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## Blunt pediatric anterior and posterior urethral trauma: 32-year experience and outcomes

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### KEYWORDS

Urethroplasty;  
Pediatric trauma;  
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**Abstract** *Objective:* To analyze our experience with delayed repair of pediatric urethral trauma.

*Materials and methods:* From 1978 to 2007, 26 boys <18 years old (mean age 15.0) presented for delayed repair of urethral stricture after blunt trauma. Anterior and posterior urethral injuries were separately stratified.

*Results:* There were 8 anterior and 18 posterior urethral strictures. All patients presented in a delayed fashion. Mean follow up of the anterior cohort was 2.9 years. All repairs were performed via a ventral onlay buccal graft or anastomotic approach. The mean follow up of the posterior cohort was 1.1 years, and all posterior urethral injuries were repaired via an anastomotic approach.

Overall success for anterior stricture disease was 88.9% and for posterior stricture disease was 89.5%. All three urethroplasty failures responded favorably to internal urethrotomy; however, one failed anterior repair and one of the two failed posterior repairs required two internal urethrotomy operations for success. No secondary urethroplasty operations were required and ultimately all patients were voiding per urethra without need for urethral dilation.

*Conclusion:* Delayed, definitive repair of pediatric urethral trauma via open urethroplasty has a high success rate.

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### Introduction

Pediatric urethral trauma is a rare injury that presents a challenge for urologists. Due to the rarity of this injury,

the management of pediatric urethral trauma has followed available treatment algorithms for adult urethral trauma. Fortunately, successful outcomes have been achieved and published for the repair of anterior and posterior traumatic pediatric urethral injuries [1–5].

Pelvic fracture is significantly associated with injury to the posterior urethra (prostatic and membranous urethra). The majority of studies examining pediatric urethra trauma have included patients with pelvic fractures after blunt trauma when assessing the incidence of pediatric urethra injury. Despite the high incidence of associated pelvic

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fracture, the incidence of posterior urethra injury after pelvic fracture is uncommon with a reported frequency of 0.47–4.2% [6,7]. Given the incidence of pediatric pelvic fractures is only 2.4–4.6%, one can easily understand the extreme rarity of pediatric posterior urethra trauma [8,9].

Pediatric anterior urethra injury (penile and bulbar urethra) is less common than posterior urethra injury. The bulbar urethra is most commonly injured in anterior urethral trauma. During anterior-directed forces to perineum, the bulbar urethra is compressed against the symphysis pubis resulting in injury ('straddle injury'). Associated pubic rami fracture after blunt pelvic trauma can also result in bulbar urethra trauma. The incidence of bulbar urethra injuries secondary to straddle injuries has been reported as 0.6–10% [6,10].

As discussed above, pediatric urethral injuries are uncommon. As such, we decided to include both anterior and posterior urethral injuries in our manuscript. Given the differences in presentation and surgical repair, anterior and posterior injuries have been stratified to two different cohorts. Our primary research aim was to present our 32-year experience with delayed surgical repair of traumatic anterior and posterior urethral injuries in a pediatric cohort. Given the broad experience with urogenital trauma at our level one trauma hospital, we queried our urogenital trauma database to examine our results.

## Materials and methods

### Study population

We retrospectively reviewed our urethral trauma database from 1978 to 2010. To ensure capture of any missed injuries, we additionally reviewed billing records for CPT (Current Procedural Terminology) codes of all anterior or posterior urethral reconstructions (CPT 53400, 53405, 53410, and 53415) performed at San Francisco General Hospital and the University of California – San Francisco Medical Center. Patients were included if they were males  $\leq 18$  years old who sustained a urethral injury from blunt trauma. We did not exclude any patients who received intervention for their stricture prior to referral to our hospital (i.e., urethral dilation, internal urethrotomy, and urethroplasty).

### Clinical outcomes

Clinical assessment consisted of history and physical, retrograde urethrogram, voiding cystogram (when possible), and uroflow (when possible). Success was defined as resolution of stricture after first attempt at open surgical repair. Failure was defined as the need for urethral dilation or internal urethrotomy after repair. Of note, no patients were placed on a protocol of intermittent self-catheterization after anterior or posterior urethroplasty.

The median and range of clinical follow up was assessed. Given the uncommon nature of this injury, a significant source of the referrals to our center were from across the western United States. As such, routine follow up after surgery was challenging. Despite this limitation, every attempt was made to follow patients every 3 months following surgery. Retrograde urethrogram and uroflow

were performed at 3 and 12 months, while uroflow and post-void residual was performed at 6 and 9 months. Internal urethrotomy was considered if obstructive flow was noted by patient history, uroflow/post-void residual, or retrograde urethrogram. Postoperative stress urinary incontinence after posterior urethroplasty was not considered as a failure. Of importance to the reading audience, we did not utilize a questionnaire to assess erectile dysfunction or stress urinary incontinence after surgical reconstruction. We fully support the use of such questionnaires and do utilize them in our current practice; however, none of these questionnaires were used when the majority of the patients in this series underwent surgical repair.

## Surgical technique

### Anterior urethra

Determination of ventral onlay buccal mucosa graft (BMG) versus anastomotic urethroplasty for anterior urethral strictures was not predicated by stricture length alone; instead this was at the discretion of the primary surgeon (JWM) on a case-by-case basis. Buccal mucosa onlay graft was performed for strictures exceeding 2 cm; however, an extended anastomotic urethroplasty procedure for strictures  $>2$  cm was employed at the primary surgeon's discretion if the bulbar stricture was proximal (i.e., closer to the membranous urethra).

### Posterior urethra

Posterior urethral strictures were repaired by an anastomotic approach for all strictures via a perineal incision as the initial incision of choice (i.e., grafts and flaps were not used). An abdominal incision was also performed if the perineal approach did not allow a tension-free urethral anastomosis. Partial or total pubectomy was performed as a length-gaining maneuver if the planned anastomosis was under tension. Partial pubectomy was performed from the perineal approach, while an abdominal incision was used if a total pubectomy was required. The corporal bodies were not split to gain additional urethral length based upon preference of the primary surgeon.

Postoperative voiding cystogram was performed 2 and 3 weeks after anastomotic anterior urethroplasty and one-stage buccal graft urethroplasty, respectively. Following posterior urethroplasty, the postoperative voiding cystogram was performed 4 weeks after repair. The urethral catheter was replaced if there was any evidence of contrast extravasation.

IRB approval was obtained from the University of California San Francisco Medical Center (H5338-26917).

## Results

Twenty-six boys were included in our analysis. There were 8 boys in the anterior urethral injury cohort and 18 boys in the posterior urethral injury cohort. The overall mean age was 15 years (range 4–18 years).

### Anterior cohort

Straddle injury was the etiology of all anterior urethral trauma cases in our cohort (Table 1). Mean follow up of the

**Table 1** Anterior urethral injury cohort.

Subject #	Injury mechanism	Age (yrs)	Prior surgery	Stricture length (cm)	Repair (cm BMG)	Follow up (yrs)	Success?
1	Straddle	17	UD	2.6	Anastomotic	0.25	Yes
2	Straddle	13	UD-DVIU-UD	1.5	Anastomotic	4.8	No
3	Straddle	13	UD	1.5	Anastomotic	7.8	Yes
4	Straddle	16	DVIU	2.3	Anastomotic	0.17	Yes
6	Straddle	17	DVIU	1.9	Anastomotic	1.2	Yes
5	Straddle	14	None	2.6	V-BMG (4)	4.3	Yes
7	Straddle	16	None	2.7	V-BMG (3)	0.97	Yes
8	Straddle	18	UD	5.5	V-BMG (6)	3.8	Yes

UD: urethral dilation, DVIU: direct vision internal urethrotomy, V-BMG: ventral onlay buccal mucosa graft.

cohort was 2.5 years. Prior endoscopic therapy was performed in all patients but two prior to referral to our institution. Mean excised stricture length was 2.6 cm as determined by intraoperative ultrasound prior to incision. Ventral onlay BMG or anastomotic urethroplasty was performed for all patients in the anterior cohort. Patients who underwent ventral BMG had a stricture length of at least 2.5 cm. Local flaps and dorsal onlay BMGs were not utilized.

Contrast extravasation was not noted at follow up voiding cystogram among any patients in the anterior cohort. The lone failure from the anterior urethra cohort was a patient who had three prior attempts at endoscopic therapy prior to referral to our institution. Surgical failure was noted at 14 months after urethroplasty. The patient underwent two successive DVIU procedures. Follow up for an additional 3 years after the second DVIU did not reveal any evidence of recurrence on uroflowmetry or cystoscopy.

Following initial surgical repair, success for the anastomotic patients was 80% (4/5), while the success of the ventral BMG group was 100% (3/3).

### Posterior cohort

All patients in the posterior urethral injury cohort had concomitant pelvic fracture after blunt trauma, and all presented to our institution in a delayed setting with a suprapubic catheter in place. Median age of this cohort was more variable (median 16.5 years, range 4–18 years) than the anterior cohort, which only included teenagers (Table 2). The majority of patients in the posterior cohort had not undergone a prior intervention. Prior urethroplasty was performed in one patient, while six other patients had previously failed various types of endoscopic therapy. There were no bladder neck injuries in the posterior urethral injury cohort.

All patients were repaired via an open perineal approach, except for one who required an abdominal-perineal approach secondary to stricture length. Partial pubectomy were required in 28% in order to achieve a tension-free anastomosis. As stated above, based upon surgeon preference, splitting the corporal bodies was not employed if

**Table 2** Posterior urethral injury cohort.

Subject	Age (yrs)	Prior surgery	Stricture length	Surgical approach	Pubectomy	Follow up (yrs)	Success?
1	17	Endo cut to light	Unknown	Perineal	Partial	2.3	Yes
2	4	Endo cut to light	3.5	Abd/Perineal	Partial	0.1	Yes
3	16	None	1	Perineal	No	1	Yes
4	9	None	Unknown	Perineal	No	3	No
5	17	None	1	Perineal	No	0.17	Yes
6	16	None	2	Perineal	Partial	0.1	Yes
7	17	None	4.5	Perineal	Partial	0.38	No
8	11	None	2	Perineal	No	0.17	Yes
9	17	None	5	Perineal	No	0.07	Yes
10	5	None	2	Perineal	Partial	5.9	Yes
11	15	None	2	Perineal	No	2.8	Yes
12	16	Endo cut to light	2	Perineal	No	0.1	Yes
13	18	None	3	Perineal	No	0.54	Yes
14	18	None	3	Perineal	No	0.43	Yes
15	11	Urethroplasty	Unknown	Perineal	No	0.85	Yes
16	18	Endo Align-KTP Laser DVIU-UD	2	Perineal	No	1.2	Yes
17	18	Endo align-UD	2.5	Perineal	No	0.33	Yes
18	17	Endo align	Unknown	Perineal	No	0.53	Yes

Endo: endoscopic, Endo align: endoscopic realignment, Abd: abdominal.

additional length was required for a tension-free urethral anastomosis. In such instances, a partial pubectomy was performed. Partial pubectomy, instead of total pubectomy, was performed to allow abdominal visualization of the posterior urethra/bladder neck. An osteotome and mallet were used, being careful not to inadvertently injure the underlying posterior urethra. Neither total pubectomy nor supracrural rerouting was performed in any patient. Mean follow up was 1.1 years (0.1–5.9 years). Contrast extravasation was not noted during postoperative voiding cystogram on any patients in the posterior cohort.

There were two failures in the posterior urethral injury cohort (Table 2). Subject #4 failed 9 months after posterior urethroplasty and required two subsequent DVIUs. He was successfully followed for 1.5 years after his second DVIU without any sign of stricture recurrence. Subject #7 failed at 4.5 months and was treated with DVIU. Overall success of the posterior cohort was 88.9% (16/18).

## Discussion

Pediatric urethral injuries are uncommon. We present our 32-year experience as a tertiary referral center experienced with urethral reconstruction. During this period, there were a total of 8 anterior and 18 posterior urethral injuries that required surgical repair. Both cohorts were primarily composed of referrals from outside hospitals across the Midwest and West Coast of the US. Accordingly, the patients were transferred months after acute management of concomitant injuries. Hence, this single-institution series constitutes our experience with delayed repair.

Repair of urethral injury can involve the anterior or posterior urethra, and surgical repair at these two distinct sites is technically different. As such, anterior and posterior urethral injuries were separated in our study. There is sparse data in the literature regarding repair of pediatric straddle injuries [11,12]. Unfortunately, the anterior cohort was too small to allow any test for significance of our surgical outcomes. Despite this, our results were encouraging. Furthermore, the surgical techniques were similar to those used to successfully repair adult straddle injuries. We did opt for extended anastomotic urethroplasty in two patients with strictures >2 cm located at the proximal bulb. Similar to adult patients, repair of such long strictures should only be done at the proximal bulbar urethra to prevent penile curvature and loss of penile length. We did utilize a buccal mucosa graft in three patients who underwent bulbar urethroplasty. These were for individualized reasons and involved a urethral lumen that was obstructive but not obliterated. We favor buccal mucosa grafts for inlay procedures as the mucosa does not contract. To reduce narrowing at the proximal and distal graft apices, we do recommend placing interrupted sutures.

In regard to the posterior cohort, more has been published concerning success and surgical approach in the pediatric setting [1–4,13]. Table 3 includes the success rates reported in recent manuscripts, which are similar to that reported in our current series (88%). Crucial to success of an anastomotic urethroplasty for posterior urethra injury is total excision of stricture and a tension-free anastomosis. We prefer to begin all pediatric posterior

urethroplasty operations via the perineal approach. If circumferential urethral mobilization does not allow a tension-free anastomosis or if excessive urethra mobilization (>2 cm) is thought to potentially result in penile shortening, additional maneuvers can be employed. We did not split the corporal bodies or perform corporal rerouting in any patients and instead opted to perform an abdominal-perineal approach in one patient who needed additional mobilization (subject #2, Table 2). Splitting the corporal bodies has been described to repair pediatric posterior urethral injuries; however, a tension-free anastomosis was possible without resorting to this step in any of our patients [12]. There is added morbidity with a second incision and potential pubectomy; however, there has not been a negative association with eventual bone growth, posture, or gait from total pubectomy in the pediatric population [1,3,5]. If pubectomy has been performed, clinicians should monitor the pubic bone with periodic plain radiographs of the pelvis to examine potential re-growth of the pubic bones medially (which could impinge upon the rerouted urethra).

Podesta and colleagues reported that no patients were successfully managed following primary alignment for posterior urethral injuries ( $n = 0/10$ ); however, a different study did report urethra patency without need for additional procedures in 45% after realignment (10/22) [1,14]. These results are significantly worse than those achieved with delayed repair. As such, we favor initial suprapubic tube placement with delayed open repair 3–6 months after acute injury. Additionally, we do not favor urethral dilation for management of pediatric urethral strictures. Endoscopic internal urethrotomy is most useful in select situations, such as short bulbar urethral strictures associated with minimal spongiofibrosis; however, repeated utilization of this procedure for recurrent strictures is not advised as it is not associated with definitive cure [15].

Compared to adult pelvic fractures, the pediatric pelvis has greater elasticity of the sacroiliac joints and symphysis pubis. In addition, there is increased plasticity of the bone, which translates to a greater force of energy required to generate a pelvic fracture. This elasticity and plasticity is likely a reason for the lower incidence of pelvic fracture in pediatric versus adult patients (4.6% vs 10%) [8]; however, when pediatric pelvic fracture occurs, the generating force is highly associated with major soft tissue and vascular injury (i.e., pelvic vasculature injury, rectal injury, visceral injury, and intestinal perforation) which will require immediate attention prior to definitive management of the associated posterior urethra injury.

**Table 3** Outcome of delayed anastomotic urethroplasty of the posterior urethra.

Series	N	Success (%)
Podesta [1]	30	26 (86.7)
Koraitim [2]	65	60 (92.3)
Das et al. [3]	10	8 (80)
Rourke et al. [4]	8	7 (87.5)
Onen et al. [13]	16	12 (75)

All patients in the posterior cohort had associated pelvic fractures. Placement of a suprapubic tube in the acute setting, or afterward if endoscopic realignment fails, is recommended while waiting for concomitant orthopedic injuries to be treated. Despite conflicting literature pertaining to suprapubic tube placement in the setting of pelvic fracture [16], we have not noted any problems (i.e., pelvic abscess or hardware infections) with suprapubic catheter use in the acute or delayed setting.

Immediate repair of traumatic urethral injuries is not recommended unless in the setting of a bladder neck injury. There were no associated bladder neck injuries in our posterior cohort; however, a discussion of their presentation and management deserves mention. Immediate repair of such challenging injuries is recommended to prevent associated complications such as pelvic abscess, urinoma, or osteomyelitis. Placement of a urethral catheter across the injury site with tacking urethral sutures for tissue approximation can be performed in addition to suprapubic tube placement in the acute setting. Care should be taken to rule out a concomitant rectal injury, as an unrecognized injury could result in necrotizing soft tissue infection. In the lone report examining outcomes after pediatric bladder neck injury, immediate repair did prevent such acute complications; however, immediate repair was not protective against urinary incontinence [17]. A recent report supports early surgical intervention to repair adult bladder neck injuries, as delayed attempts were found to be associated with significant morbidity [18].

A major limitation of our study is that almost all of our referrals were from outside hospitals, with the majority of patients from states other than California. As a result, long-term follow up was difficult due to travel distance. Referrals were from urologists with no experience with pediatric urethral trauma who readily contacted us when complications arose. Accordingly, we acknowledge limited follow up data past the initial postoperative visit in a small number of patients from our cohort who were unable to return to our institution for postoperative visits. Unfortunately, this precludes us from confidently assessing eventual successful outcome in these patients. Furthermore, this travel distance has negatively affected our ability to identify and treat any problems with impotence or stress incontinence related to the injury and/or subsequent management. Another limitation is that we did not utilize quality of life, impotence, or incontinence questionnaires that would have aided a better understanding of long-term complications following acute injury and subsequent urethral reconstruction. Given the importance of quality of life measures, we now routinely use such questionnaires for our urologic reconstruction cohort. While inclusion of these measures would have further strengthened our manuscript, we do not feel that the absence of such measures reduces the impact of our experience with these rare and challenging injuries.

## Conclusions

Successful management of pediatric anterior and posterior urethral injuries is possible using adult-based algorithms. Excision and primary anastomosis is recommended for

anterior straddle injuries; however, we have had successful outcomes using buccal mucosa onlay grafts for longer anterior strictures. In addition, delayed repair of posterior strictures via a perineal approach is feasible and successful; however, an abdominal approach may be required in select cases to achieve a tension-free urethral anastomosis.

## Conflict of interest statement

None of the authors have any conflicts of interest to report.

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## Ethical approval

IRB approval was obtained from the University of California San Francisco Medical Center (H5338-26917). Patients were not directly contacted outside of scheduled hospital visits.

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