Journal of
Pediatric
urology

REVIEW ARTICLE

Post-traumatic urethral strictures in children: What have we learned over the years?

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Abstract *Background*: Urethral stricture presents an uncommon but difficult urological problem in the pediatric population. Treatment protocols are different from in adults due to anatomical considerations.

Material and methods: A thorough manual and Medline search was conducted to review the existing literature on post-traumatic pediatric urethral strictures, with key words: stricture, children, post-traumatic, urethroplasty, pediatric.

Results: Opinion early on was that, due to the confined perineum, high incidence of supra-membranous injury resulting in less predictable distraction defects of the posterior urethra and a high incidence of prostatic displacement, transperineal urethroplasty is technically more difficult than in adults and thus the transpubic approach is more feasible. Recent reports revealed that both approaches resulted in almost the same clinical outcomes for children with post-traumatic posterior urethral strictures.

Conclusion: The ideal reconstruction for the treatment of post-traumatic posterior urethral strictures in children is bulboprostatic anastomosis. This procedure should be initially attempted through the perineum in every case. A transpubic procedure should be done only when tension-free anastomosis cannot be accomplished through the perineum.

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Introduction

Urethral trauma causing stricture disease in children most commonly results from pelvic fracture, straddle injury or iatrogenic urethral manipulation [1]. Urethral stricture presents an uncommon but difficult urological problem in the pediatric population. A consensus on optimal treatment in children is yet to be reached. Several groups have tried endoscopic urethrotomy or urethral dilatation as first-line therapy [2—8]. The reported results are conflicting and ultimately require sequential or additional procedures to achieve a satisfactory result [3,5]. Literature reviewing post-traumatic urethral strictures in children is scarce, and

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most published series of perineal urethroplasty or transpubic repair have included only a small number of patients [6—13] or the long-term follow-up has not been robust [6,8].

Most principles applicable to the open repair of post-traumatic urethral injuries in children are the same as in adults, barring a few intricacies and anatomical considerations. Nearly all cases of post-traumatic posterior urethral stenosis or obliteration in adults, regardless of length, can be corrected by one-stage transperineal end-to-end anastomotic urethroplasty. In children, due to the confined perineum, high incidence of supramembranous injury resulting in less predictable distraction defects of the posterior urethra and a high incidence of prostatic displacement, transperineal urethroplasty seems technically more difficult than in adults [14,15], and the transpubic approach more feasible. Nonetheless, recent reports revealed that the two approaches could result in almost the same clinical outcomes for children with post-traumatic posterior urethral strictures [15,16]. These proximal urethral injuries are reportedly associated with a significantly higher incidence of incontinence and failure than those at a more distal site.

A review of the urological literature revealed little attention paid to anatomical detail and, particularly, cursory reference to bone injuries leading to urethral rupture. We herein review the long-term success of urethral reconstruction in children with post-traumatic strictures, and attempt to analyze the difficulties, clinical outcome, overall success and complications of such procedures.

Is the anatomy the same as in adults?

The urinary bladder and the prostate in young boys are more abdominally located, coupled with a small confined pelvis. This is associated with decreased urethral caliber and increased tissue fragility. Additionally, the impact of a pelvic fracture is more likely to be serious and cause a higher incidence of urethral injury [l7].

The most common types of pelvic fracture reported in young boys are Malgaigne's fracture (35%) and straddle fracture with or without diastasis of the sacroiliac joint (31%). Koraitim et al. noted that involvement of the posterior pelvic arch with fractures of the anterior arch considerably increases the risk of urethral injury [17]. The highest risk is reported in straddle fracture with diastasis of the sacroiliac joint (24 times more than other pelvic fractures), followed by straddle fracture alone and Malgaigne's fracture (3.85 and 3.4 times, respectively). These types of fracture are more common in children than in adults (56% vs 24%), whereas the less serious types, such as single and ipsilateral rami fractures, are more common in the older age group (46.4 vs 31.5%) [17].

In children, the prostate is still developing and the resultant urethral injury is more likely than in adults to be a complete rupture of the delicate tissue (69% vs 42%) with a resultant higher rate of stricture formation. Urethral injury may potentially involve a more proximal site of the prostatic urethra or even the bladder neck, which increases the risk of urinary incontinence [18]. The delicate

puboprostatic ligaments of children are readily sheared off by sudden displacement of the fractured pubic rami, with a high incidence (44%) of proximal dislocation of the prostate, rendering repair of an ensuing stricture higher up much more difficult [19]. This high incidence of superior prostatic displacement may require transpubic urethroplasty, as the result of shearing of the immature puboprostatic ligaments at the time of initial trauma. Because of these differences, it has been claimed that perineal urethroplasty, successful in adults, is technically more demanding in the confined perineum of a child.

What is the accuracy of micturating cystourethrography and retrograde urethrography in children?

In children, combined preoperative cystography and retrograde urethrography are generally inaccurate for assessing the length of the disruption defect and subluxation of the prostate [18]. Sometimes the proximal urethral segment is not completely filled with contrast medium, presumably due to pain or discomfort from the procedure in young boys or loss of distensibility of the urethra inferior to the verumontanum as a result of fibrosis. Incomplete filling of the prostatic urethra may result in spurious estimation of a long distraction defect, and thus surprisingly some cases scheduled preoperatively for transpubic urethroplasty can easily be managed through the perineal route. As a corollary, it is difficult to escape the conclusion that so-called strictures of the mid prostatic urethra which have been reported in the literature are in fact bulbar prostatomembranous strictures with incomplete filling of the proximal segment. Injury to the mid prostatic or more proximal urethra is usually in the form of an anterior longitudinal tear, which does not lead to stricture formation, rather than a complete transverse cut [17]. It is difficult to understand how the shearing force of pelvic trauma could transect the whole thickness of the prostate, even when it is undeveloped, rather than snap off the stretched delicate urethra at the prostatomembranous or bulbomembranous junction. Additionally, the tears in the prostate and bladder neck are infrequently delineated by a static film and thus a dynamic retrograde urethrogram under continuous fluoroscopic control should provide more useful information.

However, of more concern is the spurious estimation of a short distraction defect, as visualized on the urethrogram, because of a urinoma cavity overlapping or continuous with the proximal segment. Due to this finding, a perineal procedure may be scheduled only to be changed to a transpubic procedure when a highly displaced prostate is found at operation. Otherwise, the cavity may be mistaken for the proximal segment and its fibrous wall may be anastomosed to the bulbar urethra, which causes recurrence of obstruction shortly after removal of the urethral stent. The cavity is a remnant of the incompletely absorbed hematoma and extravasation formed at the time of the original trauma, which persisted by continuous leaking or voiding of urine into it from the proximal segment. However, urethrography at various degrees of oblique view usually reveals the extra-urethral nature of the cavity and the actual length of the distraction defect.

Role of magnetic resonance urethrograms in children

Magnetic resonance imaging defines the length of the defect and location of the prostatic apex excellently, aiding preoperative decision making. Magnetic resonance imaging, introduced in 1992 for the evaluation of posterior urethra, provides a non-invasive method of measuring the length of the distraction defect with no problems of spurious estimation as with urethrography [20]. Also, it clearly depicts the extent of scar tissue, as well as the degree and direction of prostatic displacement, aiding in preoperative decision making [20,21]. Its role in children has not been established but seems to be promising. The limitations are performing the study with a full bladder and distending the anterior urethra, which often requires penile clamping along with minimizing the motion artefacts with the child in the claustrophobic gantry.

Acute primary realignment in children

Acute primary alignment procedures should be avoided in children [11]. In these patients, multiple associated injuries frequently take priority and suprapubic urinary diversion is the next logical step in most cases.

Optical internal urethrotomy in children

The use of direct visual internal urethrotomy (DVIU) for the treatment of post-traumatic urethral stricture in children has been plagued by a high failure rate [2–7]. Reports are mostly limited to post hypospadias repair strictures of the anterior urethra. Endoscopic urethrotomy in children has been described by various groups, with a success rate as high as 86% in selected series, but is more promising in the penile or bulbous urethra as in straddle trauma [2–7]. In many cases multiple urethrotomies are needed, which can further complicate open urethral reconstruction when required [2,3]. Others have reported poor long-term results especially for the posterior urethra [14]. Dilation and visual internal urethrotomy has been successful in a few cases but frequently leads to scarring and restructuring, making subsequent repair more difficult.

Indeed, in only 25% of cases is DVIU successful and spares the child a far more invasive procedure. The results of repeat DVIU have been dismal irrespective of stricture etiology. If the child fails the initial DVIU, repeat attempts at endoscopic correction of urethral stricture should be abandoned in favor of definitive urethroplasty.

Perineal anastomotic urethroplasty and transpubic repair

In adults, pelvic fracture urethral distraction injury usually involves the membranous urethra at some point between the apical prostatic and bulbous urethra, and perineal anastomotic repair represents the ideal treatment [22,23]. However, in children, the level of the traumatic posterior urethral distraction defect is less predictable. Boone et al. [14] noted that three distinct types of urethral injury

(supraprostatic, transprostatic and prostatomembranous) are present in this population. Moreover, because of a small prostate, violent pelvic injuries in childhood may be responsible for complete rupture of the membranous urethra as well as urethral disruption at the bladder neck [24,25]. In addition, Glassberg et al. described in children extension of the urethral disruption injury at the prostatomembranous junction into the proximal bulbar urethra [26]. Consequently, the management of traumatic posterior urethral obliteration in childhood differs from that in adulthood and it requires consideration of several factors.

Podesta [16] demonstrated comparative efficacy between the transpubic and perineal approaches for repairing urethral strictures in children secondary to pelvic fracture. He compared the outcome (stricture-free rate) in cases repaired only through the perineum (84%), versus those treated with a combined abdominoperineal approach (100%). Podesta concluded that a stricture of 3 cm or longer should be approached abdominoperineally. Netto recommended a similar choice in 1985 based on his experience [27]. In the study by Senocak et al. of transpubic repair in 10 patients, the high incontinence rate of 30% was attributable to extensive primary and iatrogenic damage to the bladder neck [12]. Patil followed 5 of 30 patients 9–13 years old who underwent transpubic urethroplasty for 7–10 years and into adulthood [28]. All patients were reported to be competent and unimpeded in daily activity, sports, and sexual function, including ejaculation and potency.

Thus, conventionally a transpubic or retropubic dissection has been advocated to reconstruct pediatric posterior urethral distractions [11–13]. However, in practice, most of the large series, including ours, have reported that a bulboprostatic anastmosis can easily be achieved by the perineal approach and the need for reteropubic dissection and transpubic approach has been infrequent [29]. Several authors have shown that the majority of strictures are located below the verumontanum [6,8,15]. These facts suggest that the pediatric urethral distractions, are, in essence, similar to those seen in adults.

Difficulties during stricture repair because of the smaller urethra in children are offset by a shorter stricture and more superficial placement of the urethra in the perineum [30]. In children, the distance between the skin and the membranous urethra is shorter than in adults and exposure of the membranous urethra is easy to perform. The anastomosis of urethral ends is not as difficult as anticipated, based on the imagined smallness of a child's perineum. The imagined difficulty in performing repairs on a confined perineum could, in fact, be overcome by the shorter distance between the perineal skin and the membranous urethra. Inverted Y-shape incisions are better for the exposure of the membranous urethra than straight incisions [30].

Open reconstruction of urethral strictures in children follows the same principles as that in adults. Historically, a one-stage Badenoch pull-through procedure of the bulbar urethra was used for strictures [31], while longer strictures were managed by transpubic anastomotic urethroplasty [31–33], or by a two-stage substitution urethroplasty and scroto-urethral inlay [34,35]. The abdominoperineal repair was reserved for complex posterior urethral defects, which included those associated with bladder neck abnormalities,

fistulae to the bladder base or rectum, periurethral cavities, and those patients with skeletal abnormalities precluding perineal access [36,37]. In the 1970s, Turner—Warwick [38] popularized a delayed one-stage perineal approach, comprising urethral mobilization followed by bulboprostatic anastomosis, to bridge defects of up to 2.5 cm. This procedure became the standard repair for short strictures, while substitution urethroplasty or transpubic urethroplasty continued to be used for longer defects or complex posterior urethral defects, respectively. Buccal mucosa has proved to be a successful grafting material, especially as a patch, for long-segment strictures not amenable to anastomotic urethroplasty [39]. Open reconstruction of urethral strictures in children has generally given favorable results, but most published series of open perineal urethral reconstruction in children have included few patients [10—13] or had only a short follow-up [6,8]. For a successful result, all fibrous tissue occupying the distraction defect, including the wall of any urinoma cavity as well as the scarred urethra inferior to the verumontanum, should be excised before a wide, oblique, tension-free, end-to-end anastomosis can be created between healthy, pliable prostatic mucosa and healthy mucosa of the bulbar urethra. Results in children are comparable to those in adults after the same procedures with a success rate of 95—97% [6]. Except for the small urethra and prostate, the confined perineum of a child does not present a special difficulty compared to adults when creating a bulboprostatic anastomosis. The earlier hypothesis was that because children tend to have a higher incidence of prostatic displacement, they need a transpubic procedure more frequently than adults.

Hafez et al. reported 35 children with post-traumatic urethral strictures, representing the second largest series after that of Koraitim [40]. Their primary and overall success rates were 89% and 100%. In addition, the large series of post-traumatic membranous urethral disruptions in children reported by Koraitim [15] showed a high success rate using the perineal (93%) and transpubic (91%) approach for bulboprostatic anastomosis. It appears feasible to approach pediatric stricture repair through a perineal incision, converting to a transpubic approach only if a tension-free anastomosis is not feasible. Inferior pubectomy through the perineal incision is required infrequently to achieve a tension-free anastomosis.

The rate of re-stricture after perineal anastomotic urethroplasty has been reported as 5—15%, usually in the case of a stricture of >4 cm [16]. Andrich et al. [41] reported a similar incidence (14%) of re-stricture 15 years after anastomotic urethroplasty. Previously, managing the failed anastomotic repair included the less than satisfactory staged scrotal inlay procedure, or even urinary diversion in the most severe cases. Others have reported successful endoscopic management of recurrent anastomotic strictures and attribute this success to the short stricture and a decrease in periurethral fibrosis after perineal repair [42]. In conclusion, the reference standard for treating post-traumatic urethral strictures in children is transperineal one-stage bulboprostatic anastomosis. Development of the intercrural space and inferior pubectomy is important in achieving a tension-free anastomosis in patients with long strictures.

This procedure should be attempted first in every case and a transpubic procedure used only if a tension-free anastomosis cannot be made through the perineum.

Symphysiotomy for pelvic fracture urethral distractions

In children some authors have promoted symphysiotomy as an alternative to the transpubic repair [43]. Symphysiotomy for stricture was initially presented in the 1960s and 1970s but few reports have appeared in the more recent literature. Symphysiotomy has been used extensively in developing countries to assist childbirth in cases of cephalopelvic disproportion with acceptably low orthopedic complications. Symphysiotomy is likely to have limited use in adults but it may be useful in children after failed primary repairs, for which most groups advocate pubectomy and subsequent transpubic repair. Basiri et al. [43] used the less invasive method of symphysiotomy in two such cases and showed acceptable results. The anterior transpubic approach provides satisfactory access to the prostatomembranous urethra with a reasonable complication rate but it entails a ventral gap in bony pelvis continuity, which may lead to hernia and abnormal gait [44,45]. Children have greater skeletal pliability than adults which forms the basis for symphysiotomy. Basiri et al. [43] have argued that pubic resection is time-consuming, creates raw surfaces of cancelous bone with bleeding potential and ultimately leaves a gap, through which herniation and limping develop. He advocated symphysiotomy, which is believed to circumvent some of these drawbacks by obviating bone excision. Pelvic leniency observed during symphysiotomy is assumed to be due in part to distraction of the anterior sacroiliac reinforcements. The angle thus created is hinged posterior, leaving all dorsal ligaments intact for support during convalescence. It is unknown whether symphysiotomy in children predicts similar success in adults, although studies from the 1970s suggest that it may.

It should be contraindicated in unstable pelvic fracture or a pelvic fracture that would become unstable if symphysiotomy was performed, as when there already exists a site of pelvic non-union and the addition of symphysiotomy would create a freely floating pelvic segment. Osteitis pubis and symphyseal non-union are potential orthopedic complications of this procedure.

The posterior sagittal pararectal approach

This technique is a good alternative approach for repair of complicated pelvic fracture urethral distraction defects, especially in children. It is safe and has the advantage of better visualization of the apex of the prostate and surgical field, with subsequent good outcomes without immediate or remote effects on the sphincteric function of the rectum or bladder. Pena et al. [7] proposed a posterior sagittal transanorectal approach that splits the posterior and anterior rectal wall with division of the whole muscle mechanism, which provides excellent exposure and good visualization of all structures. Although bivalving the anorectum is a bold maneuver, it has been shown that the anal

sphincter and anorectal canal may be incised in the midline without interfering with fecal continence. Nevertheless, a protective temporary colostomy is required before the main repair to eliminate the risk of an infectious complication [7,8]. The posterior sagittal approach to the anorectum and urethra is used to manage a spectrum of congenital anorectal anomalies [9].

Flah et al. [14] previously described this procedure in children with post-traumatic stricture of the proximal urethra in whom defects permitted primary anastomosis. Although a posterior sagittal pararectal surgical approach to the rectourethral space theoretically may compromise fecal continence, this complication remains undetected in clinical and experimental experience. Indeed, studies reveal that postoperative fecal continence as well as anorectal sphincter manometry, electromyography and histological examination are all normal in animals undergoing uncomplicated posterior sagittal pararectal dissection [15]. Whereas in the transperineal approach, the proximal end of the urethra is seen deep inside the pelvis and suturing is difficult in some cases, the operative field through the posterior sagittal approach is very wide, allowing good visualization of both urethral ends with better suturing and subsequent good result. It is important to recognize that experience and long-term follow-up with this approach for urethral distraction injuries are limited, and there may be difficulties posed to the inexperienced surgeon in terms of potential damage to the rectum, anal sphincter, or cavernous nerves.

The urethroscrotal inlay procedure

The urethroscrotal inlay procedure is of historical interest and has a high failure rate. In the present era of advanced understanding of the perineal anatomy, this is not the proper solution for post-traumatic strictures of the posterior urethra. These cases are better corrected by bulboprostatic anastomosis.

Conclusions

The ideal reconstruction for the treatment of post-traumatic posterior urethral strictures in children is bulboprostatic anastomosis. This procedure should be initially attempted through the perineum in every case. A transpubic procedure should be done only when tension-free anastomosis cannot be accomplished through the perineum. Repeated internal urethrotomies are best avoided because they produce scarring and loss of elasticity of the anterior urethra, which compromises the chance of subsequent anastomotic urethroplasty. Proper interpretation of the combined antegrade and retrograde urethrograms at various degrees of oblique view is essential for true estimation of the defect between the disrupted urethral ends. This defect may be overestimated or underestimated by nonfilling of the fibrosed urethra inferior to the verumontanum or because of a urinoma cavity connected with the proximal segment, respectively. The finding of an open bladder neck on cystography is not necessarily indicative of bladder neck incompetence and any repair may be deferred until after urethroplasty, when urethral voiding has resumed.

In children, because of the rudimentary prostate and puboprostatic ligaments, the injury is believed to be more proximal and, thus, the repair more difficult, with a higher incidence of incontinence and impotence. Transpubic or perineal—transpubic approaches were strongly recommended for children with traumatic posterior urethral strictures. Nonetheless, in experienced hands, excellent results can be achieved with one-stage transperineal bulboprostatic anastomotic urethroplasty.

Conflict of interest

None.

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