

Application of Distal Urethral Mobilization in the Duckett Procedure for Hypospadias

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Abstract: *Objective:* To investigate the value of distal urethral mobilization in the Duckett procedure. *Methods:* A retrospective analysis was conducted on 96 children with hypospadias treated between January 2017 and June 2023. Patients were divided into an observation group (52 cases) and a control group (44 cases) based on whether distal urethral mobilization was performed intraoperatively. The neourethral length, operative time, postoperative complications, maximum urinary flow rate (Qmax), and HOSE scores were compared between the two groups. *Results:* The neourethral length in the observation group was shorter than that in the control group [(2.4 ± 0.6) cm vs. (3.3 ± 0.7) cm, $p < 0.001$], while operative time was comparable between the two groups ($p = 0.077$). The overall complication rate [21.2% vs. 59.1%], urethrocutaneous fistula rate [9.6% vs. 25.0%], and reoperation rate [7.7% vs. 27.3%] were all lower in the observation group than in the control group ($p < 0.001$, 0.044, 0.010). Among those followed up for at least 12 months, the observation group demonstrated superior Qmax [(13.1 ± 2.9) mL/s vs. (11.4 ± 3.0) mL/s] and HOSE scores [(15.2 ± 1.4) vs. (13.8 ± 2.1)] compared with the control group ($p = 0.020$, $p < 0.001$). *Conclusion* This technique shortens the neourethral length, reduces the risk of urethrocutaneous fistula and reoperation, and improves midterm voiding function.

Keywords: Hypospadias; Duckett procedure; Distal urethral mobilization; Urethral plate; Urethrocutaneous fistula; Children

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1. Introduction

Hypospadias is one of the most common congenital genitourinary malformations in boys, with an incidence ranging from 1 in 300 to 1 in 200 live male births ^[1]. More than 300 surgical techniques have been documented, yet none is universally applicable to all anatomical variants ^[2]. The Expert Consensus on Hypospadias states that the recognized incidence of urethrocutaneous fistula ranges from 15% to 30% ^[3]. The transverse preputial island flap urethroplasty (Duckett procedure) is the mainstream technique for moderate to severe hypospadias in China; however, postoperative complications have not declined in parallel with the dissemination of the technique ^[4]. Flap length and urethral defect length are associated with short-term

complications^[5]. A single-center study of 136 cases reported incidences of urethrocutaneous fistula, stricture, and diverticulum after one-stage Duckett procedure of 17.6%, 12.5%, and 8.1%, respectively^[6].

Morphological studies have shown that scattered corpus spongiosum tissue surrounding the urethral plate possesses considerable blood supply, and the degree of abnormality correlates positively with hypospadias severity^[7]. However, urethral plate-preserving techniques are only suitable for distal and mid-penile cases without or with mild curvature; those with longer urethral defects still require transection of the urethral plate. Urethral mobilization and advancement follows the approach of preserving autologous urethra. Edan reported 65 cases of distal hypospadias with no urethrocutaneous fistula during follow-up and a stricture rate of 4.6%^[8]. This study introduces this concept into the Duckett procedure: before transecting the urethral plate, the dysplastic urethra distal to the meatus is mobilized en bloc together with the underlying spongiosum-like tissue, gaining space to extend toward the glans and thereby shortening the length of urethra requiring replacement by a tube.

2. Materials and methods

2.1. General information

2.1.1. Inclusion criteria

- (1) First urethroplasty;
- (2) Meatal location at the penile shaft to penoscrotal junction after curvature correction;
- (3) Sufficient dorsal preputial skin for harvesting a transverse island flap;
- (4) Follow-up of at least 6 months.

2.1.2. Exclusion criteria

- (1) History of prior urethroplasty or fistula repair;
- (2) Concomitant micropenis, cryptorchidism, or disorders of sex development;
- (3) Intraoperative assessment indicating the need for staged surgery.

According to the above criteria, 96 children who underwent the Duckett procedure at our hospital between January 2017 and June 2023 were included and divided into an observation group (52 cases) and a control group (44 cases) based on whether distal urethral mobilization was performed. Age, preoperative curvature angle, and hypospadias type did not differ significantly between the two groups ($p > 0.05$), as shown in **Table 1**. This study was approved by the hospital ethics committee (2023-KY-036).

Table 1. Comparison of general data between the two groups

Parameter	Observation group (n = 52)	Control group (n = 44)	t/χ^2	p
Age (years, $\bar{x} \pm s$)	3.2 ± 1.1	3.5 ± 1.3	1.24	0.218
Preoperative curvature angle ($^\circ$, $\bar{x} \pm s$)	26.4 ± 7.2	27.8 ± 7.6	0.94	0.350
Penile shaft type [n (%)]	31 (59.6)	26 (59.1)	0.06	0.970
Penoscrotal and scrotal type [n (%)]	21 (40.4)	18 (40.9)		

2.2. Surgical methods

All procedures were performed by the same surgical team under endotracheal general anesthesia combined with caudal block. The patient was placed in the supine position, and a 4-0 silk traction suture was placed

through the glans. A circumferential incision was made 0.5–0.8 cm from the coronal sulcus, with a U-shaped ventral extension around the proximal margin of the meatus down to the tunica albuginea. Degloving was performed superficial to Buck's fascia toward the penile base. After excision of ventral fibrous bands, an artificial erection test was performed; residual curvature exceeding 30° was corrected by dorsal tunica albuginea plication.

Distal urethral mobilization (observation group): Longitudinal incisions were made on both sides of the meatus along the junction between the urethral plate and the glans wings, extending through the mucosa to the surface of the tunica albuginea. Using fine scissors, sharp dissection was performed in the plane between the deep surface of the urethral plate and the tunica albuginea, mobilizing the urethra en bloc together with the underlying spongiosum-like tissue into the glans spongiosum, while preserving 2–3 mm of tissue on each side of the urethral plate. After mobilization, the distal urethra was grasped and advanced toward the glans to confirm absence of tension, and the proximal end of the mobilized segment was trimmed obliquely. In this group, the distal urethra was advanced by 0.5–1.6 cm, with a mean of (0.9 ± 0.3) cm. In the control group, the urethral plate and distal fibrous bands were transected according to the original Duckett technique.

Flap harvest and tubularization: The dorsal preputial inner plate was retracted at four corners to form a rectangle. The flap length was designed as the distance from the meatus to the glans tip plus 0.5 cm, with a width of 1.2 cm (< 3 years) or 1.5 cm (≥ 3 years). The vascular pedicle was dissected to the penile base, with a pedicle width no less than the flap width. The flap was tubularized over an 8–10 F silicone stent using continuous inverting sutures with 6-0 absorbable suture. The proximal end was anastomosed end-to-end to the obliquely trimmed mobilized distal urethra (or the native meatus in the control group). The distal end was brought through a glans tunnel to the glans tip to create a slit-like meatus. A dorsal pedicled dartos flap was used to cover the suture line and anastomosis.

2.3. Postoperative management and follow-up

Prophylactic second-generation cephalosporins were administered until stent removal. The dressing was removed at 5–7 days, and the stent was removed at 10–14 days. Voiding stream, caliber, and any leakage were observed. Follow-up visits were scheduled at 1, 3, 6, and 12 months postoperatively, and annually thereafter. Urethrocutaneous fistula was defined as the presence of an ectopic voiding channel after stent removal. Urethral stricture was defined as a narrowed stream or voiding difficulty confirmed by calibration or urethrography. Urethral diverticulum was determined by ventral bulging during voiding combined with ultrasonography.

2.4. Outcome measures and statistical methods

The primary outcome was the incidence of urethrocutaneous fistula within 6 months postoperatively. Secondary outcomes included urethral stricture, urethral diverticulum, wound infection, reoperation rate, neourethral length, operative time, and time to stent removal. Patients followed for at least 12 months who were able to cooperate underwent uroflowmetry, and the Hypospadias Objective Scoring Evaluation (HOSE, maximum 16 points) was used to assess meatal location and shape, urinary stream, erectile morphology, and presence of fistula. SPSS 26.0 software was used. Continuous data were expressed as $\bar{x} \pm s$ and compared using independent-samples *t*-tests. Categorical data were expressed as n (%) and compared using the χ^2 test; Fisher's exact test was used when expected frequencies were < 5. *p* < 0.05 was considered statistically significant.

3. Results

3.1. Intraoperative and early postoperative parameters

The neourethral length in the observation group was shorter than that in the control group ($p < 0.001$), while operative time did not differ significantly between the two groups ($p > 0.05$), as shown in **Table 2**.

Table 2. Comparison of intraoperative parameters between the two groups ($\bar{x} \pm s$)

Parameter	Observation group (n = 52)	Control group (n = 44)	<i>t</i>	<i>p</i>
Neourethral length (cm)	2.4 ± 0.6	3.3 ± 0.7	6.78	< 0.001
Operative time(min)	102.6 ± 18.1	96.3 ± 16.9	1.79	0.077

3.2. Postoperative complications

The overall complication rate in the observation group was lower than that in the control group ($p < 0.001$), with a statistically significant difference in the incidence of urethrocutaneous fistula ($p = 0.044$). No statistically significant differences were found in the incidences of urethral stricture, urethral diverticulum, or wound infection between the two groups ($p > 0.05$), as shown in **Table 3**.

Table 3. Comparison of postoperative complications between the two groups [n (%)]

Complication	Observation group (n = 52)	Control group (n = 44)	χ^2	<i>p</i>
Urethrocutaneous fistula	5(9.6)	11(25.0)	4.06	0.044
Urethral stricture	2(3.8)	6(13.6)	2.99	0.084
Urethral diverticulum	1(1.9)	4(9.1)	—	0.176
Wound infection	2(3.8)	3(6.8)	—	0.658
Total	11(21.2)	26(59.1)	14.48	< 0.001

Note: — indicates Fisher's exact test.

3.3. Stratified analysis and follow-up outcomes

After stratification by hypospadias type, the complication rates in the observation group were lower than those in the control group for both penile shaft type (5/31 vs. 13/26, $p = 0.006$) and proximal type (6/21 vs. 13/18, $p = 0.007$). Among 69 patients followed for at least 12 months who were able to cooperate (38 in the observation group, 31 in the control group), the observation group demonstrated superior maximum urinary flow rate [(13.1 ± 2.9) mL/s vs. (11.4 ± 3.0) mL/s, $p = 0.020$] and HOSE scores [(15.2 ± 1.4) vs. (13.8 ± 2.1), $p < 0.001$]. The reoperation rate during follow-up was 7.7% (4/52) in the observation group and 27.3% (12/44) in the control group, a statistically significant difference ($\chi^2 = 6.58$, $p = 0.010$).

4. Discussion

4.1. Anatomical basis and technical considerations

The inherent contradiction of the Duckett procedure lies in the fact that transecting the urethral plate resolves curvature but discards otherwise usable autologous urethra, thereby increasing the length of the tube required. The scattered corpus spongiosum surrounding the urethral plate possesses considerable blood supply, and the degree of abnormality worsens with hypospadias severity^[7]. Multicenter data on proximal hypospadias indicate that technique selection depends on urethral plate width, glans size, and meatal location^[10]. Distal

urethral mobilization represents a compromise between preservation and replacement. Three technical points should be emphasized: the dissection plane lies between the deep surface of the urethral plate and the tunica albuginea—too superficial risks injuring the submucosal vascular network, while too deep enters the corpus cavernosum; mobilization into the glans spongiosum is sufficient; and before anastomosis, the distal urethra should be grasped and advanced toward the glans to confirm absence of tension—if tension is evident, the approach should be converted to onlay or staged surgery.

4.2. Impact on postoperative complications

In this study, the neourethral length in the observation group was shortened by approximately 0.9 cm, the urethrocutaneous fistula rate decreased from 25.0% to 9.6%, and the overall complication rate decreased from 59.1% to 21.2%. Urethrocutaneous fistula arises from lack of corpus spongiosum support for the neourethra, poor local blood supply, and excessive tension at the anastomosis; shortening the tube simultaneously reduces the length of suture line and ischemic segment. Flap length itself is a risk factor for complications after the Duckett procedure ^[5]. In single-center follow-up, the postoperative fistula rate has been reported as high as 17.6% ^[6]; the control group in this study falls in the upper range of that interval, while the observation group was reduced to below 10%. Tang et al. found that one-stage Duckett had a lower fistula rate (7.56% vs. 18.49%) but a higher diverticulum rate (7.56% vs. 0.84%), suggesting that modified approaches each carry trade-offs; the trend toward lower diverticulum incidence in our observation group (1.9% vs. 9.1%) is consistent with their findings ^[11]. The difference in urethral stricture between the two groups did not reach statistical significance (3.8% vs. 13.6%, $p = 0.084$); insufficient sample size may account for the failure to detect a difference.

4.3. Indications and limitations

Distal urethral mobilization requires the presence of identifiable urethral plate or dysplastic urethral tissue distal to the meatus with reliable blood supply after mobilization. Three situations are unsuitable: residual curvature exceeding 30° requiring extensive release; prior surgery causing extensive local scarring and unclear tissue planes; and an extremely narrow or fibrotic, cord-like urethral plate. This study excluded cases requiring staged surgery, and the conclusions cannot be extrapolated to severe proximal hypospadias. The median follow-up in this series was less than 2 years; maximum urinary flow rate and HOSE scores reflect only midterm outcomes, and fistula and recurrent curvature may still occur during puberty ^[3]. This was a single-center retrospective cohort in which the technique was chosen by the surgeon based on intraoperative conditions, introducing selection bias, and the sample size was relatively small.

5. Conclusion

The Duckett procedure combined with distal urethral mobilization shortens the neourethral length without prolonging operative time, reduces the risk of urethrocutaneous fistula and reoperation, and improves midterm voiding function and objective scores. It is applicable to mid-penile and proximal hypospadias requiring transection of the urethral plate.

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Disclosure statement

The authors declare no conflict of interest.

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