Urethral Trauma

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Introduction

Urethral injuries are uncommon yet potentially devastating, often leading to sequelae such as stricture, impotence, infertility, and incontinence. Anterior urethral trauma most often occurs in conjunction with straddle-type injuries to the perineum; the fixed bulbar urethra is crushed against the pubic ramus. The penile urethra is less susceptible to traumatic injury because of its mobility, although penile injury during intercourse may involve the urethra. Posterior urethral injuries are those located near the external sphincter mechanism, occurring almost exclusively as a result of pelvic fracture. Urological management differs depending on the location of injury but must always secure reliable bladder drainage. Methods of diagnosis and *immediate* treatment of anterior and posterior urethral injuries are similar in many cases. Injuries to the female urethra are rare and are repaired acutely.

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Anterior Urethra

The anterior urethra is divided into two segments, the bulbar and the penile urethra. The penile urethra extends from the external meatus to the penoscrotal junction. The bulbar urethra is located just proximal, between the inferior margin of the urogenital diaphragm and the penoscrotal junction.

Blunt trauma typically affects the bulbar urethra as a result of a straddle injury from a fall, crush, or motor vehicle collision [1]. The bulbar area is susceptible to injury because of its fixed position beneath the inferior pubis [2], where it may be crushed against the inferior pubic ramus. Crush injuries of the penile urethra are uncommon; however, laceration of the tunica albuginea of the penis may extend into the penile urethra in 16–20 % of penile fracture injuries [3, 4].

Penetrating urethral injuries may occur because of gunshot wounds or stab injuries to the penis, buttock, abdomen, or scrotum. Iatrogenic anterior urethral injury is associated with traumatic endoscopic procedures or catheter placement. Delayed injury may arise from a chronic indwelling urethral catheter, particularly near the meatus, secondary to pressure necrosis, infection, or chemical irritation [5].

Diagnosis

Any blunt or penetrating injury to the perineum, genitalia, or pelvis should suggest the possibility of urethral injury, and severity can be suggested by

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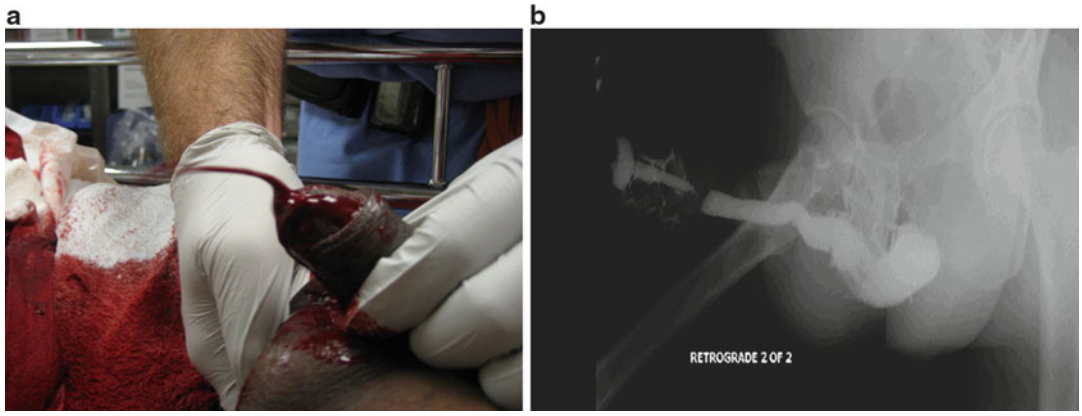

Fig. 6.1 (**a**) Blood from urethra after a worker fell astride a pipe from a height of 2 m. (**b**) Retrograde urethrogram shows contrast extravasation from injury in the bulbar urethra

information about the type of weapon used or the object or force that struck the perineum. A complete voiding history should be obtained, including ability to void spontaneously, time of last void, hematuria, dysuria, and caliber of stream.

The pattern of hematoma and ecchymosis may aid in determining which anatomic spaces are disrupted by an injury [6]. If Buck's fascia is ruptured, blood and urine can extravasate around Colles' fascia, giving a characteristic "butterfly" sign in the perineum [7]. A sleeve distribution limited to the penile shaft indicates that the injury is confined within Buck's fascia.

The finding of blood at the urethral meatus after injury warrants immediate retrograde urethrogram prior to transurethral catheterization (Fig. 6.1). Retrograde urethrography should be performed with contrast injected during film exposure in order to distend the urethra and improve anatomic visualization [8]. Fluoroscopy allows real-time evaluation and immediate appraisal of image quality. If the patient's injuries allow, urethrography should be performed with the penis on stretch and the patient in the oblique position. Contrast may be injected using a Foley catheter, inserted far enough (2–3 cm) for the balloon to be lodged within the fossa navicularis and inflated with 1–2 mL of fluid. Complete visualization of the anterior urethra without extravasation excludes urethral laceration or disruption. Extravasation of contrast is diagnostic of urethral injury; visualization of the entire anterior urethra with an area of extravasation indicates partial disruption, while extravasation with the urethra proximal to this level unfilled with contrast is likely a complete disruption. In men with intact external urinary sphincter tone, contrast may not flow more proximally into the bladder.

Initial Management

The goal of initial management is to provide urinary drainage and minimize potential complications, such as stricture, fistula, and infection. Typically, if the patient is unstable, it is not as a result of urethral injury, so resuscitation is primarily directed at associated injuries to other organs. Moreover, urologic care should be rendered efficiently and effectively in the setting of multisystem trauma; it should not interfere with ongoing treatment of other injuries.

Partial disruptions contained within Buck's fascia can often be managed with transurethral catheterization alone [9]. A Coude catheter or flexible cystoscope is often useful to bypass the injured area safely. Successful healing with a catheter alone is dependent on the preservation of a partially intact mucosa.

Blunt anterior urethral injuries associated with extensive soft tissue damage make evaluation of the extent of injury difficult. Even if urethral continuity is partially maintained, suprapubic catheter diversion is warranted as the risk of dense stricture formation is high [10]. Open debridement

of the urethra and corpus spongiosum is not advised after blunt injury because bruised, otherwise viable erectile tissue may recover even though it can appear ischemic acutely. Overzealous debridement may result in large wounds that require major delayed reconstruction [11]. Significant urethral injury associated with scarring of corpus spongiosum usually results in significant stricture that requires delayed formal urethral reconstruction [12]. Broad-spectrum antibiotics are indicated in patients with extensive extravasation of blood or urine, and suprapubic catheter diversion is advisable, even if a urethral catheter can be placed.

Suprapubic cystostomy is a practical, simple solution for acute management of major injuries. It avoids urethral manipulation and removes the risk of the patient developing acute urinary retention after urethral catheter removal. This is particularly important in crush injuries, such as severe straddle injuries, where a stricture may develop in the weeks following the injury. Suprapubic catheterization is important because it facilitates a period of "urethral rest" where the phases of wound stabilization progress without the continued trauma of an indwelling urethral catheter or repeated instrumentation [13].

Percutaneous placement of a suprapubic catheter is efficient and can be completed in the emergency department; transabdominal sonography can be used to guide the catheter's placement. We prefer to use a 16 Fr Foley catheter inserted via a peel-away sheath system. Open cystostomy may be preferable if the bladder is not palpable suprapubically or the patient is going to the operating room immediately. When suprapubic cystotomy is used as the primary treatment option, the cystotomy tube is maintained for approximately 4 weeks to allow urethral healing. It is then clamped, and voiding cystourethrography is performed. Once normal voiding is confirmed and stable, the tube can be safely removed [2]. When in doubt, a trial of voiding for 1–2 weeks with the suprapubic catheter capped is a prudent option.

Urethral injuries occurring in the context of penile fracture or penetrating trauma are best managed with primary surgical repair. Injuries in the bulbar urethra are usually easily treated by mobilization of the surrounding corpus spongiosum. The authors prefer repair over a 16Fr. catheter with fine, monofilament suture, such as 5-0 PDS. The edges of the urethra should be spatulated to avoid contraction of a concentric scar. The catheter should be left in place for 3 weeks and a voiding urethrogram done at time of removal (Fig. 6.2). Again, debridement of urethral mucosa and the corpus spongiosum should be done sparingly.

Primary repair is probably not justified for transections of the urethra following high-velocity penetrating trauma, such as by military or high-powered rifles, as the energy imparted to the surrounding tissue by the high-velocity missile may cause extensive damage to surrounding tissue that is not immediately apparent. Similarly, primary repair may not be best for extensive injuries to the penile urethra that would require heroic mobilization of the surrounding pendulous urethra, potentially leading to penile curvature. Delicate surgery, such as tissue grafting or flaps, should not be performed in the acute setting. Treatment should be suprapubic diversion, local wound care, and delayed urethral reconstruction.

Delayed Reconstruction

Stricture formation after trauma to the anterior urethra may present rapidly or years after the injury. Although some men may not appreciate symptoms of a urethral stricture that develop slowly over a period of years, many urethral injuries produce substantial tissue damage which produces unmistakable, immediate obstructive voiding symptoms. Proper treatment depends on accurate imaging. Retrograde urethrography combined with voiding cystourethrography delineates the location and severity of the stricture in most cases (Fig. 6.3). A suprapubic catheter, when present, may be used to aid in imaging of the proximal urethral segment. Occasionally repeat imaging may be required when the first attempt is inadequate; direct communication with the person performing the study is recommended.

Although contrast urethrography is informative and practical, it may not predict the degree of spongiofibrosis and tends to underestimate

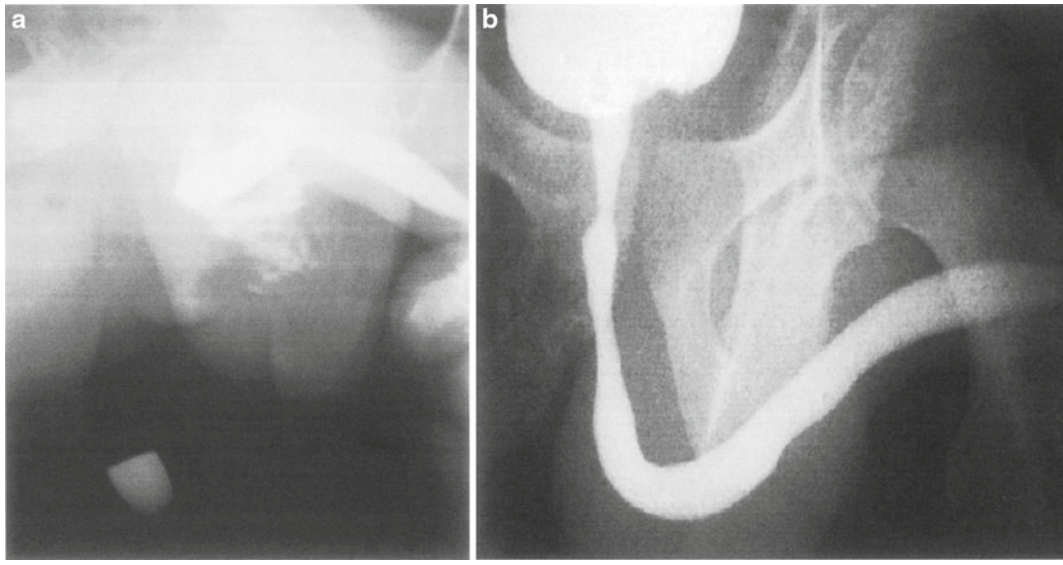

Fig. 6.2 (**a**) Retrograde urethrogram obtained after gunshot wound to buttock demonstrates extravasation from bulbar urethra and bullet retained within scrotum. Primary repair was performed acutely. (**b**) Voiding cystourethrogram 2 weeks after repair reveals completely normal urethra

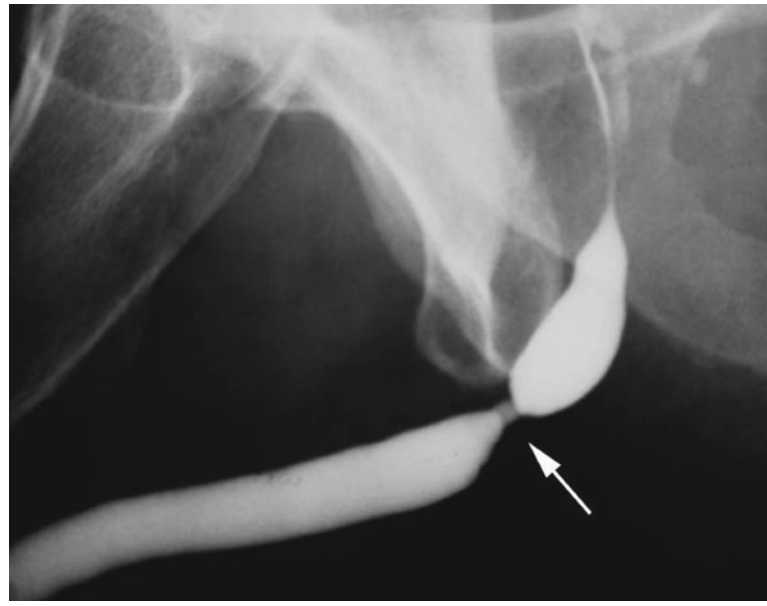

Fig. 6.3 Retrograde urethrogram demonstrates a short but severe stricture after a straddle injury in an all-terrain vehicle collision. Even though this stricture is short, it was surrounded by dense fibrosis and would not have been well treated by internal urethrotomy

stricture length in the bulbar urethra [14]. Sonourethrography is an ancillary staging technique that may complement traditional imaging techniques. Stricture length and diameter may be more precisely measured using ultrasound, resulting occasionally in selection of a different reconstructive procedure than that originally suggested by conventional urethrography [15].

Repair of a traumatic stricture should be delayed enough time to allow the scar to stabilize and most

of the inflammation to resolve, typically at least 2 months after the initial injury [16]. Most traumatic strictures are dense and will recur after dilation or endoscopic urethrotomy. Because of its high failure rate, urethrotomy is best reserved for thin diaphragmatic strictures that arise occasionally after formal repair [17]. Intermittent office dilation or self-dilation is palliative at best and often accomplishes little more than extending the tissue damage and prolonging the patient's misery.

Most traumatic strictures become completely or almost completely obliterated, requiring excision with primary anastomosis (EPA). EPA urethroplasty offers the best opportunity for a stricture-free outcome with long-term cure rates approaching 95 % [18]. Patients best suited for EPA are those who have strictures of the bulbar urethra less than 2.5 cm [19]. For longer bulbar strictures, buccal mucosa graft-augmented anastomotic urethroplasty has been shown to have a stricture-free rate of 93 % [20]. In this technique, the most severe area of stricture is excised, one wall of the urethra is anastomosed directly while the other side is replaced by a buccal mucosal graft. Excessive urethral excision can result in penile shortening or a repair that is under tension and at risk for failure.

Strictures of the penile urethra are rarely amenable to EPA. These strictures tend to be more diffuse than bulbar strictures, and their excision is more likely to produce penile curvature as the ability to mobilize surrounding urethra is not nearly as great as in the bulbar urethra. As a result, substitution procedures involving a graft or flap will be required in most cases [18]. Full-circumference replacement is less successful than an onlay procedure, and aggressive efforts should be employed to preserve or salvage the urethral plate [21].

Posterior Urethra

The posterior urethra consists of the prostatic and membranous urethra. Injuries occur in conjunction with high-energy blunt pelvic trauma and may occur through several mechanisms related to different pattern of pelvic fracture or ligamentous injury [22]. Other causes of posterior urethral injury include perineal or pelvic penetrating trauma, self-instrumentation, and pelvic diastasis without fracture [23]. Long-term complications may include complete urethral occlusion after disruption, partial urethral stenosis, post-injury erectile dysfunction, and occasionally incontinence. Of note, the term "stricture" is typically not used in situations where the urethral continuity is disrupted [24], preferring instead such descriptors as "pelvic fracture urethral disruption defect" or "stenosis."

Injury of the posterior urethra occurs in 10–20 % of all cases of pelvic fractures [25, 26]. Concomitant bladder injury occurs in 18 % of patients with urethral disruptions [27]. These can be severe, life-threatening injuries. Bleeding from fractured bone edges or lacerated blood vessels may cause a large pelvic hematoma. This may elevate and displace the bladder and prostate, stretching an intact urethra or distracting the severed or ruptured urethral ends and causing a gap in urethral continuity. This gap becomes fibrotic as the pelvic hematoma is reabsorbed over time.

Diagnosis

The diagnosis of posterior urethral injury is suggested by a history of pelvic fracture, most commonly following a motor vehicle collision or pedestrian injury, but also after a fall or crush injury. Like anterior urethral injuries, blood at the urethral meatus and inability to void warrant complete urological evaluation. A palpably full bladder or an elevated or indistinct prostate on rectal examination may raise suspicion of urethral injury, but they are insensitive predictors [28].

The pelvis may fracture in several locations and have complex fracture patterns. Fracture patterns associated with urethral injuries most often involve the anterior pubic rami (especially displaced fractures), complex fractures of both the anterior and posterior pelvic arch, and even diastasis of the pubic symphysis without fracture (Fig. 6.4) [26, 29]. Others have found the mechanism

Fig. 6.4 Posterior urethral distraction injuries may occur in conjunction with a variety of pelvic fractures. (**a**) "Straddle" fracture involving bilateral superior and inferior pubic rami, (**b**) barely perceptible pubic diastasis, and (**c**) Malgaigne fracture with vertical displacement are examples of the spectrum of pubic injuries that may be implicated

of injury to be more predictive of urethral injury than specific fracture patterns [22]. These differences illustrate the need for a high level of suspicion in all patients with significant blunt pelvic trauma.

Retrograde urethrogram should always be performed prior to transurethral catheterization when urethral injury is suspected (Fig. 6.5). These patients are often unable to be positioned obliquely, however. A simplified radiologic classification of posterior urethral injuries was proposed by a World Health Organization panel of experts [24]:

1. Posterior urethral stretched but intact
2. Partial disruption
3. Complete disruption
4. Complex injury (involves bladder neck/rectum)

Computed tomography is commonly used in diagnosis of the trauma patient and is frequently performed prior to suspicion or confirmation of a urethral injury. Sometimes the patient may have had an attempt at urethral catheterization prior to urethral evaluation. CT findings highly associated with urethral injury include obscuring of the urogenital diaphragm fat plane, the prostatic contour, or bulbocavernosus muscle, as well as hematoma of the ischiocavernosus

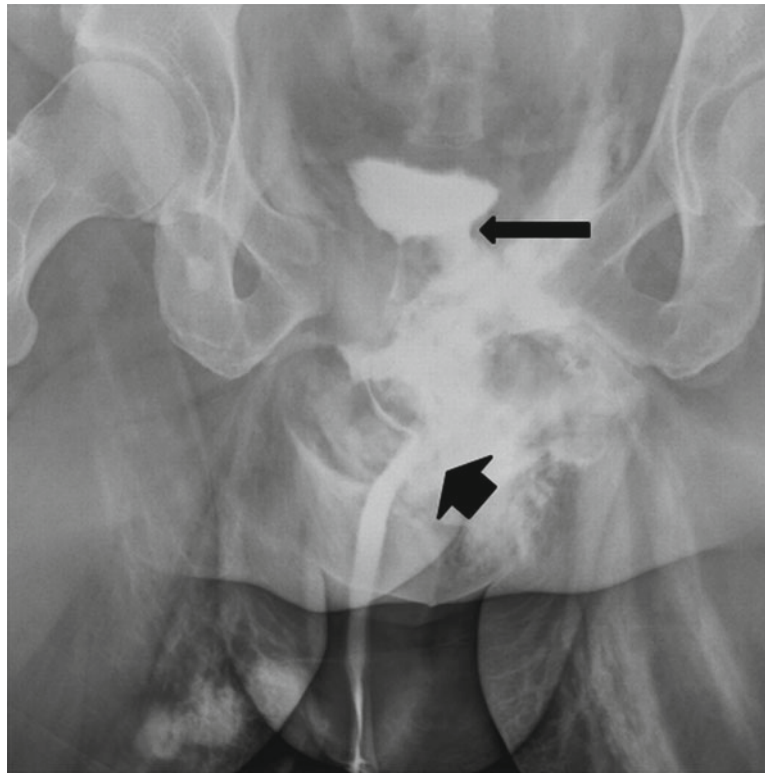

Fig. 6.5 Retrograde urethrogram shows extravasation from partial urethral injury (*short arrow*) and partial bladder filling after motor vehicle collision and pelvic fracture. Additional extravasation from extraperitoneal bladder injury (*long arrow*), confirmed at open exploration

muscle or obturator internus muscle [30]. In cases of partial urethral disruption, a blind catheterization may at times be successful prior to recognition of urethral injury, allowing for the diagnosis of a urethral injury at time of CT cystography. While magnetic resonance imaging (MRI) may be useful in planning delayed reconstruction, it has little role in the acute setting. Urethral ultrasound has no role in the diagnosis of posterior urethral injuries.

Initial Management

Initial management depends on the patient's hemodynamic stability and the status of associated orthopedic and non-orthopedic injuries. Coordination among the trauma surgeon, the orthopedist, and the urologist is critical. Two options exist for the management of posterior urethral injury: suprapubic cystostomy with delayed repair or primary urethral realignment. In the past, immediate open repair with pelvic hematoma evacuation was suggested [31]. Immediate sutured repair is not recommended because it is associated with unacceptably high rates of erectile dysfunction and incontinence [32]. Associated injuries of the bladder neck, vagina, or rectum necessitate immediate repair.

Suprapubic cystostomy alone avoids the risk of disrupting or infecting the pelvic hematoma and expedites treatment in the severely injured patient. Suprapubic cystostomy is especially advantageous when the patient is critically unstable or when realignment cannot easily be performed [32].

Primary realignment implies stenting the damaged area with a transurethral catheter. The goal is to allow a partial urethral injury to heal with a catheter in place or to align both ends of the

disrupted urethra so that they heal in the correct position as the pelvic hematoma is reabsorbed. The catheter is *not* placed on traction, and it is removed 4–6 weeks later when there is no contrast extravasation seen on retrograde or voiding urethrography [33]. Although realignment procedures have been performed either immediately or subacutely, several days after the initial injury when the patient is stable, most are doomed to failure. For this reason, a suprapubic tube should be maintained in most cases to provide immediate urinary diversion in the event that the patient goes into urinary retention. Bladder neck injuries should be repaired via open surgery during the initial presentation to prevent loss of the bladder neck's continence mechanism [34].

Manipulation of delicate and injured tissues during prolonged endoscopic realignment procedures risk infecting the pelvic hematoma or potentially damaging future continence or erectile function, and should therefore be avoided. A variety of techniques, including retrograde passage of a catheter through cystotomy under direct vision and endoscopically assisted catheter realignment have been described for realignment [23, 35]. Suprapubic cystostomy enables antegrade access to the urethra. The authors firmly believe a suprapubic catheter should be placed even if urethral realignment is successful because most patients will develop some degree of stenosis once the urethral catheter is removed (Fig. 6.6) [23]. Although orthopedic surgeons may understandably express concern that a suprapubic cystostomy tube may increase the risk of infection of hardware used for internal fixation of anterior pelvic fractures, there is little published data available for guidance. In the authors' experience, directing the catheter up away from the injured pubis is associated with a very low risk of hardware infection.

Retrospective reports indicate that some urethral injuries may heal without stenosis and may not require open reconstruction [33, 35]. Although the authors have rarely observed this phenomenon, this represents an area of controversy among reconstructive experts. One argument in favor of primary realignment is that patients who develop stenosis may have a technically easier reconstruction due to the disrupted ends of the urethra being in closer proximity than in cases where alignment had not been performed [36]. Proponents suggest that stenosis after realignment may often be treated with internal urethrotomy. However, recurrent stenosis after endoscopic treatment occurs in over 80 % of patients, and repeat endoscopic treatments are even more likely to fail [37]. We have observed considerable delays and complications arising as a result of failed realignment procedures in young men who ultimately were salvaged by open urethroplasty.

Rates of erectile dysfunction and incontinence with primary realignment have been comparable to those achieved by delayed repair [23, 25]. Over 50 % of patients who have a pelvic fracture urethral disruption injury will report some degree of erectile dysfunction [38]; historical rates of incontinence for both methods are <5 % [32]. Most authorities now believe that impotence and incontinence result from the initial injury, not secondary to surgical management [39]. Delayed return of potency is not uncommon, occurring as late as 3 years after injury [40].

Delayed Reconstruction

Posterior urethroplasty will be necessary in patients who have a significant urethral continuity defect after pelvic injury. This includes almost all patients treated with suprapubic cystostomy alone at the time of injury. Some patients who have undergone primary realignment may not need open surgical reconstruction, but those who develop significant stenosis may need formal urethroplasty. Patients having undergone realignment procedures should have follow-up urethroscopy and/or urethrography to ensure urethral patency.

As the pelvic hematoma is reabsorbed, the gap between the prostatic apex and the distal edge of the urethra is reduced, typically leaving a 1- to 2-cm gap of fibrosis. Complete excision of the scar and direct urethral anastomosis (Fig. 6.7) is performed when the patient has recovered from major associated injuries, usually after about 3 months [41].

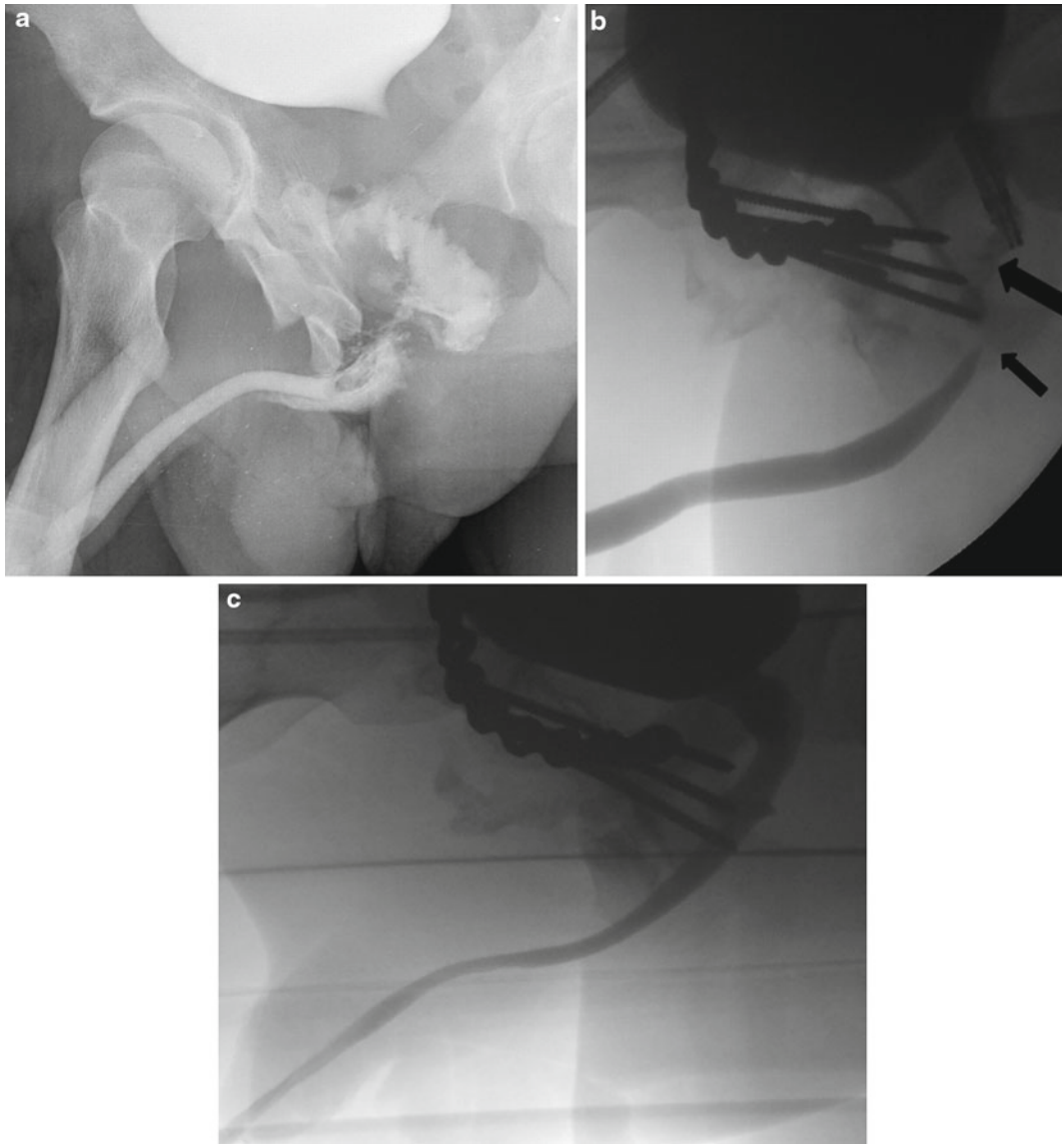

Fig. 6.6 (**a**) Retrograde urethrogram shows complete urethral disruption after pelvic crush injury. Contrast in bladder is from prior intravenous contrast for abdominal CT scan. Note that the bladder is elevated out of the pelvis. (**b**) Patient underwent primary urethral realignment at time of internal fixation repair of pelvic fracture. Stenosis developed (*small arrow*) after urethral catheter removal. Note stone fragments (*large arrow*), formed during prolonged catheterization, in urethra above level of stenosis and distal to antegrade urethroscope. (**c**) Voiding urethrogram after successful posterior urethroplasty

Retrograde urethrography with simultaneous cystography helps to determine the length of the defect and competency of the bladder neck. Alternatively, flexible antegrade cystoscopy may be combined with retrograde urethrography when the patient is unable to pass contrast below the bladder neck. MRI [42] or CT cystourethrography [43] can provide additional information in selected complex or reoperative cases.

Complete resection of the fibrotic segment with end-to-end anastomosis is the most successful method for posterior urethral reconstruction [44]. Mobilization of the bulbar urethra distally to the penoscrotal junction takes advantage of the

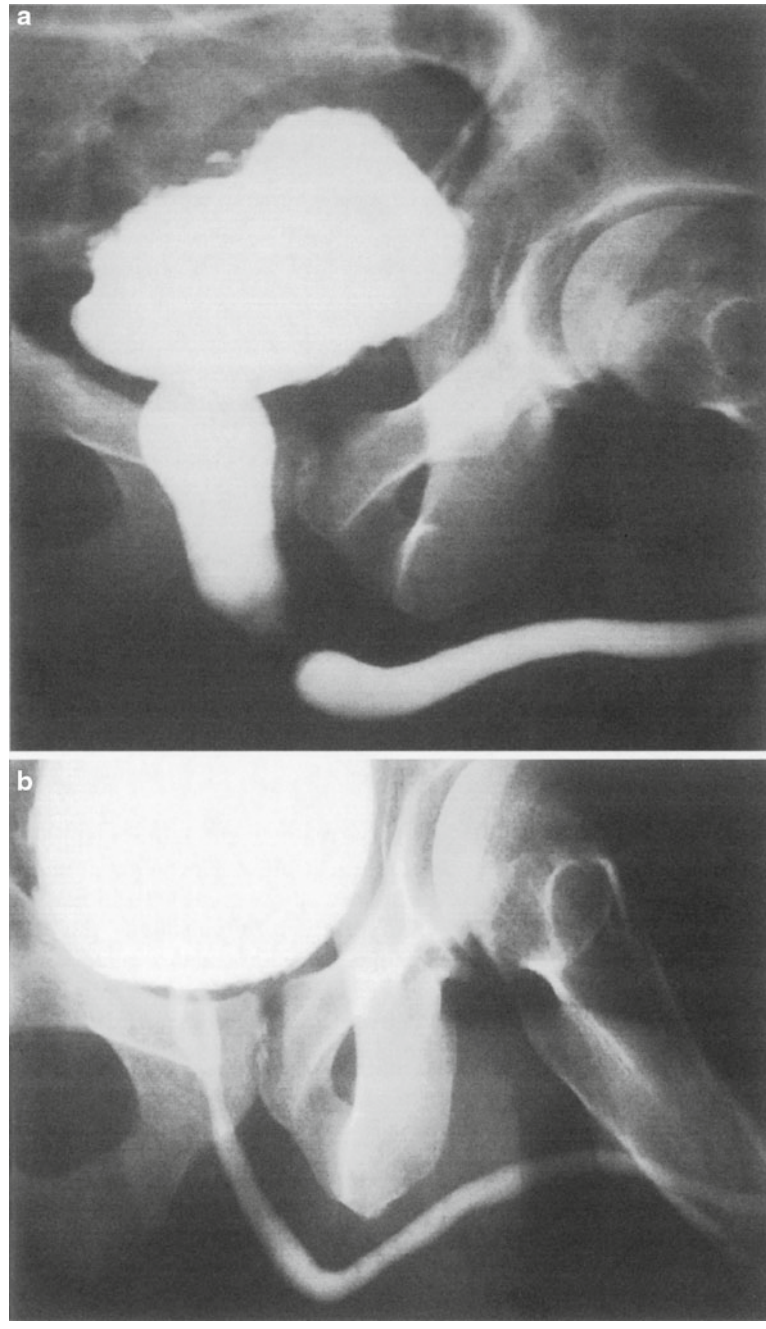

Fig. 6.7 (**a**) Combined retrograde urethrography/voiding cystourethrogram reveals urethral gap 3 months after posterior urethral disruption. (**b**) Postoperative voiding cystourethrogram after successful posterior urethral reconstruction via excision/primary anastomosis technique reveals normal urethral lumen

elasticity of the bulbar urethra to make up most urethral defects. If necessary, corporal body separation, inferior pubectomy or supracrural urethral rerouting may be utilized in sequential fashion to bridge the defect [45], although the authors have found these steps to be unnecessary nearly always, time-consuming, and occasionally harmful [46]. Although a perineal approach is

adequate in most cases, transpubic procedures are appropriate for complex or reoperative cases in which a tension-free bulbo-membranous anastomosis is not otherwise possible [47, 48]. Unlike anterior urethral reconstruction, tissue grafts and flaps are rarely indicated.

Posterior urethroplasty is highly successful having over 85–90 % long-term stricture-free success without additional intervention, in experienced hands [37, 49]. Incontinence is uncommon after posterior urethroplasty, and erectile dysfunction as a result of urethroplasty itself is rare [37]. Because most disruptions occur at the bulbo-membranous junction [50], some external sphincter function may remain intact. In others, continence after posterior urethral reconstruction relies on the bladder neck and prostate. An open bladder neck on a preoperative cystogram, however, does not prove functional incompetence [51, 52]. Understanding the contribution of the bladder neck to urinary continence is important in these patients; future prostate surgery may compromise this function.

Summary

Urethral injury may be of secondary importance at the time of presentation of the acute trauma victim. However, devastating urological complications such as sexual dysfunction, incontinence, and urethral stenosis or stricture may drastically impair quality of life, often long after other injuries are healed. A high index of suspicion is necessary to ensure early, accurate diagnosis and prompt, effective treatment of urethral injuries.

Urethral injury should be considered in the setting of penile fracture, pelvic fracture, or penetrating trauma to the genitalia, pelvis, or perineum. Blood at the meatus always indicates the need for retrograde urethrogram or flexible cystoscopy in the trauma setting.

Immediate repair is usually possible in urethral injuries associated with penile fracture or penetrating injuries to the anterior urethra. For pelvic fracture urethral injuries, suprapubic cystostomy with delayed reconstruction is a safe, proven strategy, although primary realignment with catheter placement is reasonable when it is possible without heroic measures. Continence and potency rates seem to be associated more with the nature of the injury than with the method of urological management.

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