



Open Access

ORIGINAL ARTICLE

Operational Andrology

# Application of the Mathieu combined tunnel technique for repairing glans dehiscence after failed hypospadias repair

Qi-Gen Xie<sup>1,2</sup>, Kai Xia<sup>2</sup>, Xiang-Ping Li<sup>2</sup>, Peng Luo<sup>2</sup>, Zuo-Qing Li<sup>1</sup>, Cheng Su<sup>1</sup>, Chun-Hua Deng<sup>2</sup>

Repairing glans dehiscence after failed hypospadias repair is challenging for pediatric surgeons. Here, we introduced and evaluated a newly modified Mathieu technique, Mathieu combined tunnel (MCT), which involves multiple custom-designed flaps for the shortage of flap source material after repeated operations; we also constructed a tunnel to avoid the glans incision that may carry new risks of dehiscence. This retrospective study included 26 patients who were consecutively admitted to the First Affiliated Hospital of Sun Yat-Sen University (Guangzhou, China) for glans dehiscence repair after failed hypospadias repair from October 2014 to October 2020; sixteen patients underwent surgery using the MCT (MCT group) and ten patients underwent surgery using the tubularized incised plate (TIP) technique (TIP group). The operative time, blood loss, postoperative complications, normal urethral meatus rate, success rate, and Hypospadias Objective Penile Evaluation (HOPE) score were compared between the two groups. The MCT group achieved an overall satisfactory penile appearance and voiding function, with a higher rate of normal urethral meatus (15/16, 93.8%) and a lower rate of glans dehiscence (1/16, 6.2%), compared with the TIP group (70.0% and 30.0%, respectively). However, these differences were not statistically significant, possibly because of the limited number of patients (all  $P > 0.05$ ). Mean postoperative HOPE scores were similar in the MCT group (mean  $\pm$  standard deviation:  $8.83 \pm 0.89$ ) and TIP group ( $8.94 \pm 0.57$ ) ( $P > 0.05$ ). No significant differences were found between the two groups in terms of blood loss and success rate, nor in the rates of various complications (e.g., fistula, urethral stricture, and glans dehiscence). In conclusion, the MCT technique appears to be feasible and reliable for repairing glans dehiscence after failed hypospadias repair.

*Asian Journal of Andrology* (2022) 24, 311–316; doi: 10.4103/aja202163; published online: 15 October 2021

**Keywords:** failed hypospadias; glans dehiscence; Mathieu; tubularized incised plate (TIP); tunnel

## INTRODUCTION

Congenital hypospadias is one of the most common male urogenital tract malformations, affecting approximately 1 in 150–300 newborn boys.<sup>1</sup> The main goals of hypospadias repair surgery are to correct abnormal ventral curvature of the penis (chordee), reconstruct the urethra with a normal urethral meatus, and achieve a satisfying functional and cosmetic outcome. In pursuit of these goals, over 300 surgical procedures have been described; the exploration of novel techniques with lower risk of complications and better outcomes is ongoing.<sup>1</sup> Unfortunately, despite intensive efforts to improve the corresponding surgical techniques over multiple decades, the incidence of postoperative complications remains in the range of 3.32%–22.14%.<sup>2</sup> Short-term postoperative complications include urethrocutaneous fistula, urethral stricture, glans dehiscence, and urethral diverticulum; long-term postoperative complications include lower urinary tract symptoms (LUTS), unsatisfactory penile appearance, chordee, and infertility.<sup>3,4</sup> These complications affect the physical and psychological development of boys with hypospadias, usually requiring repeated operations.<sup>5,6</sup> Moreover, abnormal urination posture and repeated hospitalizations may lead to social phobia and personality disorders.<sup>3</sup>

Glans dehiscence is one of the most common serious postoperative complications of hypospadias repair, which commonly leads to the pursuit of revision urethroplasty.<sup>5</sup> Repairing glans dehiscence after failed hypospadias repair is challenging for pediatric surgeons because of multiple surgical problems, such as an insufficient source of flap materials, urethral plate scar formation, and increased psychological stress in both patient and surgeon; other problems include high risks of new glans dehiscence and fistula.<sup>6</sup> For these reasons, a superior technique is required to obtain a satisfactory outcome and avoid repeated failures after repair.

Mathieu urethroplasty is a classic technique that uses the meatal-based flap as urethral material; this technique is mainly indicated for patients with distal hypospadias, as well as patients with failed hypospadias.<sup>5,7</sup> However, the classic Mathieu technique may produce an abnormal opening of the urethral meatus (such as a fish-mouth-like opening at the ventral side of the penis, rather than a slit-like opening at the tip of the glans penis); moreover, its flap selection method is monotonous,<sup>8,9</sup> which limits its application in patients with failed hypospadias who exhibit varied anatomy. In patients with failed hypospadias, the urethral materials are usually irregularly distributed

<sup>1</sup>Department of Pediatric Surgery, First Affiliated Hospital, Sun Yat-Sen University, Guangzhou 510080, China; <sup>2</sup>Department of Andrology, First Affiliated Hospital, Sun Yat-Sen University, Guangzhou 510080, China.

Correspondences: Dr. CH Deng (dengchh@mail.sysu.edu.cn) or Dr. C Su (sucheng@mail.sysu.edu.cn)

Received: 05 April 2021; Accepted: 03 August 2021

around the urethral meatus after urethral dehiscence, which limits the application of revision urethroplasty using a traditional meatal-based flap.<sup>10</sup> Moreover, during the classic procedure, a glans incision is performed to reconstruct the urethra, which may carry new risks of glans dehiscence. Therefore, the Mathieu technique must be modified in accordance with the needs of real patients. In our center, we have been using a newly modified Mathieu technique for 7 years, Mathieu combined tunnel (MCT), which involves multiple custom-designed flaps to address the problem of insufficient flap source material; we have also constructed a tunnel through the glans to the new opening of urethral meatus at the tip of the glans penis, thus avoiding a glans incision. The first aim of this study was to introduce the MCT technique. The second aim of this study was to evaluate the superiority of the MCT technique by comparison with the tubularized incised plate (TIP) technique, another procedure widely applied in the repair of failed hypospadias.<sup>11</sup>

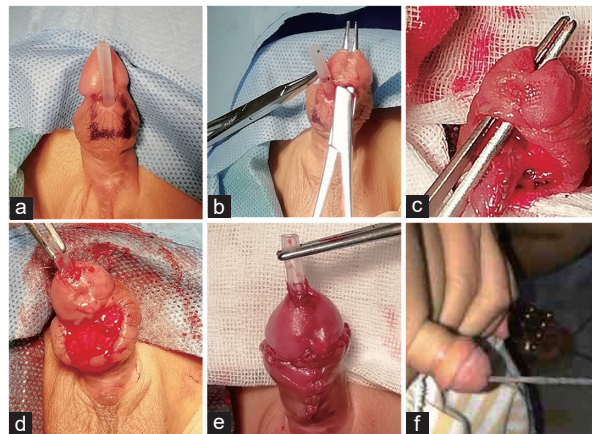
## PATIENTS AND METHODS

### Patients

The study was approved by the Ethics Committee of the First Affiliated Hospital of Sun Yat-sen University (Guangzhou, China; approval number: [2021]095) and the informed consent was exempt for the study was retrospective; the study was performed in accordance with the tenets of the Declaration of Helsinki. Clinical data and outcomes were collected regarding consecutive patients with glans dehiscence after failed hypospadias repair who were admitted to our center from October 2014 to October 2020. The inclusion criteria were as follows: complete clinical data and successful follow-up; failed hypospadias (*i.e.*, glans dehiscence with the urethral meatus opening at the middle penis, distal penis, or coronary sulcus; the concomitant fistula was located in the proximal penis or scrotum, far from the urethral meatus to enable separate closure); and the MCT or TIP technique was adopted. Duckett or free foreskin graft urethroplasty was not performed in any patient because the foreskin had been previously removed in all patients. The operations were performed by three surgeons (CS, Li Zhou, and Zhe Xu; each surgeon has performed over 300 hypospadias repairs) in our center. The patients were allocated into MCT or TIP groups according to the urethral plate findings: if the urethral plate was sufficiently wide with mild scarring, the TIP technique was attempted first; if the urethral plate was extremely narrow or exhibited severe scarring, the MCT technique was used.

### MCT technique

After general endotracheal anesthesia and disinfection, an anchoring suture was placed on the glans penis. The chordee was evaluated under artificial erection, and the proximal urethra was checked to exclude strictures and diverticula. On the basis of the patient's age and the width of the glans penis, a suitable urethral stent was selected and inserted using either a 6–10-Fr Foley catheter (CLINY, Dalian, China) or a multihole urethral stent (10-Fr ventricular drainage tube, Life Science Corporation, Yangzhou, China). The incision extending to the tunica albuginea was made on the basis of the available skin tissue, enabling the harvest of a proximal rectangular flap (Figure 1a and 2a), distal Y-shaped flap (Figure 2e), or distal rectangular flap (Figure 2i). The flap length was identical to the length of the urethral defect; its width was 1–1.2 cm. A sufficient amount of subcutaneous tissue was reserved around the meatus to ensure flap vascularity. The chordee was corrected after flap dissection, if necessary. The flap was then turned over distally, or turned toward the midline, to prepare for urethroplasty. The flap was sutured around the stent using 6/0 absorbable sutures with a subcuticular continuous suture technique to achieve urethroplasty



**Figure 1:** Mathieu combined tunnel technique. (a) Incision and meatal-based flap. (b) Construction of tunnel. (c) Urethroplasty. (d) The neourethra was passed through the tunnel. (e) Incision suture. (f) Postoperative voiding.

(Figure 1c, 2b, 2f, and 2j). Near the tunica albuginea, a 5-mm-diameter tunnel was constructed from the coronary sulcus or meatus to the tip of the glans penis using a mosquito clamp (Figure 1b), then electrocoagulated to stop bleeding. The distal end of the neourethra and stent were passed through the tunnel and fixed in the tip of the glans penis (Figure 1d, 2c, 2g, and 2k). Above the tunica albuginea, bilateral incision flaps were fully loosened to suture the subcutaneous tissue and skin in layers without tension. Lastly, the incision was closed according to the remaining skin flap (Figure 1e, 2d, 2h, and 2l). In some patients, cat ear protrusions in the ventral glans penis formed by glans dehiscence; these were excised to ensure better cosmetic appearance. The penis was dressed with two layers of gauze. Patients with recurrent wound infections and fistulas underwent suprapubic cystostomy.

### TIP urethroplasty technique

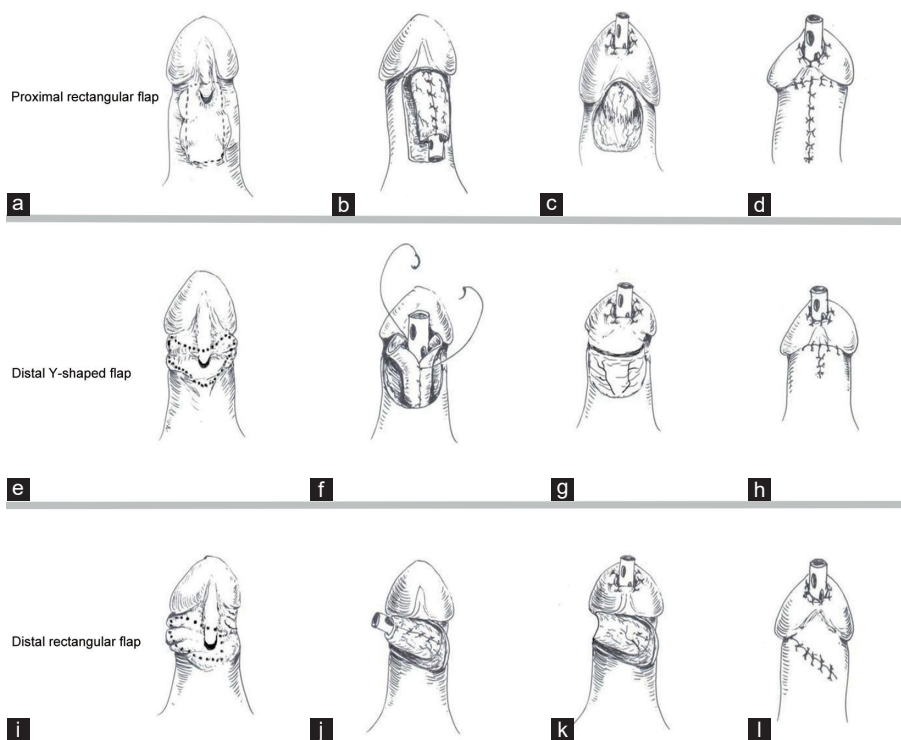
TIP urethroplasty was performed in accordance with standard technique.<sup>12</sup> The selection of stent and urine drainage in the TIP group was identical to the method used in the MCT group.

### Postoperative management

Patients in both groups underwent identical postoperative management. First- or second-generation cephalosporins were injected for 3 days. The stent was cleared daily at 3 days postoperatively, and the penis was disinfected regularly. Urination was observed after the stent was removed at 10–14 days postoperatively.

### Follow-up

Follow-up was conducted via telephone, WeChat, or outpatient review to evaluate each patient's complications, voiding function (satisfactory voiding function was defined as a thick urinary stream with no hesitancy or difficulty), and penile appearance. The patients were regularly followed up by the surgeons at 1 month and 6 months postoperatively; the final follow-up assessments were performed in March 2021 with a similar follow-up length between the MCT (mean  $\pm$  standard deviation:  $32.3 \pm 17.9$  months) and TIP ( $29.1 \pm 20.8$  months) ( $P = 0.68$ ) groups. Analyzed factors included rates of urethrocutaneous fistula, urethral stricture, glans dehiscence, wound infection, chordee, LUTS, normal urethral meatus (*i.e.*, at the tip of the glans penis, slit-like, and vertical) and success (normal urethral meatus, without complications involving fistula, urethral diverticulum, severe urethral stricture, or chordee), and Hypospadias Objective Penile Evaluation (HOPE) score<sup>13</sup> (total score = 10 points).



**Figure 2:** Schematic diagram of Mathieu combined tunnel technique (drawn by CS and QGX). (a–d) Proximal rectangular flap technique: (a) incision, (b) urethroplasty, (c) the neourethra were passed through the tunnel, (d) incision suture. (e–h) Distal Y-shaped flap technique: (e) incision, (f) urethroplasty, (g) the neourethra were passed through the tunnel, (h) incision suture. (i–l) Distal rectangular flap technique: (i) incision, (j) urethroplasty, (k) the neourethra were passed through the tunnel, (l) incision suture.

### Statistical analyses

SPSS Statistics version 22.0 (IBM, Armonk, NY, USA) was used for statistical analysis; comparisons between groups were performed using the Chi-squared test, Fisher's exact test, and Student's *t*-test. The data are presented as mean  $\pm$  standard deviation (s.d.).  $P < 0.05$  was considered statistically significant.

## RESULTS

### Patient characteristics

In total, thirty-six consecutive patients with glans dehiscence after failed hypospadias repair visited our center and underwent surgeries from October 2014 to October 2020. Five patients with incomplete data and failed follow-up were excluded, as were 5 patients who underwent free skin graft or two-stage repair. The remaining 26 patients were included in the following comparative analysis. Sixteen patients who underwent surgery using the MCT technique were assigned to the MCT group; ten patients who underwent surgery using the TIP technique were assigned to the TIP group.

All patients had previously undergone repair by the TIP, two-stage, Duckett, or free foreskin graft urethroplasty procedures; the total number of previous operations ranged from 1 to 6. There were no statistically significant differences between the two groups in preoperative demographic characteristics (Table 1).

### Intraoperative results

In the MCT group, ten patients utilized proximal rectangular flaps, while six patients utilized distal Y-shaped flaps; the mean tunnel length was 1.13 cm (s.d.: 0.58 cm, range: 0.5–3.0 cm). The mean operative time was longer in the MCT group ( $119.0 \pm 36.1$  min) than that in the

TIP group ( $87.0 \pm 36.1$  min) ( $P = 0.04$ ); blood loss (estimated by the surgeons) did not significantly differ between the MCT group ( $9.19 \pm 6.21$  ml) and the TIP group ( $8.50 \pm 6.55$  ml) ( $P = 0.79$ ).

### Postoperative complications and outcomes

In the MCT group, fifteen patients achieved a slit-like urethral meatus at the tip of the glans penis, as well as satisfactory penile appearance and voiding function (Figure 1f and 3e–3l). The MCT group exhibited a higher normal urethral meatus rate (15/16, 93.8%) and lower incidence of glans dehiscence (1/16, 6.2%), compared with the TIP group (70.0% and 30.0%, respectively); however, these differences were not statistically significant (both  $P = 0.26$ ). Mean postoperative HOPE scores were similar in the MCT group ( $8.83 \pm 0.89$ ) and the TIP group ( $8.94 \pm 0.57$ ) ( $P = 0.71$ ); in the MCT group, the postoperative score was significantly higher than the preoperative score ( $6.53 \pm 1.34$ ) ( $P < 0.001$ ). Additionally, no significant differences were found between the two groups with regard to the success rate, nor with respect to the complication rates of urethrocutaneous fistula, urethral stricture, glans dehiscence, wound infection, chordee, and LUTS (all  $P > 0.05$ ; Table 2).

## DISCUSSION

Patients with glans dehiscence after failed hypospadias repair who underwent surgery using the MCT technique achieved excellent cosmetic and functional outcomes in our study. Glans dehiscence leads to secondary hypospadias, which considerably affects penile appearance and voiding function; thus, it requires revision urethroplasty.<sup>5</sup> However, repairing glans dehiscence after failed hypospadias repair is challenging for surgeons. In contrast to primary hypospadias, it is difficult to repair secondary hypospadias using the foreskin, because this tissue has been



**Figure 3:** Preoperative penile appearance, postoperative penile appearance and voiding of 4 patients (case 1–4) who underwent MCT technique. Preoperative penile appearance of (a) case 1, (b) case 2, (c) case 3, and (d) case 4 was unsatisfactory. Postoperative penile appearance of (e) case 1, (f) case 2, (g) case 3, and (h) case 4 was improved with normal urethral meatus at the top of glans. Voiding of (i) case 1, (j) case 2, (k) case 3, and (l) case 4 was satisfactory with thick urinary stream. Case 1 in e was left with deep glanular groove.

removed in most affected patients. Thus, Mathieu,<sup>5</sup> TIP,<sup>14</sup> two-stage,<sup>6</sup> free skin graft, and mucosa urethroplasties<sup>15</sup> are more practical in patients with failed hypospadias. Various technical modifications to improve outcomes have gradually been described with respect to the surgical repair of failed hypospadias; however, the total incidence of complications has remained high, especially concerning fistula and glans dehiscence.<sup>5,6,15</sup> The cosmetic outcomes of failed hypospadias repair are inconsistent with patient expectations. Thus far, there is no superior method for glans dehiscence after failed hypospadias repair. However, in this study, patients who underwent surgery using the MCT technique achieved satisfactory penile appearance with a comparatively high HOPE score and adequate voiding function (**Figure 3**). Thus, we conclude that the MCT technique is suitable for repairing glans dehiscence after failed hypospadias repair.

The TIP technique was rapidly popularized by Snodgrass for its good cosmetic outcomes<sup>12</sup> and has been widely applied in the repair of failed hypospadias.<sup>5,14</sup> However, the high risk of glans dehiscence has limited the application of this technique in repairing glans dehiscence after failed hypospadias repair. A systematic review by Winberg *et al.*<sup>16</sup> revealed that the incidences of fistula in patients undergoing Mathieu and TIP urethroplasty procedures were both 13%; however, the incidence of urethral stricture was higher in the TIP group (5%) than that in the Mathieu technique group (2%). After TIP repair, Snodgrass *et al.*<sup>17</sup> reported that the incidence of glans dehiscence was up to 5%; another study of 500 patients demonstrated high rates of re-operation (18.6%) and glans dehiscence (6.4%).<sup>18</sup> Glans dehiscence is associated with a small glans (<14 mm),<sup>19,20</sup> a narrow and flat urethral plate, an oversized stent, wound infection, and improper repair technique. Especially with respect to the TIP technique, after urethral plate utilization and stent insertion, the glans incision exhibits high tension and can easily cause dehiscence. In this study, 14 of 26 patients had previously developed glans dehiscence following initial TIP repair. Scarring of the urethral plate and a lack of neourethral coverage tissues

**Table 1: Comparison of preoperative demographic data**

Preoperative demographic data	MCT (n=16)	TIP (n=10)	P
Age (month), mean±s.d.	67.9±37.9	74.0±43.9	0.72
Type of hypospadias, n (%)			0.99
Distal	3 (18.8)	2 (20.0)	
Midshaft	3 (18.8)	2 (20.0)	
Proximal	10 (62.5)	6 (60.0)	
Primary repair technique, n (%)			0.55
TIP	8 (50.0)	6 (60.0)	
Two-stage	5 (31.2)	4 (40.0)	
Duckett	2 (12.5)	0 (0)	
Free foreskin graft	1 (6.2)	0 (0)	
Concomitant complications, n (%)			
Chordee	1 (6.2)	1 (10.0)	1.0
Fistula	3 (18.8)	5 (50.0)	0.19
Number of previous operations, n (%)			0.59
1	6 (37.5)	4 (40.0)	
2	6 (37.5)	2 (20.0)	
≥3	4 (25.0)	4 (40.0)	
Position of urethral meatus, n (%)			0.82
Coronal	7 (43.8)	5 (50.0)	
Distal penile	4 (25.0)	3 (30.0)	
Middle penile	5 (31.3)	2 (20.0)	
Urethral defect (cm), mean±s.d.	1.87±0.93	1.31±0.55	0.07
HOPE score, mean±s.d.	6.53±1.34	6.50±0.78	0.94

HOPE: Hypospadias Objective Penile Evaluation, total score=10 points; MCT: Mathieu combined tunnel; TIP: tubularized incised plate; s.d.: standard deviation

further limit application of the TIP technique in patients with failed hypospadias. Therefore, in this study, the MCT technique was used in 16 of 26 patients whose urethral plate was narrow and scarred. The TIP group seemed to exhibit higher incidence of glans dehiscence (30.0%), compared with the MCT group (6.2%). Notably, use of the

**Table 2: Comparison of postoperative complications and outcomes**

Complication or outcome	MCT (n=16)	TIP (n=10)	P
Urethrocutaneous fistula, n (%)	2 (12.5)	1 (10.0)	1.0
Urethral stricture, n (%)	4 (25.0)	2 (20.0)	1.0
Glans dehiscence, n (%)	1 (6.2)	3 (30.0)	0.26
Wound infection, n (%)	2 (12.5)	2 (20.0)	0.63
Normal urethral meatus, n (%)	15 (93.8)	7 (70.0)	0.26
Chordee, n (%)	1 (6.2)	1 (10.0)	1.0
LUTS, n (%)	1 (6.2)	1 (10.0)	1.0
Success, n (%)	13 (81.2)	6 (60.0)	0.37
HOPE score, mean±s.d.	8.83±0.89	8.94±0.57	0.71

HOPE: Hypospadias Objective Penile Evaluation, total score=10 points; MCT: Mathieu combined tunnel; TIP: tubularized incised plate; LUTS: lower urinary tract symptoms; s.d.: standard deviation

MCT technique led to superior appearance of the urethral meatus, compared with the TIP technique. Therefore, the TIP technique might not be the best option for patients with failed hypospadias.

The Mathieu technique provides a single-stage surgical option for failed hypospadias and has been frequently described as a salvage procedure.<sup>5,11,21,22</sup> The distribution of skin tissues around the meatus considerably differs among patients with glans dehiscence; therefore, the classic flap does not allow sufficient urethroplasty in some patients. Additionally, the classic Mathieu technique can produce an abnormal urethral meatus (fish-mouth-like opening at the ventral side of the penis, rather than at the tip of the glans penis) with unsatisfactory penile appearance.<sup>8,9</sup> Therefore, a series of modified Mathieu techniques have been proposed for use in patients with primary hypospadias, but not in patients with failed hypospadias.<sup>8,9,23,24</sup>

The MCT technique had three major technical modifications and advantages, compared with the classic Mathieu technique. First, the MCT technique adopted multiple custom-designed flaps; a proximal rectangular, distal rectangular, or distal Y-shaped flap was selected according to the concrete distribution of skin tissues around the meatus, which enriched the flap variety. Second, the tunnel technique was combined; a tunnel was constructed between the urethral meatus or coronary sulcus and the tip of the glans, and the neourethra was passed through this tunnel, thereby avoiding incision in the glans penis. Third, the unique incision and flap design ensured that the neourethra suture line did not overlap with the skin suture line, presumably reducing the risk of fistula. These modifications are expected to solve the problem of insufficient material and avoid glans dehiscence for patients with failed hypospadias. In this study, the MCT group achieved a higher normal urethral meatus rate and lower incidence of glans dehiscence, compared with the TIP group, indicating that the MCT technique might provide better surgical outcomes. Therefore, the MCT technique could be appropriate for use in patients with failed hypospadias.

The application of the tunnel technique in hypospadias is effective for preventing glans dehiscence.<sup>25–27</sup> Gecit *et al.*<sup>26</sup> applied the Kutlay technique (a single-stage repair technique that combines two horizontal meatal-based flaps with the tunnel technique) in 31 patients with primary distal hypospadias; none of the patients subsequently developed glans dehiscence and only one patient developed fistula. The MCT technique also employs the tunnel technique to avoid longitudinal incision of the glans penis, thus reducing the risk of glans dehiscence and achieving a slit-like meatus at the tip of the glans. Importantly, only 1 patient in the MCT group developed glans dehiscence; the remaining patients achieved a normal urethral meatus, which substantially improved their cosmetic and functional outcomes (Figure 3).

The main MCT technical considerations were as follows. First, the proximal rectangular flap was preferred if available; this allowed the neourethra to be completely protected by the tunnel and provided a lower risk of fistula. Second, the flap was sufficient to surround the 6–10-Fr stent; harvesting a flap that was excessively wide would result in insufficient flap tissue to cover the urethra and close the incision. Third, tunnel initiation was ideally performed from the urethral meatus, far from the coronary sulcus (*i.e.*, more than 5 mm), to reduce the risk of coronal fistula. Fourth, the tunnel was ideally near the tunica albuginea and in the middle of the glans penis to ensure sufficient depth, thus reducing the risk of glans dehiscence. Notably, one patient developed glans dehiscence because the tunnel was excessively shallow. Fifth, the tunnel diameter was approximately 5 mm to reduce the risks of urethral stricture and splitting of the glans penis. Sixth, following distal splitting of the glans, suturing of the slit was essential. Seventh, the TIP technique was recommended for patients with deep glanular grooves, whereas the MCT technique was not. If the MCT technique was applied to the patients with deep glanular grooves, these deep glanular grooves would remain obvious and affect the patient's cosmetic appearance (Figure 3e); however, the shallow glanular groove would disappear and eventually a larger glans would be acquired upon application of the MCT technique.

The present study had some limitations. Notably, it was a single-center, retrospective, nonrandomized controlled study. Thus, a prospective randomized controlled study with a larger cohort is needed to evaluate this technique more comprehensively. However, this study provided a new technique for surgical management of failed hypospadias and it also improved the type of meatal-based flap available for use in the Mathieu technique. Moreover, it confirmed that the MCT technique exhibited an excellent therapeutic effect for patients with failed hypospadias; this effect was not inferior to the effect of the TIP technique. Another important limitation of this study was the small number of patients; this small sample size may have contributed to the absence of statistically significant differences between the two groups.

## CONCLUSIONS

The MCT technique appears to be a feasible and reliable procedure for repairing glans dehiscence after failed hypospadias repair; in this study, it produced excellent outcomes. The MCT technique may help to obtain a normal urethral meatus, reduce the risk of glans dehiscence, and improve cosmetic and functional outcomes. It could be suitable for broader clinical applications.

## AUTHOR CONTRIBUTIONS

CHD and CS designed the study and edited the manuscript. QGX wrote the manuscript. KX and XPL edited the manuscript. ZQL contributed to data collection. PL supervised the study. All authors read and approved the final manuscript.

## COMPETING INTERESTS

All authors declared no competing interests.

## ACKNOWLEDGMENTS

This study was supported by grants from the National Natural Science Foundation of China (No. 81971314).

## REFERENCES

- van der Horst HJ, de Wall LL. Hypospadias, all there is to know. *Eur J Pediatr* 2017; 176: 435–41.
- Pohl HG, Rana S, Sprague BM, Beamer M, Rushton HG. Discrepant rates of hypospadias surgical complications: a comparison of U.S. News & World Report and Pediatric Health Information System® data and published literature. *J Urol*



- 2020; 203: 616–23.
- 3 Gul M, Hildorf S, Silay MS. Sexual functions and fertility outcomes after hypospadias repair. *Int J Impotence Res* 2020; 33: 149–63.
  - 4 Retik AB, Atala A. Complications of hypospadias repair. *Urol Clin North Am* 2002; 29: 329–39.
  - 5 Turkyilmaz Z, Karabulut R, Atan A, Sonmez K. Redo hypospadias repair: comparison of three different methods. *Urol Int* 2020; 104: 391–5.
  - 6 Badawy H, Soliman A, Moussa A, Youssef M, Fahmy A, *et al*. Staged repair of redo and crippled hypospadias: analysis of outcomes and complications. *J Pediatr Urol* 2019; 15: 151.e1–10.
  - 7 Mathieu P. [Treatment of glanular and coronal hypospadias]. *J Chir* 1932; 39: 481–6. [Article in French].
  - 8 Hadidi AT. The slit-like adjusted Mathieu technique for distal hypospadias. *J Pediatr Urol* 2012; 47: 617–23.
  - 9 Mansoor K, Tsang T, Okoro PE. Preservation of glanular cleft in the configuration of a vertical slit neomeatus in modified mathieu hypospadias repair. *Afr J Paediatr Surg* 2019; 16: 10–3.
  - 10 Nozohoor Ekmark A, Svensson H, Arnbjörnsson E, Hansson E. Failed hypospadias repair: an algorithm for secondary reconstruction using remaining local tissue. *J Plast Reconstr Aesthet Surg* 2015; 68: 1600–9.
  - 11 Karabulut A, Sunay M, Erdem K, Emir L, Erol D. Retrospective analysis of the results obtained by using Mathieu and TIP urethroplasty techniques in recurrent hypospadias repairs. *J Pediatr Urol* 2008; 4: 359–63.
  - 12 Snodgrass WT. Tubularized incised plate (TIP) hypospadias repair. *Urol Clin North Am* 2002; 29: 285–90.
  - 13 van der Toorn F, de Jong TP, de Gier RP, Callewaert PR, van der Horst EH, *et al*. Introducing the HOPE (Hypospadias Objective Penile Evaluation)-score: a validation study of an objective scoring system for evaluating cosmetic appearance in hypospadias patients. *J Pediatr Urol* 2013; 9: 1006–16.
  - 14 Hayashi Y, Kojima Y, Mizuno K, Nakane A, Tozawa K, *et al*. Tubularized incised-plate urethroplasty for secondary hypospadias surgery. *Int J Urol* 2001; 8: 444–8.
  - 15 Aldaqadossi HA, Shaker H, Youssef H, Kotb Y, Eladawy M. Outcomes of staged lingual mucosal graft urethroplasty for redo hypospadias repair. *J Pediatr Urol* 2019; 15: 519.e511–7.
  - 16 Winberg H, Arnbjörnsson E, Anderberg M, Stenström P. Postoperative outcomes in distal hypospadias: a meta-analysis of the Mathieu and tubularized incised plate repair methods for development of urethrocutaneous fistula and urethral stricture. *Pediatr Surg Int* 2019; 35: 1301–8.
  - 17 Snodgrass W, Cost N, Nakonezny PA, Bush N. Analysis of risk factors for glans dehiscence after tubularized incised plate hypospadias repair. *J Urol* 2011; 185: 1845–9.
  - 18 Sarhan OM, El-Hefnawy AS, Hafez AT, Elsherbiny MT, Dawaba ME, *et al*. Factors affecting outcome of tubularized incised plate (TIP) urethroplasty: single-center experience with 500 cases. *J Pediatr Urol* 2009; 5: 378–82.
  - 19 Bush NC, DaJusta D, Snodgrass WT. Glans penis width in patients with hypospadias compared to healthy controls. *J Pediatr Urol* 2013; 9: 1188–91.
  - 20 Bush NC, Villanueva C, Snodgrass W. Glans size is an independent risk factor for urethroplasty complications after hypospadias repair. *J Pediatr Urol* 2015; 11: 355.e351–5.
  - 21 Bar-Yosef Y, Binyamini J, Matzkin H, Ben-Chaim J. Salvage Mathieu urethroplasty: reuse of local tissue in failed hypospadias repair. *Urology* 2005; 65: 1212–5.
  - 22 Emir L, Erol D. Mathieu urethroplasty as a salvage procedure: 20-year experience. *J Urol* 2003; 169: 2325–6.
  - 23 De Grazia E, Cigna RM, Cimador M. Modified-Mathieu's technique: a variation of the classic procedure for hypospadias surgical repair. *Eur J Pediatr Surg* 1998; 8: 98–9.
  - 24 Nezami BG, Mahboubi AH, Tanhaeivash R, Turchi A, Kajbafzadeh AM. Hypospadias repair and glans augmentation using a modified Mathieu technique. *Pediatr Surg Int* 2010; 26: 299–303.
  - 25 Su C, Yang T, Zhang Z, Xu Y, Liang Q. Para-meatus skin incision with long channel technique for midshaft hypospadias repair without penile curvature. *Urology* 2012; 79: 1143–8.
  - 26 Gecit I, Isik D, Pirincci N, Bilici S, Gunes M, *et al*. Kutlay technique for hypospadias repair. *Int Urol Nephrol* 2012; 44: 1311–8.
  - 27 Yang T, Xie Q, Liang Q, Xu Y, Su C. Two-stage repair with long channel technique for primary severe hypospadias. *Urology* 2014; 84: 198–201.

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

©The Author(s)(2021)