

Pediatric/Reconstructive Urology

Clinical Factors That Predict Successful Posterior Urethral Anastomosis With a Gracilis Muscle Flap

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Purpose: We evaluated the preoperative clinical factors that affect the surgical outcome of posterior urethral anastomosis (PUA) with a gracilis muscle flap (GMF) to determine which factors predict benefit from the use of the GMF.

Materials and Methods: This was a retrospective analysis of 49 patients who underwent a delayed PUA with a GMF. A successful clinical outcome was defined as achieving a peak urinary flow rate greater than 15 mL/s at 3 and 12 months postoperatively without evidence of stricture recurrence on a retrograde urethrogram or cystourethroscopy at 3 months postoperatively. Multiple clinical factors were evaluated by use of univariate and multivariate analyses.

Results: The outcome of 21 of 49 patients (42.9%) was deemed successful. The mean age of the 49 patients was 37.2±13.5 years and the mean follow-up duration was 43.4±28.0 months. The length of the urethral defect was significantly shorter in patients with a successful outcome than in patients with an unsuccessful outcome ($p=0.010$). The outcome differed significantly depending on whether the patients had a previously successful urethroplasty ($p=0.036$) or whether they had suffered a pelvic bone injury ($p=0.012$). Multivariate logistic regression analyses revealed that a previous urethroplasty was the only preoperative clinical factor that significantly affected the surgical outcome in PUA with a GMF (odds ratio, 0.218; 95% confidence interval, 0.050 to 0.947; $p=0.042$).

Conclusions: A history of previous urethroplasty is a preoperative clinical factor that significantly affects the surgical outcome in PUA with a GMF; the procedure is more likely to be successful in patients who have not previously undergone urethroplasty.

Keywords: Surgical anastomosis; Surgical flap; Urethral stricture

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INTRODUCTION

The golden triad for a successful outcome in posterior urethral anastomosis (PUA) has been defined as complete excision of scarred tissue, a lateral fixation of healthy urethral end mucosa, and the creation of a tension-free anastomosis [1,2]. Even in patients with unfavorable conditions, such as a stricture gap that exceeds 3 cm, a previously failed repair, associated perineal fistulas, rectourethral fistulas, periurethral cavities, false passages, or an open bladder, the aforementioned factors are key to a successful urethral reconstruction [3]. However, these complex conditions may

require removal of a vast amount of tissue, which creates a large dead space. In such situations, additional methods are required to overcome the difficulties that arise.

A gracilis muscle flap (GMF) has been widely used in reconstructive surgical procedures such as rectourethral fistula repair because the GMF is long enough to reach the perineum and is endowed with a good blood supply from well-vascularized muscle [4,5]. Thus, the GMF was introduced to manage urethral end-to-end anastomosis and the perianastomotic dead space by wrapping the urethral anastomosis and filling the perianastomotic dead space. The GMF likely supplements the blood supply to the im-

paired vascularity of an anastomosis and prevents the compression of the urethral anastomosis by a perianastomotic hematoma.

We previously reported that a GMF can be useful in patients with a stricture longer than 3 cm and in patients who have previously undergone perineal urethroplasty [6]. Although we confirmed its therapeutic effects, whether to apply a GMF to all urethroplasties remains debatable because its benefits have only been demonstrated in a limited number of cases, and a GMF necessitates another long incision of the thigh. Therefore, better evidence is required to determine the indications for the use of a GMF. The objective of our study was to evaluate the preoperative clinical factors that affect surgical outcome to determine who will benefit from the use of a GMF in PUA.

MATERIALS AND METHODS

1. Patients

After acquiring approval from the CHA Bundang Medical Center Institutional Review Board, we reviewed the medical records of 202 patients who underwent urethral reconstruction for a traumatic urethral injury between February 2001 and June 2011. Patients aged ≥ 18 years who had undergone a delayed PUA with the use of a GMF owing to posterior urethral injury were evaluated; PUA patients with neurogenic issues that affected voiding were excluded. Patient follow-up had continued for at least 12 months. A successful outcome was defined as meeting the following criteria: 1) peak urinary flow rate greater than 15 mL/s at 3 and 12 months postoperatively, 2) no evidence of stricture recurrence on retrograde urethrogram or cystourethroscopy at 3 months postoperatively, and 3) no obstructive urinary symptoms for at least 12 months postoperatively. Patients were divided into two groups according to whether they experienced a successful surgical outcome.

2. Preoperative and operative procedures

The length of the urethral defect and patency of the anterior urethra was assessed by voiding cystourethrography with retrograde urethrography. Patients with anterior urethral strictures were excluded. The bladder neck and length of urethral defect were assessed by urethroscopy and antegrade cystourethroscopy through the suprapubic cystostomy tract.

All patients were placed in a lithotomy position and underwent an inverted Y-shaped perineal incision. The distal urethral end was identified by retrograde passage of a metallic urethral sound and the proximal urethral end was identified by antegrade passage of a metallic urethral sound through the suprapubic cystostomy tract. After determining the extent of the urethral defect, all fibrotic tissues of the urethral defect including any periurethral scar tissue were completely excised. To avoid tension on the suture site, urethral end-to-end anastomosis was performed by using a progressive perineal approach for midline separation of the proximal corporal bodies, inferior pubectomy,

and supracorporal urethral rerouting. The proximal and distal ends of the urethra were spatulated and an anastomosis between the two ends was performed over a 16-Fr silicon urethral catheter using 4-0 or 5-0 Vicryl sutures. The gracilis muscle interposition was performed as previously reported [6]. The skin incision was made parallel to the long axis of the gracilis muscle of the left thigh. The gracilis muscle was dissected from the medial aspect of the left thigh and released from its insertion. The GMF was rotated, and its distal end was brought to the perineal area through a subcutaneous tunnel. The muscle was then wrapped around the anastomosed urethra, and the perineal defect was filled with the rotated GMF. A suprapubic catheter was placed for urinary diversion, and two suction drains were placed in the retropubic space.

3. Follow-up and data analysis

The urethral catheter was removed 3 weeks postoperatively if no extravasation was visualized on retrograde urethrography. Uroflowmetry was performed after removal of the catheter. The suprapubic catheter was removed if the patient voided in the same manner as before the urethral injury. If any symptoms of obstruction or poor urinary flow were present, retrograde urethrography was performed to confirm the urethral stricture.

Age, body mass index (BMI), a history of previous surgery, the cause of the urethral injury, incidence of pelvic bone injury, incidence of bladder injury, incidence of rectal injury, the urethral lengthening procedure, the length of urethral defect, and the time interval between the original urethral injury and the PUA or between a previous urethroplasty and the PUA were all evaluated for their influence on surgical outcome. Data are shown as the mean \pm standard deviation (SD). The age, BMI, time interval, and urethral defect length of patients whose surgical outcome was successful were compared with those values in patients whose surgical outcome was unsuccessful by t-test. The number of patients who had undergone a previous urethroplasty; the cause of the urethral injury; the incidence of pelvic bone injury, bladder injury, or rectal injury; and the number of patients who had undergone each urethral lengthening procedure were compared between patients with a successful surgical outcome and those with an unsuccessful outcome by using the chi-square test and Fisher exact test. To identify the preoperative clinical factors that affected surgical outcome, univariate and multivariate logistic regression analyses were performed. Regression analysis results are shown as the odds ratio (OR) and 95% confidence interval (CI). Statistical analyses were performed by using IBM SPSS ver. 19.0 (IBM Co., Armonk, NY, USA). Data are presented as mean \pm SD. A p-value less than 0.05 was considered statistically significant.

RESULTS

Forty-nine patients underwent a delayed PUA using a GMF to treat a posterior urethral injury (Table 1). The

TABLE 1. Comparison between patients with and without a successful posterior urethral anastomosis using a gracilis muscle flap

Characteristic	Total (n=49)	Success (n=21)	Failure (n=28)	p-value ^a
Age (y)	37.2±13.5 (19.0–68.0)	34.8±10.5 (20.0–54.0)	39.0±15.3 (19.0–68.0)	0.289 ^c
Body mass index (kg/m ²)	22.3±2.8 (16.4–31.1)	21.8±2.2 (17.4–26.0)	22.7±3.2 (16.4–31.1)	0.319 ^c
Time interval (mo) ^b	12.1±9.6 (2.0–36.0)	9.2±9.4 (2.0–34.0)	14.3±9.2 (2.0–36.0)	0.062 ^c
Urethral defect length (cm)	3.9±1.3 (1.0–7.0)	3.3±1.2 (1.0–5.0)	4.3±1.3 (2.0–7.0)	0.010 ^c
Previous operation history (yes/no)	20/29	5/16	15/13	0.036 ^d
Cause (traffic accident/straddle injury)	43/6	18/3	25/3	0.518 ^e
Pelvic bone injury (yes/no)	39/10	13/8	26/2	0.012 ^e
Bladder injury (yes/no)	7/42	2/19	5/23	0.683 ^e
Rectal Injury (yes/no)	5/44	4/17	1/27	0.150 ^e
Lengthening procedure				0.150 ^e
UM+CS	6	4	2	
UM+CS+IP	29	14	15	
UM+CS+IP+UR	14	3	11	

Values are presented as mean±standard deviation (range).

UM, urethral mobilization; CS, corporal separation; IP, inferior pubectomy; UR, urethral rerouting.

^a:p<0.05 was considered statistically significant. ^b:Time interval between the original urethral injury and the bulbo-prostatic anastomosis or between a previous urethroplasty and the bulbo-prostatic anastomosis. ^c:t-test. ^d:Chi-square test. ^e:Fisher exact test.

TABLE 2. Logistic regression analysis for factors affecting surgical outcome in patients with posterior urethral anastomosis using a gracilis muscle flap

Parameter	Univariate			Multivariate		
	p-value	OR	95% CI	p-value	OR	95% CI
Urethral defect length ^a	0.017	0.514	0.298–0.887	0.120	0.557	0.267–1.164
Previous operation history	0.040	0.271	0.078–0.944	0.042	0.218	0.050–0.974
Pelvic bone fracture	0.016	0.125	0.023–0.675	0.251	0.305	0.040–2.317

OR, odds ratio; CI, confidence interval.

^a:Parameters were analyzed as a continuous variable per unit.

TABLE 3. Success rate according to the urethral defect length

Urethral defect length (cm)	Success rate, % (n)
< 2	100 (2/2)
≤ 2, < 3	60.0 (3/5)
≤ 3, < 4	50.0 (3/6)
≤ 4, < 5	38.1 (8/21)
≤ 5, < 6	37.5 (3/8)
≤ 6, < 7	0 (0/2)
≤ 7, < 8	0 (0/2)

mean age of the 49 patients was 37.2±13.5 years (range, 19 to 68 years) and the mean follow-up duration was 43.4±28.0 months (range, 12 to 126 months). The outcome of 21 of the 49 patients (42.9%) was deemed successful.

The urethral defect was significantly shorter in patients with a successful outcome than in patients with an unsuccessful outcome (p=0.010) (Table 1). There were significant differences between the two outcome groups in terms of surgical history (p=0.036) and pelvic bone injury (p=0.012). The two groups did not differ in terms of age,

BMI, time interval, cause of the urethral injury, incidence of bladder injury, incidence of rectal injury, or the urethral lengthening procedure.

Table 2 shows the results of the univariate and multivariate logistic regression analyses of the effect of preoperative clinical factors on surgical outcome. Multivariate logistic regression analysis revealed that only previous surgical history (OR, 0.218; 95% CI, 0.050 to 0.947; p=0.042) was a significant preoperative clinical factor in predicting the outcome of a delayed PUA using a GMF. Urethral defect length and pelvic bone fracture were not predictive of surgical outcome.

Table 3 shows the success rates versus the urethral defect length in patients who underwent a delayed PUA using a GMF. As the urethral defect length increased, the success rate decreased. In cases in which the urethral defect was shorter than 4 cm, success rates exceeded 50%. However, when the urethral defect was longer than 4 cm but shorter than 6 cm, the success rate fell below 40%. No successful outcome was observed in any case in which the urethral defect was longer than 6 cm.

Table 4 shows success rates according to the urethral lengthening procedure in patients who underwent a de-

TABLE 4. Success rate according to the urethral lengthening procedure

Urethral lengthening procedure	Success rate, % (n)
UM+CS	66.7 (4/6)
UM+CS+IP	48.3 (14/29)
UM+CS+IP+UR	21.4 (3/14)

UM, urethral mobilization; CS, corporal separation; IP, inferior pubectomy; UR, urethral rerouting.

laid PUA using a GMF. As the urethral lengthening procedure progressed, the success rate also decreased. Among patients treated with urethral mobilization, corporal separation, and inferior pubectomy, the success rate was 48.3%. Among patients treated with an additional urethral rerouting procedure, the success rate was 21.4%.

DISCUSSION

The GMF has been used previously to repair urethral strictures, in which case an epilated GMF was used, and to reconstruct the urinary sphincter in the treatment of post-prostatectomy incontinence [7,8]. In these two different trials, reconstruction using a GMF was deemed feasible; both techniques take advantage of the good blood supply to the GMF. On the basis of these results, we previously demonstrated the therapeutic effects of using a GMF in recurrent complete posterior urethral stricture [6]. However, the therapeutic benefit of the GMF in PUA is unproven in the treatment of other conditions, such as in cases without prior surgery or in the treatment of relatively short urethral strictures. Rather than providing a benefit, the wrapping of the GMF around the anastomosed urethra may actually increase the tension on it. To identify the therapeutic effect of the GMF in PUA, a randomized controlled study is required; before that type of study can be carried out, the selection criteria for use of a GMF must be defined. Therefore, we evaluated the preoperative clinical factors affecting surgical outcome to define the proper indications for this technique.

In our study, only a history of previous surgical treatment significantly affected the surgical outcome in PUA with a GMF. Patients without prior urethroplasty had a better chance of a successful PUA with a GMF than did patients with a prior history. The success rate in patients who had not undergone prior urethroplasty was 55.1% compared with 25.0% in patients who had undergone a prior urethroplasty. Similarly, a previous failed urethroplasty was reported to significantly decrease the success rate of subsequent anastomotic urethroplasty [9]. A failed urethroplasty can cause widespread fibrosis, ischemia from impaired vascularity, and shortening of the urethra so that its length is inadequate for mobilization, thus deteriorating the patient's surgical situation. In contrast, one study indicated that repeat urethroplasty is feasible with good surgical results even in patients with failed previous oper-

ations [10]. However, the mean stricture length in this study was relatively short and the number of patients was too low to confirm the result. In another report in which repeat surgery was used to successfully treat urethral stricture after an initial failed urethroplasty, the authors suggested that various stricture management techniques including a transpubic approach should be performed [11]. Therefore, we believe that previous urethroplasty history will adversely affect the surgical outcome.

Because mobilization of the anterior urethra can provide an additional 4.5 cm of elastic lengthening, and 2 cm of this length is used to trim and spatulate the two urethral ends, a urethral defect length exceeding 3 cm usually demands a progressive perineal approach to achieve a tension-free anastomosis [12-14]. Nevertheless, this process may increase the dead space around the urethra and result in the formation of a hematoma owing to the increased chance of bleeding. A perianastomotic hematoma and a dissection of the periurethral tissue for mobilization may deteriorate the blood supply of an anastomosis and consequently result in an unsuccessful surgery. However, the length of the urethral stricture does not predict the surgical outcome in treating traumatic posterior urethral strictures [9]. In our study, the longer the urethral defect, the lower the success rate (Table 3). The urethral defect length seemed to affect surgical outcome, but the effect was not significant. We suppose that the urethral lengthening procedure ensured a tension-free anastomosis, or that a GMF may have helped to overcome the large perianastomotic dead space caused by the long urethral defect. On the other hand, wrapping of the GMF around the anastomosed urethra may increase tension on the urethra. If the perianastomotic dead space is small because of a short urethral defect, there is less need to fill the dead space, or worse, tension on the anastomosed urethra may increase. However, these possibilities were not really addressed by our study. We believe that the GMF may be beneficial in most cases because perianastomotic dead space is created to a certain extent during any urethral mobilization.

Although the urethral lengthening procedure did not significantly affect surgical outcome, the success rate became lower with more aggressive procedures (Table 4). In particular, the success rate was very low in cases of PUA with urethral rerouting. This technique is thought to have little benefit in PUA and we agree that its benefit is limited [15]. Taken together, the preoperative clinical factors that predict a successful PUA with the use of a GMF do not differ from those predicting the success of any PUA. We previously showed the therapeutic effects of using a GMF to treat recurrent complete posterior urethral stricture. However, PUA with a GMF is more likely to be successful in patients without prior operative manipulation.

In this study, the overall success rate was 42.9%, which is lower than previously reported success rates in excess of 90% [1-2,12]. This discrepancy may result from the inclusion of more complex cases in our study group, such as the inclusion of more cases with a long urethral defect, a

history of previous urethroplasty, and pelvic bone injury. Moreover, we did not intend to evaluate the contribution of a GMF in the success rate of PUA but to evaluate the factors that predict a successful PUA with a GMF.

Instead of the GMF, the pedicled omentum or the scrotal dartos muscle have been used to wrap the urethral anastomosis and fill the perianastomotic dead space [16,17]. In particular, the pedicled omentum may simplify the treatment of abdominoperineal urethroplasty. A pedicled omental flap is supple and absorbs inflammatory debris, but bowel herniation has been reported with its use [17]. In this respect, a GMF will be a more suitable option for obliterating the perianastomotic dead space in a perineal PUA.

Our study was limited by a patient group comprising rather difficult cases that were all thought to be characterized by a large dead space. We use a GMF as frequently as possible if the defect size around the urethral anastomosis is considered large or hematoma formation is feared. This selection bias may have affected the results of the study. However, we believe that our results are valid concerning the use of a GMF because the GMF will be used primarily in these more complex cases.

Future studies that include predictive imaging to preoperatively estimate the amount of fibrotic tissue to be removed and the size of the dead space around the anastomosed urethra should be performed; these measurements are usually made during surgery. Magnetic resonance imaging has been reported to aid in delineating the precise site and density of scar tissue in posterior urethral distraction defects [18]. The preoperative measurement of the amount of fibrotic tissue and the dead space size by imaging can be used preoperatively to indicate when a GMF should be used.

CONCLUSIONS

The results of our study demonstrate that a prior history of urethroplasty is a significant preoperative clinical factor in determining the surgical outcome of PUA with a GMF. PUA with a GMF in patients who have not previously undergone surgery is more likely to be successful than that in patients with a prior history. This observation may aid in choosing patients who will benefit from a PUA with a GMF.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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