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Surgical treatment of pelvic fracture urethral distraction defects in boys: which approach is suitable?

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Pelvic fracture urethral distraction defects (PFUDDs) are relatively infrequent in boys, and treatment for PFUDDs presents one of the most difficult problems in urological practice. Anastomotic urethroplasty is considered an ideal surgical procedure for PFUDDs in boys. However, various surgical approaches for anastomotic urethroplasty have been proposed, including a simple transperineal approach, a transperineal intercorporal septal separation approach, a transperineal inferior pubic approach, and a combined transpubic-perineal approach. This study aims to determine which surgical approach is best for PFUDDs in boys. We retrospectively identified 22 boys with PFUDDs aged 2–14 years who underwent anastomotic urethroplasty via different approaches between January 2008 and December 2017. Follow-up was performed in all the 22 patients for 6–123 (mean: 52.0) months. Finally, 20 of the 22 boys (90.9%) were successfully treated, including 1 of 2 patients treated with a simple transperineal approach, 3 of 3 with a transperineal approach with intercorporal septal separation, 14 of 15 with a transperineal inferior pubic approach, and 2 of 2 with a combined transpubic-perineal approach. Two patients had failed outcomes after the operation, and stenosis recurred. Based on the outcome of the 22 patients, we can draw a preliminary conclusion that most boys (20/22) can be treated with a transperineal inferior pubic approach or simpler procedures without the need of completely removing or incising the pubis. The combined transpubic-perineal approach can be used in cases of extremely long urethral distract defects.

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INTRODUCTION

Surgical treatment of pelvic fracture urethral distraction defects (PFUDDs) in boys remains a challenging problem in urological practice. A variety of surgical strategies for treating PFUDDs in boys have been recommended, including urethral dilatation, endoscopic urethrotomy, and anastomotic urethroplasty.^{1,2} Anastomotic urethroplasty, which has been successfully performed in adults, is considered the ideal surgical treatment for posterior urethral stenosis and distraction defects in boys.^{3,4} Various surgical approaches for anastomotic urethroplasty have been proposed, including but not limited to a simple transperineal approach, a transperineal intercorporal septal separation approach, a transperineal inferior pubic approach, and a combined transpubic-perineal approach.^{5–7} Often, the location and length of the urethral distraction defects, an undeveloped prostate, the pelvic anatomy inherent of pediatric patients, and concomitant bladder neck injuries make urethral repair extremely difficult.⁸

Shanghai Jiao Tong University Affiliated Sixth People's Hospital (Shanghai, China) is the largest urethral referral center in China, and the large number of pediatric patients treated for PFUDDs allowed us

to retrospectively analyze patient records and to preliminarily evaluate the effectiveness of different surgical approaches. The purpose of this retrospective study was to analyze our 10-year experience of end-to-end anastomotic urethroplasty for treating PFUDDs and to evaluate which surgical approach is appropriate. All the children were treated with either perineal approaches or a combined transpubic-perineal approach.

PATIENTS AND METHODS

Patients and preoperative preparations

After approval of the Ethics Committee of Shanghai Jiao Tong University Affiliated Sixth People's Hospital, we retrospectively reviewed all the demographic and clinical data of 22 pediatric patients who underwent anastomotic urethroplasty through a four-step method of surgical correction of PFUDDs from January 2008 to December 2017 using our medical record system. All clinical data were obtained from Dr. YL Sa's team. The average age was 8.5 (range: 2–14) years, and the average disease course was 10.5 (range: 3–22) months. In all children, the repair was performed at least 3 months after the initial urethral trauma or last urethral operation. All surgeries were performed by Dr. YL Sa. The demographics and

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clinical data are shown in **Table 1**. Informed consent was obtained from the parents of all boys who were included before the beginning of the study.

Before the operation, combined voiding and retrograde cystourethrography (**Figure 1a**) was performed to determine the location and length of urethral distraction defects, the morphology of the bladder neck, and whether there was a concomitant urinary fistula. Retrograde ureteroscopy and antegrade cystourethroscopy were also routinely applied to further determine the length of the defect segment and the anatomical location of the obliteration. All patients underwent urinalysis, urine culture, and sensitivity testing after admission, and penicillin (Nuosailin, H14023782, Challenge and Young, Shanghai, China) or sensitive antibiotics were preoperatively initiated to prevent infection. Povidone-iodine saline irrigation of the bladder and urethra was performed twice daily for all boys. The two boys with urethrorectal fistulas were given soapsuds enemas into the rectum once daily for 3 days before surgery.

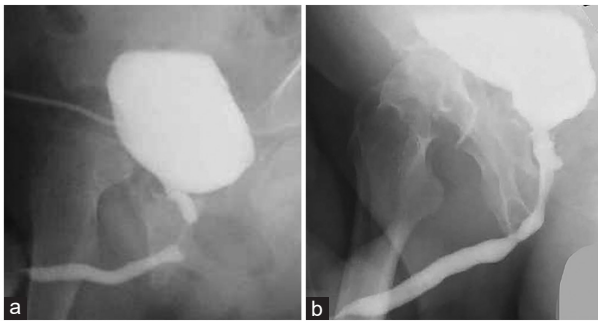


Figure 1: (a) Preoperative combined voiding and retrograde cystourethrography. (b) Postoperative combined voiding and retrograde cystourethrography.

Surgical techniques

Patients were placed in the standard lithotomy position after general anesthesia. Urethroplasty was performed according to previously described methods.^{4,6,9} Briefly, an inverted Y-shaped incision was made in the perineum, the distal bulbar urethra was circumferentially mobilized, and the fibrous tissue between the two ends of the disrupted posterior urethra was completely excised. The distal urethra was mobilized without exceeding the penoscrotal junction, followed by circumferential mobilization and trimming of the proximal urethra (**Figure 2a** and **2b**). It is essential to limit the exposure of the proximal urethral end to reduce the risk of injury to the nervi erigentes. Direct anastomosis through a simple transperineal approach was performed to achieve an epithelium-to-epithelium tension-free anastomosis (**Figure 2c**). To avoid injury to the anterior wall of the rectum when separating the proximal urethra, we used a thick beanbag to raise the hips of the patients and removed the scarred urethra and surrounding tissues along the ventral margin of the urethra. If the dissection was not sufficient, we performed intercorporal septal separation and then, if that was not sufficient to bridge the gap, an inferior pubectomy was performed. If the procedures still did not allow accurate reestablishment of urethral continuity, we proceeded with the incision or removal of a trapezoid-shaped wedge of the pubis, allowing for a tension-free anastomosis.

For the two patients with urethrorectal fistulas, the whole proximal urethra was carefully dissected and separated from the rectum after complete dissection of the obstructive fibrous scar tissue. The fibrous fistulous tract was completely excised, and the fistula margins in the rectum were then freshened. The rectum was repaired in two layers using 3-0 or 4-0 polyglactin continuous sutures. Urethral reconstruction was performed as described above. Then, a subcutaneous dartos pedicle flap was carefully detached from one side and interposed between the rectum and the repaired urethra to separate the suture lines.

Table 1: Demographics and clinical data of the 22 patients with pelvic fracture urethral distraction defects

Case	Age (year)	Injury mechanism	Initial treatment	Previous urethral surgery	Concomitant urethrorectal fistula	Surgical approach	Defect length (cm)	Follow-up (months)	Outcome
1	3	Crush	SC	U	No	TIPA	2.0	26	Success
2	6	Fall	SC	-	No	TIPA	2.5	123	Success
3	7	Crush	SCC	-	Yes	CTPA	4.5	12	Success
4	8	Collision	SC	-	No	TIPA	3.5	22	Success
5	8	Collision	SC	-	No	TIPA	3.0	6	Success
6	8	Collision	SC	-	No	TIPA	3.0	63	Success
7	8	Collision	SC	-	No	CTPA	5.5	12	Success/UI
8	9	Collision	SC	-	No	TACBS	1.5	77	Success
9	9	Collision	SC	U	No	TIPA	3.0	65	Success
10	9	Collision	SC	-	No	TIPA	3.0	32	Success
11	10	Crush	SCC	-	Yes	TIPA	5.0	31	Failure
12	10	Collision	ER	-	No	STA	1.5	85	Failure
13	10	Collision	SC	-	No	TACBS	2.5	35	Success
14	10	Collision	ER	U	No	TIPA	3.5	10	Success/UI
15	10	Fall	SC	-	No	TACBS	2.0	39	Success
16	10	Collision	SC	DVIU, U	No	TIPA	2.5	93	Success
17	11	Collision	SC	-	No	TIPA	4.5	55	Success
18	12	Collision	ER	-	No	STA	2.0	96	Success
19	12	Collision	SC	U	No	TIPA	3.0	110	Success
20	12	Collision	ER	DVIU	No	TIPA	4.5	49	Success
21	13	Collision	SC	U	No	TIPA	3.5	48	Success
22	14	Collision	ER	DVIU	No	TIPA	5.5	55	Success

ER: endoscopic realignment; SC: suprapubic cystostomy; SCC: suprapubic cystostomy and colostomy; DVIU: direct vision internal urethrotomy; U: urethroplasty; STA: simple transperineal approach; TACBS: transperineal approach with corporeal body separation; TIPA: transperineal inferior pubic approach; CTPA: combined transpubic-perineal approach; UI: urinary incontinence; -: no previous history of urethral surgery.

Postoperative management

At the end of the procedure, suprapubic catheterization was used for bladder drainage, and a grooved silicone indwelling catheter (FC162300, Integral, Hangzhou, China) was left in place for at least 3 weeks. All patients were evaluated with uroflowmetry at the time of catheter removal and at 3 and 12 months postoperatively, unless they were unable to urinate. Some patients were reexamined for combined voiding and retrograde cystourethrography (**Figure 1b**) at the outpatient clinic at 3 months postoperatively. The suprapubic catheter was removed after successful trials of voiding, which was generally 1 week after urethral catheter removal. Then, they were followed up by outpatient visit or through telephone. A successful outcome was defined as reestablishment of a uniform urethral caliber and no further urethral dilatations, internal urethrotomies, or additional surgical procedures needed.⁹ The repair was considered as a failure if stenosis remained, if recurrent stenosis developed and the patient required repeated urethral dilatation or other definitive surgical therapy, or if the patient required self-catheterization.

RESULTS

Follow-up was obtained in all the 22 patients for 6–123 (mean: 52.0) months. Finally, the total success rate of all surgical strategies was 90.9% (20/22), including 1 of 2 patients (50.0%) treated with a simple transperineal approach, 3 of 3 (100%) with a transperineal intercorporeal septal separation approach, 14 of 15 (93.3%) with a transperineal inferior pubic approach, and 2 of 2 (100%) with a combined transpubic-perineal approach (**Table 1**). The mean urethral defect lengths of boys treated by the four above-mentioned approaches were 1.8 cm, 2.0 cm, 3.5 cm, and 5.0 cm, respectively. The mean Q_{\max} examined at the time of catheter removal and at 3 and 12 months postoperatively was 19.6 (range: 12.5–30.8) ml s^{-1} , 14.4 (range: 10.2–25.3) ml s^{-1} , and 16.4 (range 11.5–21.6) ml s^{-1} , respectively (**Figure 3**).

Two patients had failed outcomes after the operation, and stenosis recurred. The two failed patients exhibited stenosis recurrence on the 2nd day after urethral catheter removal. Their Q_{\max} values were 6.4 ml s^{-1} and 5.5 ml s^{-1} at the time of catheter removal. However, they could not urinate after 1 day. Stenosis recurrence was observed in one patient with a urethrorectal fistula, which was managed by the transperineal inferior pubic approach due to surgical wound infection, and he was successfully treated with a tubed perineoscrotal flap urethroplasty 6 months later. The other patient who was managed by the simple perineal approach failed because of urethral anastomosis with high tension. Finally, he was cured by anastomotic urethroplasty through a transperineal inferior pubic approach. The intestinal stoma was restored 3–4 months postoperatively, when restenosis and extravasation were absent on cystourethrography.

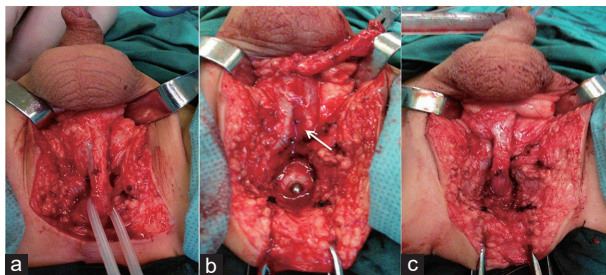


Figure 2: (a) The bulbar urethra was circumferentially mobilized. (b) Circumferential mobilization and spatulation of the proximal urethra; the white arrow shows the site of intercorporeal septal separation. (c) Tension-free anastomosis was achieved.

Mild stress urinary incontinence, which was classified according to daily pad usage,^{10,11} occurred in two boys (aged 8 and 10 years). The two boys had not received any surgical treatment except for pelvic floor muscle exercises under the guidance of professionals. After half a year, one of them gradually recovered.

DISCUSSION

In recent decades, China's industrialization and transportation industry has experienced an unprecedented period of rapid development. The etiology of urethral stricture has gradually evolved, and a recent multicentric survey showed that the rate of traumatic urethral stenosis increased, especially for PFUDDs.¹² However, the incidence of PFUDDs in boys is extremely rare, and the treatment of PFUDDs is complicated. Treating PFUDDs with dilatation and endoscopic urethrotomy is unlikely to provide a lasting cure. Transperineal end-to-end anastomotic urethroplasty has become the most commonly used strategy, and its cure rate is the highest of all strategies.^{12,13} According to a recent report, the overall success rate in children is 89% after anastomotic urethroplasty.¹⁴ However, a variety of surgical approaches for anastomotic urethroplasty have been proposed,^{5–7} and it is unclear which surgical approach is suitable for children.

An ideal surgical approach for PFUDDs should allow for excellent exposure of the obstructed segment and smooth manipulation of the instruments in the limited surgical field. Moreover, the ideal approach should result in a relatively minor surgical trauma and few postoperative complications. Most of the principles suitable for open repair of PFUDDs in children and adults are the same, barring a few intricacies and differences in anatomical characteristics.¹ Some children have a relatively narrow pelvis. Due to the confined perineal space and prepubertal prostate in children, there is often a high incidence of prostate displacement and even bladder neck laceration, resulting in less predictable disruption defects of the disconnected posterior urethra and making urethral repair more difficult in children than in adults.¹⁵

In this study, we present our 10-year experience of end-to-end anastomotic urethroplasty through four approaches to help achieve a high success rate for children with PFUDDs. In all cases, we chose a progressive strategy, starting with dissection of the urethra, removal of the obstructed fibrous urethral segment, dissection and circumferential mobilization of the distal and proximal urethra, and direct anastomosis of the urethra. Intercorporeal septal separation or even inferior pubectomy was performed if the urethral length was inadequate, followed by combined transpubic-perineal anastomotic urethroplasty if inferior pubectomy was unsatisfactory for achieving tension-free urethral mucosa-to-mucosa anastomosis. Finally, the overall success rate of one-stage operations was 90.9%, and all children had a good urinary stream with no residual and no restenosis. Among the children with PFUDDs, twenty were treated with a transperineal inferior pubic approach or simpler procedures. Only two were treated with a combined transpubic-perineal approach.

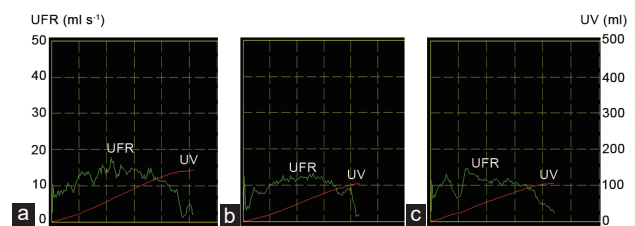


Figure 3: Uroflowmetry (a) at the time of catheter removal and at (b) 3 months and (c) 12 months postoperatively. UFR: urinary flow rate; UV: urinary volume.

In adults, the perineal approach is usually effective for simple PFUDDs without complications. However, it remains controversial whether this method is suitable for children. Due to some intricate factors and anatomical considerations in children that restrict surgical exposure, Kramer *et al.*¹⁶ have advocated the use of the combined transpubic-perineal approach for PFUDDs in children. Currently, however, the combined transpubic-perineal approach is rarely used for posterior urethroplasty in developed countries, especially for children, because of the high risk of surgical trauma.^{9,17} Although complete incision or removal of the pubis will adequately expose the disrupted proximal urethra, pelvic stability may be compromised, and children may suffer from chronic pelvic pain and gait disturbances for a long time. Although there are few advantages to the transpubic approach, total pubectomy has not been recommended as a first-line treatment option for PFUDDs in children in the last two decades. Based on our experiences, we can treat posterior urethral defects up to 5.5 cm long through a transperineal inferior pubic approach. Distal mobilization of the anterior urethra, intercorporal septal separation, and cuneiform excision of the inferior pubis were successively performed to broaden the surgical exposure site, which not only shortened the distance between the two urethral ends but also improved the visualization of the proximal urethra and facilitated surgical repair. Of the boys, most (20/22) were successfully treated with the transperineal inferior pubic approach or simpler procedures.

Unfortunately, stenosis recurred in two patients without a previous surgical history. Recurrence was observed in one case with urethrorectal fistula due to surgical wound infection, and he was successfully treated with a tubed perineoscrotal flap urethroplasty 6 months later. The other patient had a failed outcome because of urethral anastomosis with high tension. Finally, he was cured by end-to-end anastomotic urethroplasty through a transperineal inferior pubic approach. In addition, two boys developed mild stress urinary incontinence.^{10,11} According to preoperative voiding cystourethroscopy, neither of these patients suffered from a bladder neck injury, which can lead to urinary incontinence. Postoperative flexible cystourethroscopy showed no enlarged bladder neck. Pelvic fractures or surgical procedures might cause dysfunction of the internal urethral sphincter to some extent. Because of their very young ages, we first encourage children to improve continence through daily pelvic floor muscle exercises.

Although we have achieved an excellent therapeutic effect through the progressive strategy mentioned above in recent years, our study has some limitations. The patient cohort was too small to draw any general conclusions and provided little therapeutic experience. We still need to draw conclusions from a large number of cases in future clinical work. Furthermore, the exact mechanisms of urinary incontinence were not investigated in detail because of the young age of these patients.

CONCLUSIONS

The progressive strategy is effective for boys with PFUDDs, and the transperineal inferior pubic approach is suitable for pediatric patients. Most boys can be treated with the transperineal inferior pubic approach or simpler procedures without the need of completely removing or incising the pubis. The combined transpubic-perineal approach can be used in cases of extremely long urethral distraction defects.

AUTHOR CONTRIBUTIONS

LW carried out the project and drafted the manuscript. HLG participated in the project design and manuscript drafting. HQS and JG helped collecting the clinical data. CRJ participated in all operations as an assistant and helped revising the manuscript. FC helped revising the project design. YLS performed operations for all patients, conceived of the study, and supervised the project. All authors read and approved the final manuscript.

COMPETING INTERESTS

All authors declare no competing interests.

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