cathelineau X, *et al.* Transrectal focused ultrasound combined with transurethral resection of the prostate for the treatment of localized prostate cancer: Feasibility study. J Urol. 2004;171(6 Pt 1):2265-2267.
- 130. Blana A, Hierl J, Rogenhofer S, *et al.* Factors predicting for formation of bladder outlet obstruction after high-intensity focused ultrasound in treatment of localized prostate cancer. Urology. 2008;71(5):863-867.
- 131. Wei JT, Calhoun E, Jacobsen SJ. Urologic diseases in America project: Benign prostatic hyperplasia. J Urol. 2005;173(4):1256-1261.
- Lee YH, Chiu AW, Huang JK. Comprehensive study of bladder neck contracture after transurethral resection of prostate. Urology. 2005;65(3):498-503.
- Rassweiler J, Seemann O, Schulze M, et al. Laparoscopic versus open radical prostatectomy: A comparative study at a single institution. J Urol. 2003;169(5):1689-1693.
- 134. American Urological Association Education and Research Inc. Results of the treatment outcomes analyses. 2003. Available: http://www.auanet.org/content/guidelines-and-quality-care/clinical-guidelines/main-reports/bph-management/chapt\_3\_ appendix.pdf; Accessed: October 10. 2010.
- 135. Tan A, Liao C, Mo Z, *et al.* Meta-analysis of holmium laser enucleation versus transurethral resection of the prostate for symptomatic prostatic obstruction. Br J Surg. 2007;94(10):1201-1208.
- Riehmann M, Knes JM, Heisey D, et al. Transurethral resection versus incision of the prostate: A randomized, prospective study. Urology. 1995;45(5):768-775.

- Al-Singary W, Arya M, Patel HR. Bladder neck stenosis after transurethral resection of prostate: Does size matter? Urol Int. 2004;73(3):262-265.
- 138. Greene LF, Leary FJ. Contractures of the vesical neck following transurethral prostatic resection. Surg Gynecol Obstet. 1967;124(6):1277-1282.
- 139. Orandi A. Transurethral incision of the prostate. J Urol. 1973;110(2):229-231.
- 140. Kletscher BA, Oesterling JE. Transurethral incision of the prostate: A viable alternative to transurethral resection. Semin Urol. 1992;10(4):265-272.
- Abrams P, Chapple C, Khoury S, et al. Evaluation and treatment of lower urinary tract symptoms in older men. J Urol. 2009;181(4):1779-1787.
- 142. McVary KT, Roehrborn CG, Avins AL, *et al.* Update on AUA guideline on the management of benign prostatic hyperplasia. J Urol. 2011;185(5):1793-1803.
- 143. Benoit RM, Naslund MJ, Cohen JK. Complications after prostate brachytherapy in the Medicare population. Urology. 2000;55(1):91-96.
- 144. Bullock TL, Brandes SB. Adult anterior urethral strictures: A national practice patterns survey of board certified urologists in the United States. J Urol. 2007;177(2):685-690.
- Elliott SP, McAninch JW, Chi T, et al. Management of severe urethral complications of prostate cancer therapy. J Urol. 2006; 176(6 Pt 1):2508-2513.
- 146. Gómez-Iturriaga Piña A, Crook J, Borg J, *et al.* Median 5 year follow-up of 125iodine brachytherapy as monotherapy in men aged<or=55 years with favorable prostate cancer. Urology. 2010;75(6):1412-1416.
- 147. Sikafi Z, Butler MR, Lane V, et al. Bladder neck contracture following prostatectomy. Br J Urol. 1985;57(3):308-310.
- 148. Wettlaufer JN, Kronmiller P. The management of post-prostatectomy vesical neck contracture. J Urol. 1976;116(4):482-483.
- Vanni A, Zinman L, Buckley J. Management of recurrent bladder neck contractures with urethrotomy and mitomycin C [abstract]. J Urol. 2010;183(4):e426.
- Kulb TB, Kamer M, Lingeman JE, et al. Prevention of post-prostatectomy vesical neck contracture by prophylactic vesical neck incision. J Urol. 1987;137(2):230-231.
- 151. Aygün C, Peskircioglu L, Tekin MI, et al. Endoscopic treatment of complete bladder neck obstruction by transurethral Seldinger technique. Int J Urol. 2001;8(8):455-456.
- 152. Rusnak B, Castaneda-Zuniga W, Kotula F, et al. An improved dilator system for percutaneous nephrostomies. Radiology. 1982;144(1):174.
- 153. Herschorn S, Carrington E. S-shaped coaxial dilators for male urethral strictures. Urology. 2007;69(6):1199-1201.
- 154. Giesy JD, Finn JC, Hermann GD, et al. Coaxial balloon dilation and calibration of urethral strictures. Am J Surg. 1984;147(5):611-614.
- 155. Bapat SS. A new endoscopic urethral dilator. J Urol. 1979;122(1):30-33.
- 156. Soloway MS. Optical dilator to obviate blind urethral dilatation prior to endoscopic resections. Urology. 1988;31(5):427-428.
- Ramchandani P, Banner MP, Berlin JW, et al. Vesicourethral anastomotic strictures after radical prostatectomy: Efficacy of transurethral balloon dilation. Radiology. 1994;193(2):345-349.
- Geary ES, Dendinger TE, Freiha FS, et al. Incontinence and vesical neck strictures following radical retropubic prostatectomy. Urology. 1995;45(6):1000-1006.
- Popken G, Sommerkamp H, Schultze-Seemann W, et al. Anastomotic stricture after radical prostatectomy. Incidence, findings and treatment. Eur Urol. 1998;33(4):382-386.
- 160. Hayashi T, Yoshinaga A, Ohno R, *et al.* Successful treatment of recurrent vesicourethral stricture after radical prostatectomy with holmium laser: Report of three cases. Int J Urol. 2005;12(4):414-416.
- Lagerveld BW, Laguna MP, Debruyne FM, et al. Holmium: YAG laser for treatment of strictures of vesicourethral anastomosis after radical prostatectomy. J Endourol. 2005;19(4):497-501.

- 162. Eltahawy E, Gur U, Virasoro R, et al. Management of recurrent anastomotic stenosis following radical prostatectomy using holmium laser and steroid injection. BJU Int. 2008;102(7):796-798.
- Meulen T, Zambon JV, Janknegt RA. Treatment of anastomotic strictures and urinary incontinence after radical prostatectomy with urolume wallstent and AMS 800 artificial sphincter. J Endourol. 1999;13(7):517-520.
- 164. Zivan I, Stein A. New modality for treatment of resistant anastomotic strictures after radical prostatectomy: UroLume urethral stent. J Endourol. 2001;15(8):869-871.
- 165. Elliott DS, Boone TB. Combined stent and artificial urinary sphincter for management of severe recurrent bladder neck contracture and stress incontinence after prostatectomy: A long-term evaluation. J Urol. 2001;165(2):413-415.
- 166. Magera JS Jr, Inman BA, Elliott DS. Outcome analysis of urethral wall stent insertion with artificial urinary sphincter placement for severe recurrent bladder neck contracture following radical prostatectomy. J Urol. 2009;181(3):1236-1241.
- 167. Chiou RK, Howe S, Morton JJ, *et al.* Treatment of recurrent vesicourethral anastomotic stricture after radical prostatectomy with endourethroplasty. Urology. 1996;47(3):422-425.
- 168. Kuyumcuoglu U, Eryildirim B, Tarhan F, *et al.* Antegrade endourethroplasty with free skin graft for recurrent vesicourethral anastomotic strictures after radical prostatectomy. J Endourol. 2010;24(1):63-67.
- 169. Yurkanin JP, Dalkin BL, Cui H. Evaluation of cold knife urethrotomy for the treatment of anastomotic stricture after radical retropubic prostatectomy. J Urol. 2001;165(5):1545-1548.
- 170. Anger JT, Raj GV, Delvecchio FC, *et al.* Anastomotic contracture and incontinence after radical prostatectomy: A graded approach to management. J Urol. 2005;173(4):1143-1146.
- 171. Wessells H, Morey AF, McAninch JW. Obliterative vesicourethral strictures following radical prostatectomy for prostate cancer: Reconstructive armamentarium. J Urol. 1998;160(4):1373-1375.
- 172. Schlossberg S, Jordan G, Schellhammer P. Repair of obliterative vesicourethral stricture after radical prostatectomy: A technique for preservation of continence. Urology. 1995;45(3):510-513.
- 173. Theodoros C, Katsifotis C, Stournaras P, *et al.* Abdomino-perineal repair of recurrent and complex bladder neck-prostatic urethra contractures. Eur Urol. 2000;38(6):734-740.
- 174. Simonato A, Gregori A, Lissiani A, *et al.* Two-stage transperineal management of posterior urethral strictures or bladder neck contractures associated with urinary incontinence after prostate surgery and endoscopic treatment failures. Eur Urol. 2007;52(5):1499-1504.
- 175. Herschorn S. Management of post-radical prostatectomy complete bladder neck occlusion [abstract]. J Urol. 2007;177(4):14.
- 176. Ullrich NF, Wessells H. A technique of bladder neck closure combining prostatectomy and intestinal interposition for unsalvageable urethral disease. J Urol. 2002;167(2 Pt 1):634-636.
- 177. Herschorn S, Thijssen AJ, Radomski SB. Experience with the hemi-Kock ileocystoplasty with a continent abdominal stoma. J Urol. 1993;149(5):998-1001.
- 178. Rowland RG, Mitchell ME, Bihrle R, et al. Indiana continent urinary reservoir. J Urol. 1987;137(6):1136-1139.

# Committee



# Urethral Strictures in Children

#### CHAIRS

George W. Kaplan, United States John W. Brock, United States

#### MEMBERS

Margit Fisch, Germany Mamdouh M. Koraitim, Egypt Howard M. Snyder, United States

# Committee

# CONTENTS

### Anterior Urethra-Primary Anastomosis

9.1	Background	243
9.2	Introduction	243
9.3	Methods	243
9.4	Meatal Strictures	244
9.5	Anterior Urethra	245
9.6	Posterior Urethra	246
9.7	Discussion	246
	9.7.1 Meatal strictures	246
	9.7.2 Anterior urethra	247
	9.7.3 Posterior urethra	247
9.8	Recommendations	248
	9.8.1 Meatal stenosis	248
	9.8.2 Anterior (penile and bulbar) urethral strictures	249
	9.8.3 Posterior urethral stenoses/pelvic fracture Urethral Injuries	249
9.9	References	250

### 9.1 Background

A literature search was performed through PubMed for articles published from 1990 to the present (c. 2010) on strictures in children. There were 32 articles, which provided the data for this review.

The articles were divided into those that reviewed meatal strictures, anterior (penile and bulbar) urethral strictures, and posterior urethral strictures. Some articles dealt with strictures in both the anterior and posterior urethra. The studies were rated according to the level of evidence and the grade of recommendation using the International Consultation on Urological Diseases (ICUD) standards.

### 9.2 Introduction

Lower tract urinary obstruction is a common problem in pediatric urology. Many of the problems, e.g., posterior and anterior urethral valves, are well characterized. However, strictures of the urethra are more common than urethral valves, yet their etiology and management are not well defined. This review attempts to synthesize the existing literature and to present a consensus to guide management and future research.

### 9.3 Methods

A committee was appointed by the Société Internationale d'Urologie (SIU). The chair conducted a literature search through PubMed for peer-reviewed articles on strictures in children and identified 508 English-language articles from 1990 to the present (c. 2010). These were divided into four groups (A–D) using sequential numbering by fours and one group was sent to each of the committee members. The members were asked to screen their assigned group of articles and select those that were prospective or retrospective series that contained reported data on at least 10 patients 18 years of age or younger. The committee members had previously agreed to extract the following data:

- 1. Etiology of the stricture
- 2. Pertinent information regarding patient presentation (age, symptoms, physical find-ings, laboratory investigations)
- **3.** Imaging (retrograde urethrography, voiding cystourethrography, ultrasound)
- 4. Flow rates, if used
- Treatment (dilation, direct vision urethrotomy, end-to-end anastomosis, flaps, patchgraft onlay—skin vs. buccal mucosa, dorsal vs. ventral onlay, staged vs. single stage)

- 6. Criteria of success
- 7. Length of follow-up
- Modality to diagnose post-treatment recurrence (symptoms, imaging, flow rate, urethroscopy)
- **9**. Minimum follow-up to exclude recurrence

In total, 447 articles were eliminated from further review because they were duplicate listings, not about strictures in children, review articles, expert opinion without data to support the opinion, case series of < 10 children, or series of both adults and children where the children were not separately identifiable.

The remaining 61 articles were reviewed by the entire committee and a further 29 were eliminated because, despite previous screening, they did not deal with urethral strictures in children (in four cases), the pediatric patients could not be separately identified in a series of children and adults (in nine cases), they were duplicates (in eight cases), they had fewer than 10 pediatric patients in the series (in four cases), or were reviews (in four cases). This left 32 articles to provide the data for this review.

The articles were then divided into those that reviewed meatal stenosis (five articles), anterior (penile or bulbar) urethral strictures (13 articles), and posterior urethral strictures (22 articles). Some of the articles dealt with strictures in both the anterior and posterior urethra. Hence, the total is actually > 32. The studies were rated according to the level of evidence and the grade of recommendation using ICUD standards (1,2).

### 9.4 Meatal Strictures

There were between 18 and 100 patients in each of the five series that reported meatal strictures (3-7). The level of evidence of each these articles was 3. Patients ranged in age from 20 months to 15 years. The symptoms with which they presented were decreased stream, prolonged voiding times, or deflected stream.

There was no information about physical examination, laboratory studies, flow rates, or imaging, although one series did mention a pinhole meatus as a physical finding (3).

The treatments used included self-dilation (4), meatotomy using EMLA cream (5), and everting meatoplasty (3). Meatotomy or meatoplasty were used in three series and were successful in 98%–100% of cases; however follow-up was only 13 months in one series (6), > 3 months in another (5), and not stated in a third.

Dilation was successful in 36% and 89% of cases in two series, but many patients required 4 months to 3 years of treatment to achieve success, with 1–9 years of follow-up (4,7). Success was defined as no symptoms and a good stream. The etiology of the meatal strictures was thought to primarily be possible diaper dermatitis in circumcised boys. A few were thought to be secondary to hypospadias repair or lichen sclerosus (LS).

### 9.5 Anterior Urethra

There were between 7 and 119 patients in each of the 13 series that reported children with strictures of the anterior urethra, i.e., the penile or bulbar urethra (8–20). One paper, which reported seven children with anterior urethral strictures also reported seven children with posterior urethral strictures (8). The level of evidence of these articles was 3. The patients' ages ranged from antenatal diagnosis to 18 years. Symptoms included hematuria, pain, daytime wetting, daytime and nighttime wetting, urinary tract infection, retention, decreased stream, straining to void, and dysuria.

There was no information about any physical findings. The glomerular filtration rate was obtained in one series (9). Otherwise, there was no information about laboratory studies. Flow rates were obtained in two series (10,11). Although some children had an obstructive pattern, many had a normal flow pattern despite having a stricture. Voiding cystourethrography and retrograde urethrography were used in four series to diagnose strictures (9,10,12,13); cystoscopy was used in five series, three of which did not use imaging (12–16).

The treatments used included direct vision internal urethrotomy (DVIU) in five series, with a reported success rate of 35%–58% (9,10,17–19); dilation in two series, with 35%–40% success (9,11); dilation with a guide wire in two series, with 42%–84% success (12,14); urethroplasty (excision and re-anastomosis) in three series, with 100% success (8,13,15); buccal mucosal or skin graft in three series, with 87%–100% success (8,13,17); and KTP laser urethrotomy in one series, with 84% success.

Success was defined as good flow and no urinary tract infection (UTI). Follow-up varied from 3 to 44 months. If the patients were followed for at least 4 years, 65% of the strictures treated with direct vision urethrotomy recurred (17–19). The etiology of the strictures was congenital (idiopathic), hypospadias, and trauma.

One series compared stricture rates when different suture materials were used to repair the urethra (20). Strictures were more likely to form if polydioxanone (PDS) was used as suture material (68% developed strictures) as opposed to chromic or polyglycolic acid (PgA) (24% and 7% developed strictures, respectively).

In dealing with strictures following hypospadias repair, open repairs were successful in 87% of cases (17). Direct vision urethrotomy was successful in only 35%–58% of cases of post-hypospadias repair strictures (17–19). While Nd:YAG (neodymium-doped yttrium aluminum garnet) laser urethrotomy was reported to be successful in 84% of cases, the follow-up was short (16).

### 9.6 Posterior Urethra

There were 22 series that included children with posterior urethral stenoses (8,12–15,18,19,21–34). The level of evidence of these articles was 3. The number of patients in each series ranged from 2 to 68. Five series had fewer than 10 children with posterior urethral stenoses but all five also had children with anterior urethral strictures, so that the total number of children reported in each of these series was 10 or more (8,13,14,18,19). Patient age ranged from 2 to 18 years. There was no information regarding symptoms or physical findings.

Urinalysis and urine cultures were reported in two series (21,22) and creatinine was recorded in one (23). Simultaneous antegrade and retrograde urethrograms were reported in 13 series (12,21–32). Cystoscopy was used in six series (12,22,24,26,27,33). Intravenous pyelograms (IVPs) were done in five series, which were all older series (22,23,25,28,29). Flow rates were used post-operatively in five series (12,18,22,27,33).

One series, using urodynamics, showed decreased capacity and compliance, longer voiding times, and decreased flow rates post-treatment (24). A suprapubic tube at the time of injury followed by a perineal end-to-end anastomosis was used in nine series with a success rate between 50% and 93% (8,13,15,18,21,25,30–32). If pubectomy was considered necessary, inferior partial pubectomy was preferred over anterior excision. Augmentation urethroplasty with a tube graft was successful in only 33% of cases (21), while scrotal inlay procedures were successful in 46% (25). Cut-to-the-light procedures were uniformly unsuccessful (34). Dilation with a guide wire was successful in 42% of cases (12,14). Direct vision urethrotomy was successful in 33%–50% of cases (19,33).

Success was defined as no symptoms and no recurrences. The etiology of the posterior urethral strictures was almost always trauma (external or, rarely, iatrogenic). Follow-up was 6 months to 20 years. All of the series examined were pelvic fracture urethral injuries

### 9.7 Discussion

#### 9.7.1 Meatal strictures

It is apparent from this review that the quality of the existing evidence to guide the management of urethral strictures in children is weak and consists almost entirely of retrospective case series. Nevertheless, there are certain opinions that have emerged from this review. Firstly, certain terms, specifically *success* and *recurrence*, should be defined so that there can be unanimity of interpretation of results. A distinction should be made between an unsuccessful outcome and a recurrence of the original stricture. Meatal stenosis arises most frequently in circumcised boys and is thought to be caused by diaper dermatitis. The presenting symptoms are usually a decreased or deflected stream. Meatotomy and meatoplasty are reliable methods of management. Urethral dilation, although sometimes successful, requires repeated dilation over a long period of time to be successful.

Prospective studies in which circumcised boys who are in diapers are randomized to routine application of petroleum jelly ointment to the glans and meatus versus observation without ointment might prove helpful in elucidating the prevention of this problem.

### 9.7.2 Anterior urethra

Strictures of the anterior urethra are often idiopathic (perhaps congenital) or traumatic in origin. However, post-hypospadias strictures also occur with some frequency in the anterior (penile and bulbar) urethra, sometimes as a result of the repair itself and sometimes produced by the catheter used for post-operative drainage.

Strictures of the anterior urethra usually produce symptoms of irritation (hematuria, dysuria, wetting) or obstruction (straining to void or retention). They are best diagnosed with radiographic or endoscopic imaging of the urethra. Unfortunately, flow rates are unreliable unless they demonstrate an obstructive flow pattern. Direct vision urethrotomy is effective in only half of cases, but is probably is not harmful if used only once. Dilation does not seem to be an appropriate treatment, as it must be repeated many times over the patient's life.

End-to-end anastomosis after excision of the stricture is the most effective treatment when it is anatomically feasible, even for post-hypospadias strictures. When end-to-end anastomosis is not feasible, a patch graft of buccal mucosa or skin is usually successful. Inlay procedures are not nearly as successful. It would seem that PDS is best avoided as suture material in urethral repairs.

There is a need for basic research in urethral wound healing, as well as long-term longitudinal studies of clinical results after hypospadias repair and stricture repair. This might elucidate the length of follow-up needed to state with some certainty that a successful outcome has been achieved.

Because urethral strictures in children are not commonly seen, even in centres where there are many urethral reconstructions performed, centres could pool their data to obtain greater numbers, using questionnaires and standardized investigations for consistency in data collection. This may lead to a better understanding of the causes of an unsuccessful outcome.

### 9.7.3 **Posterior urethra**

Stenoses/obliterations of the posterior urethra are almost always traumatic in origin, usually in association with a pelvic fracture. Most of the evidence regarding initial management at the time of injury suggests that placement of a suprapubic catheter is the preferred management. There are no data in children to compare primary endoscopic realignment with placement of a suprapubic catheter alone but adult data would suggest that this approach has merit. Strictures were imaged pre-repair using a simultaneous combination of retrograde and antegrade images of the urethra.

Although the evidence comes from case series, it would appear that delayed end-to-end anastomosis of the urethra through a perineal approach after excision of the stricture is the management most likely to prove successful. Pubectomy, whether inferior or anterior (superior), is only rarely indicated to effect repair, even in children, since a tension-free anastomosis is usually attainable in a perineal approach. A combined perineal and abdominal approach may be indicated in complex cases associated with problems such as bladder neck incompetence or urethral fistulas to the bladder base or rectum.

It seems clear that cut-to-the-light procedures do not work and should be abandoned as definitive therapy. Once again, basic research on urethral wound healing and long-term longitudinal studies of clinical results is needed. Additionally, the one study of urodynamic changes after repair of posterior urethral strictures needs to be repeated. If these findings are confirmed, there needs to be further studies to find reasons for these changes and methods to prevent their occurrence.

### 9.8 Recommendations

### 9.8.1 Meatal stenosis

1. Meatotomy or meatoplasty is generally successful and is the recommended management. Dilation, when successful, requires repeated dilations over extended periods of time and for that reason is not recommended (A).

#### 9.8.2 **Anterior (Penile and Bulbar) Urethral Strictures**

- 1. Flow rates may reveal an obstructive pattern, but the flow pattern may be normal despite the presence of a stricture; hence, uroflowmetry cannot be relied upon to rule out a stricture (B).
- 2. Voiding cystourethrography, retrograde urethrography, and cystoscopy are recommended for diagnosing strictures (A).
- 3. Urethroplasty (excision and re-anastomosis), when feasible, provides the best results, but buccal mucosal or skin grafts are successful if excision and re-anastomosis is not appropriate (A).
- 4. Direct vision internal urethrotomy or dilation is successful in only one third of cases if followed for 5 years, and is not recommended as a first-line treatment (A).
- 5. In dealing with hypospadias strictures, open repairs are usually successful (B).

#### 9.8.3 **Posterior Urethral Stenoses/Pelvic Fracture Urethral Injuries**

- 1. Simultaneous antegrade and retrograde urethrography provides good visualization of the stricture (A).
- End-to-end urethral anastomosis using a perineal approach offers the best chance of success. If pubectomy is necessary to achieve a tension-free anastomosis, inferior partial pubectomy is preferred over anterior (superior) partial excision, especially if a perineal approach is used; however, either approach can yield satisfactory results (A).
- 3. Augmentation with a tube graft and scrotal inlay procedures are successful less often than excision and anastomosis and should be resorted to only in the presence of extensive scarring or shortening of the anterior urethra, which are usually a result of previous failed endoscopic or surgical attempts at repair (A).
- 4. Cut-to-the-light procedures are uniformly unsuccessful and are not recommended. In fact, the literature examined says that "it is not an efficacious procedure in children" (A).

### 9.9 References

- 1. Abrams P, Khoury S, Grant A. Evidence-based medicine overview of the main steps for developing and grading guideline recommendations. Prog Urol. 2007;17(3):681–684.
- 2. Agency for Health Care Policy and Research. Clinical practice guidelines development: Methodological perspectives. Washington DC: US Department of Health and Human Services, Public Health Service; 1992. p. 115-127.
- el-Kasaby AW, el-Baz MA, el-Zayat T. Eversion meatoplasty in management of urethral meatal stenosis. Int Urol Nephrol. 1996;28(2):229-233.
- 4. Searles JM, MacKinnon AE. Home-dilatation of the urethral meatus in boys. BJU Int. 2004;93(4):596-597.
- Cartwright PC, Snow BW, McNees DC. Urethral meatotomy in the office using topical EMLA cream for anesthesia. J Urol. 1996;156(2 Pt 2):857-858.
- Persad R, Sharma S, McTavish J, et al. Clinical presentation and pathophysiology of meatal stenosis following circumcision. Br J Urol. 1995;75(1):91-93.
- 7. Radojicic ZI, Perovic SV, Stojanoski KD. Calibration and dilatation with topical corticosteroid in the treatment of stenosis of neourethral meatus after hypospadias repair. BJU Int. 2006;97(1):166-168.
- Shenfeld OZ, Gdor J, Katz R, *et al.* Urethroplasty, by perineal approach, for bulbar and membranous urethral strictures in children and adolescents. Urology. 2008;71(3):430-433.
- 9. Banks FC, Griffin SJ, Steinbrecher HA, *et al.* Aetiology and treatment of symptomatic idiopathic urethral strictures in children. J Pediatr Urol. 2009;5(3):215-218.
- 10. Sugimoto M, Kakehi Y, Yamashita M, *et al.* Ten cases of congenital urethral stricture in childhood with enuresis. Int J Urol. 2005;12(6):558-562.
- 11. Garibay JT, Reid C, Gonzalez R. Functional evaluation of the results of hypospadias surgery with uroflowmetry. J Urol. 1995;154(2 Pt 2):835-836.
- 12. Chiang DT, A Dewan P. Guide wire-assisted urethral dilation in pediatric urology: Experience of a single surgeon. Urol J. 2007;4(4):226-229.
- Rourke KF, McCammon KA, Sumfest JM, et al. Open reconstruction of pediatric and adolescent urethral strictures: Long-term followup. J Urol. 2003;169(5):1818-1821.
- Dewan PA, Gotov E, Chiang D. Guide wire-assisted urethral dilatation for urethral strictures in pediatric urology. J Pediatr Surg. 2003;38(12):1790-1792.
- Hafez AT, El-Assmy A, Sarhan O, et al. Perineal anastomotic urethroplasty for managing post-traumatic urethral strictures in children: The long-term outcome. BJU Int. 2005;95(3):403-406.
- 16. Faerber GJ, Park JM, Bloom DA. Treatment of pediatric urethral stricture disease with the neodymium:yttrium-aluminum-garnet laser. Urology. 1994;44(2):264-267.
- 17. Duel BP, Barthold JS, Gonzalez R. Management of urethral strictures after hypospadias repair. J Urol. 1998;160(1):170-171.
- Hafez AT, El-Assmy A, Dawaba MS, et al. Long-term outcome of visual internal urethrotomy for the management of pediatric urethral strictures. J Urol. 2005;173(2):595-597.
- Hsiao KC, Baez-Trinidad L, Lendvay T, et al. Direct vision internal urethrotomy for the treatment of pediatric urethral strictures: Analysis of 50 patients. J Urol. 2003;170(3):952-955.
- DiSandro M, Palmer JM. Stricture incidence related to suture material in hypospadias surgery. J Pediatr Surg. 1996;31(7):881-884.
- 21. Orabi S, Badawy H, Saad A, *et al.* Post-traumatic posterior urethral stricture in children: How to achieve a successful repair. J Pediatr Urol. 2008;4(4):290-294.

- Senocak ME, Ciftci AO, Büyükpamukçu N, et al. Transpubic urethroplasty in children: Report of 10 cases with review of the literature. J Pediatr Surg. 1995;30(9):1319-1324.
- 23. Kardar AH, Sundin T, Ahmed S. Delayed management of posterior urethral disruption in children. Br J Urol. 1995;75(4):543-547.
- 24. Otgün I, Karnak I, Senocak ME, *et al.* Late urodynamic findings after treating traumatic rupture of the posterior urethra in boys. BJU Int. 2006;97(2):367-370.
- 25. Koraitim MM. Posttraumatic posterior urethral strictures in children: A 20-year experience. J Urol. 1997;157(2):641-645.
- Balkan E, Kilic N, Dogruyol H. The effectiveness of early primary realignment in children with posterior urethral injury. Int J Urol. 2005;12(1):62-66.
- 27. Basiri A, Shadpour P, Moradi MR, *et al.* Symphysiotomy: A viable approach for delayed management of posterior urethral injuries in children. J Urol. 2002;168(5):2166-2169.
- Podestá ML, Medel R, Castera R, et al. Immediate management of posterior urethral disruptions due to pelvic fracture: Therapeutic alternatives. J Urol. 1997;157(4):1444-1448.
- 29. Avano lu A, Ulman I, Herek O, et al. Posterior urethral injuries in children. Br J Urol. 1996;77(4):597-600.
- El-Sheikh MG, Ziada AM, Sadek SZ, et al. Pediatric and adolescent transperineal anastomotic urethroplasty. J Pediatr Urol. 2008;4(5):333-336.
- Singla M, Jha MS, Muruganandam K, et al. Posttraumatic posterior urethral strictures in children–Management and intermediateterm follow-up in tertiary care center. Urology. 2008;72(3):540-543.
- Zhang J, Xu YM, Qiao Y, et al. An evaluation of surgical approaches for posterior urethral distraction defects in boys. J Urol. 2006;176(1):292-295.
- Hosseini SY, Safarinejad MR. Early versus delayed internal urethrotomy for recurrent urethral stricture after urethroplasty in children. Urol J. 2005;2(3):165-168.
- Tollefson MK, Ashley RA, Routh JC, et al. Traumatic obliterative urethral strictures in pediatric patients: Failure of the cut to light technique at long-term followup. J Urol. 2007;178(4 Pt 2):1656-1658.

# Advancing Urology Worldwide



#### www.siu-urology.org

SIU Central Office | 1155 University Street, Suite 1155, Montréal, Québec, Canada H3B 3A7 Telephone: +1 514 875 5665 Fax: +1 514 875 0205 Email: central.office@ siu-urology.org

## The Société Internationale d'Urologie

The Société Internationale d'Urologie is the world's only truly international professional organization serving the global urological community. Founded in Paris in 1907, the SIU now serves its members from its Central Office in Montreal, Canada.

SIU members represent the full spectrum of clinicians and investigators from all subspecialties that come together to diagnose, treat and support patients with urological disease.

The Society's mission is to enable urologists in all nations, through international cooperation in education and research, to apply the highest standards of urological care to their patients. The SIU is unique in its international scope and its commitment to effecting positive and sustainable change in nations across the world.



The SIU promotes its mission objectives through annual world congresses, training scholarships, equipment donation and maintenance in training centres, donation of teaching materials, and support of the International Consultation on Urological Diseases (ICUD).

Previous ICUD Consultations have addressed the following topics: Urogenital Trauma (2002), Bladder Cancer (2004), Congenital Genital Anomalies (2006), Stone Disease (2007), Penile Cancer (2008, Testicular Cancer (2009), Vesicovaginal Fistula (2010), Urethral Strictures (2010), Prostate Cancer (2011) and Male Lower Urinary Tract Symptoms (2012). Future Consultations include Congenital Anomalies in Children and Upper Tract Transitional Cell Carcinoma (both 2013).

The SIU continues to support its guest lecturer series in conjunction with national urological associations who are interested in hosting an SIU lecture. *Urology* (the "Gold Journal") is the official journal of the SIU.

#### Why Join the SIU?

The Société Internationale d'Urologie is an international democratic body whose first objective is to promote cooperation, education and exchange among urologists of all nations and cultures.

Joining the SIU raises funds for Society activities, heightens awareness of the important work that the Society undertakes in the interest of patient health and welfare, particularly in underserved countries, and provides a truly international forum for specialists active in this area.

Application for membership must be supported by each country's National Section. Active members of each National Section elect a National Delegate and Deputy Delegate to liaise with the Society and to represent them at the National Delegates' Meeting held during each SIU Congress.

All SIU members have a voice in this inclusive organization, which is committed to building increasingly far-reaching educational and endowment activities.

SIU members benefit from the following:

- A subscription to Urology, the "Gold Journal" (international non-member price: \$494 US)
- At least 20% off non-member registration fees at SIU congresses. With the annual cost of membership only \$150 US, you actually offset the cost of membership when you attend our next Congress.
- Online access to the SIU members-only section to view the international membership directory, access exclusive video streaming of live surgeries as they happen, network with international members and training centers, and pay dues online.
- Online access to ICUD Consultation publications
- Quarterly SIU Newsletter
- Peer recognition of belonging to an internationally-respected society
- Annual membership fees are \$150, however, developing countries receive a discount on annual dues. Trainee members are not required to pay unless they wish to receive Urology, in which case a nominal fee is charged.

Please contact central.office@siu-urology.org or visit the website for more details: www.siu-urology.org



