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Transperineal anastomotic urethroplasty with distal transection versus proximal transection: How to predict?

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Abstract

Objectives: To evaluate the pubourethral stump angle (PUA) to determine the site of urethral transection during transperineal anastomotic urethroplasty (TAU).

Patients and methods: Patients diagnosed with pelvic fracture urethral distraction defect who underwent preoperative magnetic resonance (MR) urethrography and were treated with TAU between June 2019 and December 2021 were retrospectively reviewed. According to the site of urethral transection during TAU, patients were classified into proximal and distal groups receiving TAU with proximal and distal transection, respectively. The demographic and clinical data were recorded. The PUA was measured on sagittal T2-weighted MR urethrography. The relationship between the site of urethral transection and PUA was analyzed.

Results: Sixty-seven patients were included. Forty-one and 26 patients were included in the proximal and distal groups, respectively. Finally, the success rates in the proximal and distal groups were 95.1% and 92.3%, respectively. The PUAs were 123.7° ± 14.6° and 86.5° ± 9.8° ($p = 0.005$), respectively. The curves for the 2 groups intersected between 90° and 110°. The scribing effects at 90°, 100°, and 110° in the 2 groups were compared in detail. Compared with 90° and 110°, 100° had the highest sensitivity as the demarcation line.

Conclusions: In the treatment of pelvic fracture urethral distraction defect, the PUA on MR urethrography is an objective and valid parameter for evaluating the site of urethral transection during TAU. A PUA >100° indicates that proximal transection should be preferentially attempted.

Keywords: Pelvic fracture; Urethra; Anastomotic urethroplasty; Magnetic resonance; Urethrography

1. Introduction

Transperineal anastomotic urethroplasty (TAU), first proposed in 1976,[1] has been used to treat pelvic fracture urethral distraction defects (PFUDDs) for >50 years. Transperineal anastomotic urethroplasty is recognized as the gold standard method for reconstruction of PFUDD because of its high success rate and low incidence of complications.[2–4] The key steps of TAU include bulbar urethral mobilization (first), transection of the stenotic urethra (second), scar resection (third), and urethral anastomosis (fourth). Scar resection is the most difficult and risky step. However, the difficulty of scar resection is directly affected by the first 2 steps. Therefore, choosing an appropriate method to complete the first 2 steps significantly reduces the difficulty of the third step.

In traditional TAU, the bulbar urethra was circumferentially mobilized and transected at the distal end of the stenotic scar. This method did not reduce the difficulty of scar resection and exposure of the proximal disrupted urethral end; however, it increased the risk of intraoperative rectal injury. According to the modified TAU strategy reported in our previous studies,[5–7] in the first and second steps, the urethra was directly mobilized to the proximal side of the stenotic scar, and the position of the urethral transection was selected at the proximal end of the stenosis. After transection, the opening of the proximal urethral stump was directly exposed. Thus, the difficulty of resection of the proximal and distal scars was significantly reduced. However, not all patients are suitable for modified TAU. The choice of proximal or distal transection is not arbitrary; however, it needs to be judged based on objective evidence. Evidence comes from the depth of the proximal urethral stump and local manipulatable space.

The pubourethral stump angle (PUA), first proposed in 2018 by Horiguchi et al.,[8] is defined as the angle between the long axis of the pubis and line between the proximal urethral end and the lower border of the inferior pubic ramus. The PUA can be measured using magnetic resonance (MR) urethrography. It has high value for evaluating the depth of the proximal urethral stump and local manipulatable space. In this study, we evaluated the role of the PUA in the selection of urethral transection sites.

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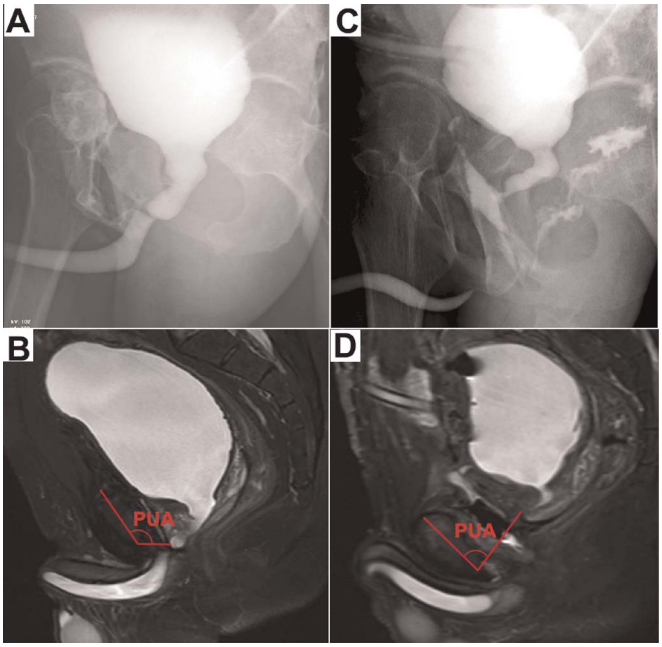

Figure 1. Preoperative RVCUG and MR urethrography in the 2 groups. (A) and (B) show RVCUG and MR urethrography of the proximal group, respectively. (C) and (D) represent RVCUG and MR urethrography of the distal group, respectively. MR = magnetic resonance; PUA = pubourethral stump angle; RVCUG = retrograde and voiding cystourethrography.

2. Materials and methods

2.1. Patients

After obtaining approval from the Ethics Committee of Shanghai Jiao Tong University Affiliated Sixth People's Hospital, all male patients who underwent TAU for the treatment of PFUDD by a single surgeon between June 2019 and December 2021 were screened. Patients who underwent preoperative dynamic contrast-enhanced MR urethrography were included. Patients with bladder neck injury, false passage, urethrorectal fistula, plate fixation on the pubis, or incomplete clinical and follow-up data were excluded. All patients underwent suprapubic cystostomy for urinary diversion prior to urethroplasty. Transperineal anastomotic urethroplasty was performed at least 3 months after the initial trauma or last failed intervention. Preoperative retrograde and voiding cystourethrography (RVCUG) and flexible cystoscopy were preliminarily used to evaluate the length, depth, and complications. Furthermore, MR urethrography was used to evaluate the position and depth of the proximal urethral stump relative to the pubis. The demographic and clinical data were recorded.

2.2. MR urethrography and PUA measurement

Magnetic resonance urethrography was performed using a 3.0-T MR imaging unit (Siemens, Erlangen, Germany). After filling the bladder and anterior urethra with normal saline, the patients were instructed to urinate in the supine position. Subsequently, they were scanned by the MR imaging system using a pelvic phased-array coil: conventional axial T1-weighted imaging (repetition time [TR], 555, echo time [TE], 9.9, 20 cm × 20 cm field of view, 3.0-mm thickness with 2.8-mm interval); sagittal, axial, and coronal T2-weighted imaging (TR, 4500, TE, 125, 20 cm × 20 cm field of view, 3.0-mm thickness with 2.5-mm interval); and enhanced 3-dimensional T1 gradient echo sequence (TR, 5.7, TE, 2.5, 20 cm × 20 cm field of view, 2.5-mm reconstructed thickness with 2.5-mm interval). The PUA was defined as the angle between the long axis of the pubis and the line between the proximal urethral end and the lower border of the inferior pubic ramus. This was measured using sagittal T2-weighted MR urethrography (Fig. 1).

2.3. Anastomotic urethroplasty strategy

2.3.1. First: anastomotic urethroplasty with proximal transection[5] (proximal group) Under general anesthesia, all patients were placed in the standard lithotomy position. The distal bulbar urethra was completely mobilized distally up to the penoscrotal junction through an inverted Y-shaped incision in the perineum. Under the guidance of a metal sound in the proximal urethra that passed through the suprapubic cystostomy tract (SCT), the stenotic urethral segment was circumferentially mobilized proximal to the proximal urethral stump. The urethra was then transected at the proximal side of the stenotic scar to expose the proximal disrupted urethral stump (Fig. 2A). The remaining scars at the distal and proximal urethral ends were trimmed to expose the healthy urethral mucosa and allow suturing. Finally, tension-free mucosa-to-mucosa anastomosis was performed using a silicon catheter. If necessary, ancillary procedures, including intercorporal septal separation or inferior pubectomy, may be performed to expand the surgical field or reduce anastomotic tension.

2.3.2. Second: anastomotic urethroplasty with distal transection[5] (distal group) The bulbar urethra was fully mobilized distally up to the penoscrotal junction through an inverted Y-shaped incision. After confirming the location of the stenosis by using a metal sound in the distal urethra, the urethra was transected at the distal side of the stenotic scar (Fig. 2B). The distal scar was then trimmed to expose the healthy distal urethral mucosa. Under the guidance of a metal sound in the proximal urethra that passed through the SCT, the

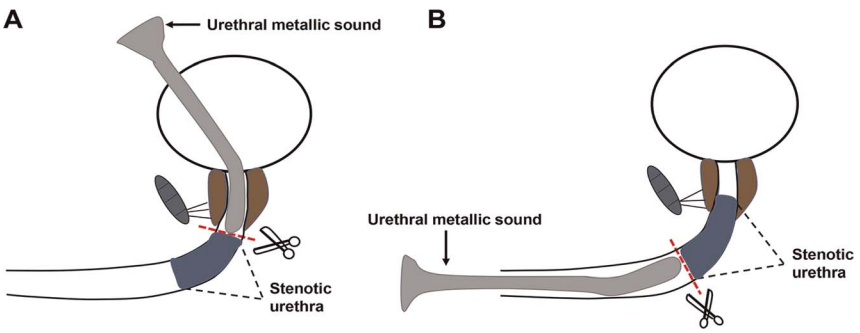

Figure 2. Schematic diagram of (A) TAU with proximal transection and (B) TAU with distal transection. TAU = transperineal anastomotic urethroplasty.

remaining proximal scar covering the proximal urethral stump was meticulously resected layer by layer to reach the healthy urethral mucosa. Urethral anastomosis was performed over a silicone catheter using 8 interrupted 4–0 polyglactin sutures. Ancillary procedures may also be required.

2.4. Postoperative management and follow-up

The urethral catheters were removed 3–4 weeks after operation. After catheter removal, the patients were reexamined at 3, 6, and 12 months and every year thereafter. Successful anastomotic urethroplasty was defined as the reestablishment of a uniform urethral caliber using flexible cystoscopy, with no further interventions needed. Postoperative complications were classified using the Clavien-Dindo classification.[9] Erectile function was assessed using the International Index of Erectile Function-5 questionnaire.[10] Urinary continence was classified as normal, grade I, or grade II. Grade I was occasional incontinence without urinal pad demand, and grade II was incontinence requiring the use of urinal pads.[11]

2.5. Statistical analysis

According to the position of the urethral transection in TAU, patients were classified into 2 groups (proximal and distal). Data were analyzed using the Statistical Package of Social Science software (SPSS version 21). Intergroup differences in the measurement data were analyzed using an independent sample t test. The chi-square test was used to evaluate differences in categorical variables between the 2 groups. A value of $p < 0.05$ was considered statistically significant.

3. Results

3.1. Patient characteristics and surgical strategy

A total of 69 patients with PFUDD underwent MR urethrography and TAU. Two patients with incomplete follow-up data were excluded. Finally, 67 patients were included in this study. Among these, 41 (61.2%) were included in the proximal group receiving TAU with proximal transection, and 26 (38.8%) in the distal group receiving TAU with distal transection (Table 1). No statistically significant differences were observed in age, body mass index, disease course, immediate management, concomitant urethrorectal fistula, or history of failed urethroplasty between the 2 groups. Although the length of stenosis between the 2 groups did not show a significant statistical difference ($p = 0.379$), the length of the stenosis in the proximal group was obviously shorter than that in the distal group (2.7 ± 0.7 cm vs. 3.7 ± 0.6 cm). Moreover, in immediate management, the proportion of patients who underwent primary realignment was higher in the proximal group than in the distal group (26.8% vs. 19.2%) ($p = 0.565$). The operative time was significantly shorter in the proximal group than in the distal group ($p < 0.005$). All 67 patients were followed up for 3–31 months (median, 14 months). The final success rates in the proximal and distal groups were 95.1% (39/41) and 92.3% (24/26), respectively. No rectal injury occurred during the surgery in either group. The incidences of postoperative complications, erectile dysfunction and urinary continence, did not differ significantly between the 2 groups (Table 2).

3.2. PUA on MR urethrography and surgical strategy

The association between preoperative PUA on MR urethrography and the surgical strategy is also listed in Table 1. The PUA in the proximal group and distal group was 123.7° ± 14.6° (range, 96.7°–149.5°) and 86.5° ± 9.8° (range, 69.5°–106.8°), respectively. A significant difference was observed between the 2 groups ($p = 0.005$). The detailed distribution of PUA degrees in the 2 groups is shown in Figure 3. The curves for the 2 groups intersected between 90° and 110°. The scribing effects at 90°, 100°, and 110° in the 2 groups were compared in detail. At 90°, 8 patients (30.8%) in the distal group had a PUA >90°, and no patients in the proximal group had a PUA <90°. For 100°, 3 patients (11.5%) in the distal group had a PUA >100°, and 2 (4.9%) in the proximal group had a PUA <100°. At 110°, none of the patients in the distal group had a PUA >110°, and 9 (22.0%) in the proximal group had a PUA <110°. Compared with 90° and 110°, 100° had the highest sensitivity.

4. Discussion

In this study, the PUA was used for the first time to assess the depth of the proximal urethral stump in patients with PFUDD and as a reference for selecting the position of urethral transection during TAU. Moreover, the PUA degrees in the proximal and distal groups were significantly different, with a relatively clear dividing line.

Transperineal anastomotic urethroplasty is the classic procedure for the treatment of PFUDD. In our previous report,[5] according to the different positions of the urethral transection, the TAU strategy was divided into 2 surgical methods: TAU with proximal transection and TAU with distal transection. Proximal transection is preferred for patients with a superficial proximal urethral stump. Conversely, distal transection can be performed in patients with a relatively deep

Table 1

Patient characteristics and clinical data.

Characteristics	Distal (n = 26)	Proximal (n = 41)	p
Age, mean ± SD (range), yr	38.9 ± 10.5 (18–61)	40.2 ± 12.3 (19–66)	0.260
BMI, mean ± SD (range), kg/m^2	22.9 ± 2.8 (19–29)	24.2 ± 2.4 (18–30)	0.154
Disease course, mean ± SD (range), mo	12.3 ± 18.9 (3–89)	14.0 ± 28.0 (3–164)	0.619
Immediate management, n (%)			0.565
Primary realignment	5 (19.2)	11 (26.8)	
Suprapubic cystostomy	21 (80.8)	30 (73.2)	
Patients with urethrorectal fistula, n (%)	1 (3.8)	1 (2.4)	1.000
History of failed urethroplasty, n (%)	7 (26.9)	7 (17.1)	0.368
Stenosis length, mean ± SD (range), cm	3.7 ± 0.6 (2.5–5)	2.7 ± 0.7 (1.5–4.5)	0.379
PUA on MR urethrography, mean ± SD (range), degree	86.5 ± 9.8 (69.5–106.8)	123.7 ± 14.6 (96.7–149.5)	0.005
Operation time, mean ± SD (range), min	100.6 ± 16.7 (75–150)	81.8 ± 11.5 (60–120)	<0.005
Intraoperative blood loss, mean ± SD (range), mL	297.3 ± 135.4 (100–800)	202.7 ± 97.5 (50–600)	0.431

BMI = body mass index; MR = magnetic resonance; PUA = pubourethral stump angle; SD = standard deviation.

Table 2

Postoperative complications and functional assessment.

Characteristics	Distal (n = 26)	Proximal (n = 41)	*p*
Complication classification (Clavien-Dindo), n (%)			0.837
I	7 (26.9)	11 (26.8)	
II	3 (11.5)	3 (7.3)	
III	0 (0)	0 (0)	
IV	0 (0)	0 (0)	
V	0 (0)	0 (0)	
Total	10 (38.5)	14 (34.1)	
Complication type, n (%)			
Wound bleeding	0 (0)	1 (2.4)	0.612
Delayed wound healing	1 (3.8)	2 (4.9)	0.668
Wound numbness	2 (7.7)	3 (7.3)	0.650
Hematoma	4 (15.4)	5 (12.2)	0.489
Epididymo-orchitis	2 (7.7)	3 (7.3)	0.650
Wound infection	1 (3.8)	0 (0)	0.388
Postoperative ED, n (%)			0.814
Normal	8 (30.8)	15 (36.6)	
Mild	6 (23.1)	12 (29.3)	
Moderate	7 (26.9)	8 (19.5)	
Severe	5 (19.2)	6 (14.6)	
Postoperative UI, n (%)			0.567
Normal	21 (80.8)	35 (85.4)	
Grade I	4 (15.4)	6 (14.6)	
Grade II	1 (3.8)	0 (0)	

ED = erectile dysfunction; UI = urinary continence.

proximal urethra. However, how to judge which method was suitable for a patient was only based on the relatively subjective judgment of the chief surgeon, such as rough assessment based on urethrogram, observing the integrity of the verumontanum by flexible cystoscopy before surgery, and palpating the metallic sound placed in the proximal urethra passing through the SCT in the perineum during surgery. This subjective judgment makes it difficult to popularize this new surgical strategy. Therefore, an objective and valid parameter for assessing the depth of the proximal urethral stump and the selection of an appropriate surgical method are required. However, there have been few reports on this topic.

Which parameters are most suitable for assessing the locational depth of the proximal urethra? In some reports, the depth of the proximal urethral region was determined by measuring the vertical and horizontal vertical distances, or the direct distance from the proximal urethral stump to the inferior pubic border.[8,11] However, simply measuring these vertical distances does not accurately represent the true depth of the proximal urethra. Pelvic fractures can cause severe longitudinal or lateral dislocation of the proximal urethra. Displacement in different directions causes varying degrees of obstruction of the proximal urethra by the pubic symphysis. In anastomotic urethroplasty using the perineal approach, a reconstructive urologist generally observes along the long axis of the pubic symphysis, which obstructs the view of the urologist. Therefore, the long axis of the pubic symphysis is considered a reference for assessing the location depth of the proximal urethral stump. Therefore, the concept and significance of PUA have emerged. Pubourethral stump angle represents a combination of measurements of the relative longitudinal and lateral vertical distances from the proximal urethral stump to the inferior pubic ramus border. Compared to measuring distances, PUA has certain advantages in terms of depth. When the PUA is small, the proximal urethral stump is typically deep and hidden behind the pubic symphysis. As the PUA decreases, the difficulty in mobilizing the proximal urethra increases. The proximal urethra is more easily exposed when the PUA is enlarged. Therefore, by what means can PUA be accurately measured?

Although conventional RVCUG has been developed for decades,[12,13] it still has limitations. During the examination, each patient was asked to lean on 1 side and remain in a semirecumbent position. In patients with PFUDD, a preoperative evaluation is typically performed using urethrography. The length and depth of stenosis are single and independent factors. Occasionally, the length of the stenosis is short, but its location is deep, making surgery difficult. Sometimes, the stenosis is long, but its position is relatively shallow, making surgery relatively simple. The length of the urethral stricture alone is not an effective predictor for surgical planning. In addition, the pubic symphysis is not visualized. Determining the true length of the urethral stricture and anatomical relationship between the urethra and pubis from the images obtained in this situation was challenging. Inexperienced doctors find it difficult to predict the difficulty of surgery accurately. Pubourethral stump angle is an indicator that combines parameters such as the length and depth of stenosis, as well as the displacement of the proximal urethra in the sagittal plane. This can help surgeons understand the difficulty of surgery and formulate better preoperative surgical plans. MR urethrography is a new technique for assessing urethral stenosis that emerged >10 years ago.[14] Compared with RVCUG, the biggest advantage of MR urethrography is that it can clearly show the anatomical relationship between the proximal urethra and the long axis of the pubic symphysis.[15,16] Therefore, the PUA can be measured using sagittal MR urethrography images. As demonstrated by the results, the 2 curves intersected between 90° and 110°. In this interval, we focused on comparing the differences of 3 angles: 90°, 100°, and 110°. When comparing with 90° and 110°, determining whether 100° had the highest sensitivity was not difficult. Therefore, we chose 100° as the approximate demarcation point and used it as the basis for selecting the 2 surgical options. We strongly recommend TAU with distal transection when the PUA is ≤100°. Proximal transection can be attempted when the PUA is >100°. The ultimate goal of posterior urethroplasty is to remove the surgical scar, locate the distal and proximal urethral ends, and perform

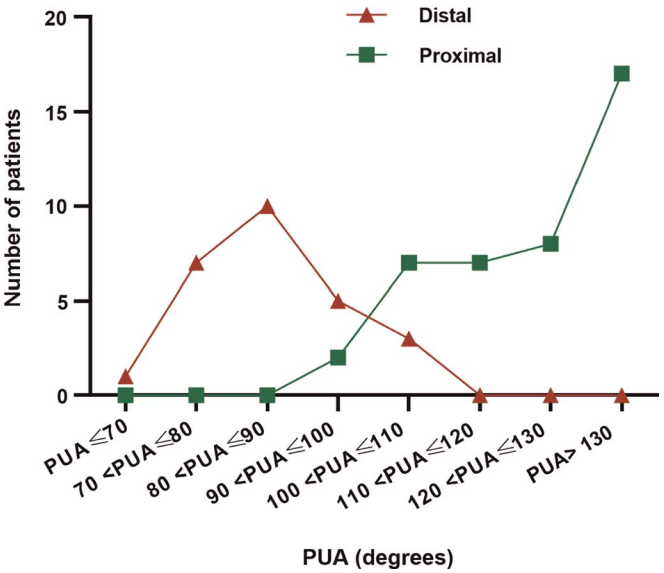

Figure 3. The distribution curves of the PUA degrees in proximal and distal groups. PUA = pubourethral stump angle.

the anastomosis. Our data showed that the operative time of the patients in the proximal transection group was significantly shorter than that of the patients in the distal transection group (Table 1). Intraoperative rectal injury can be easily avoided under the guidance of the urethral curve. In addition, no significant difference was observed in the success rate of the surgery between the 2 groups, with both success rates being above 90%.

Limitations

Although the PUA as an objective parameter was preliminarily demonstrated to be useful in assessing the depth of the proximal urethra and in selecting an appropriate surgical method, this study still had limitations. First, this was a single-center, retrospective study. This undoubtedly decreases the applicability of our conclusions. However, the demarcation point of the PUA may not be precise. In the future, a prospective multicenter study with a larger sample size is required. Second, fixing the pelvis or femur with a plate is contraindicated for MR urethrography. This limits the applicability of MR urethrography to a certain extent. Third, the cost of MR urethrography is several times higher than that of RVCUG in China. Despite these limitations, we believe that the results of this study will greatly help urologists perform urethral reconstruction.

5. Conclusions

In the surgical treatment of PFUDD, the PUA on MR urethrography is an objective and valid parameter for evaluating the urethral transection site in TAU. A PUA >100° indicates that proximal urethral transection should be preferentially attempted. A PUA of ≤100° indicates that TAU with distal transection is strongly recommended.

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None.

Statement of ethics

This study was approved by the institutional review board of Shanghai Jiao Tong University Affiliated Sixth People's Hospital. No participant's consent was taken because it was a retrospective review on the electronic database. All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of interest statement

The authors declare no conflicts of interest.

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Author contributions

LW, XL, YS: Participated in research design;
LW, WS, GC: Participated in the writing of the manuscript;
RL, CJ, ZL, YL: Participated in the performance of the research;
LW, XY XL: Participated in data analysis.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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