

One-stage repair of proximal hypospadias by modified Duckett urethroplasty with spacious outflow tract preventing urethral stricture

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Abstract

Background

Proximal hypospadias is challenging for pediatric surgeons, with frequent postoperative complications, particularly urethral strictures. To develop a modified Duckett urethroplasty to reduce the incidence of urethral strictures in proximal hypospadias.

Methods

We retrospectively studied patients with proximal hypospadias who underwent either the modified Duckett urethroplasty or Byar's two-stage procedure between January 2020 and June 2022 at Sichuan Provincial People's Hospital and Shenzhen Children's Hospital, respectively. The modified Duckett urethroplasty included a spacious outflow tract and long-bevel anastomosis. Efficacy was compared with Byar's two-stage procedure.

Results

A total of 120 patients underwent the modified Duckett urethroplasty, and 143 underwent Byar's two-stage procedure. Urethral defects were similar in size between the two groups. Complication rates in the modified group were lower than those in the two-stage group (11.7% vs. 26.6%, $P=.003$). The urethral stricture rate was markedly lower in the modified group than in the two-stage group (0% vs. 7.0%, $P=.009$). The mean maximum flow rates significantly differed between the modified and two-stage groups (9.4 ± 3.0 vs. 5.7 ± 2.3 ml/s, $P < 0.001$). In the modified group, Optimal cosmesis was achieved with slit-like meatus and fluent urine stream.

Conclusions

The modified Duckett urethroplasty with a spacious outflow tract and long-bevel anastomosis, can prevent urethral strictures and reduce complications, demonstrating superiority over Byar's two-stage repair. The modified Duckett urethroplasty could be recommended to treat proximal hypospadias widely.

Introduction

Hypospadias is a common disease in children with an incidence rate of 1.89/1000 [1]. Proximal hypospadias poses significant surgical challenges due to severe penile curvature and long urethral defects [2], resulting in complex repairs and high complication rates—particularly urethral strictures, which cause substantial morbidity [3, 4].

Surgical methods for proximal hypospadias include one-stage repairs, such as Duckett's [5–7] and Koyanagi's procedures [8, 9], and two-stage repairs, such as Byar's and Braka's procedures [10–13]. The Duckett urethroplasty, also called transverse preputial island flap urethroplasty, introduced in 1980 [14], improved outcomes but carries > 9% urethral stricture risk [15, 16]. Consequently, many surgeons switched to two-stage repair [17], yet complications remain frequent, and treatment duration is prolonged [3].

Postoperative urethral strictures mainly occur at the anterior urethra and urethral anastomosis [15]. To address this, we modified the Duckett technique by incorporating a spacious outflow tract and long-bevel anastomosis, to reduce the occurrence of urethral strictures. This study compared modified Duckett urethroplasty with Byar's two-stage repair, to study the efficacy and safety.

Methods

Study design and Patients

This was a retrospective study. Patients who underwent either the modified Duckett urethroplasty or Byar's two-stage procedure at Sichuan Provincial People's Hospital and Shenzhen Children's Hospital between January 2020 and June 2022 were enrolled in this study. All surgical procedures were performed by three senior pediatric urologists (≥ 10 years of experience and > 500 prior hypospadias repairs). The surgeons had comparable technical proficiency, minimizing operator-dependent bias.

Inclusion criteria: Patients aged < 14 years with proximal hypospadias who underwent either modified Duckett urethroplasty or Byar's two-stage procedure with > 2-year follow-up.

The exclusion criteria were as follows: 1) sexual development or abnormal chromosomal disorders, 2) previous history of hypospadias surgery, and 3) insufficient follow-up or incomplete patient records.

Parameters: Age, location of urethral meatus, penile curvature, glans width, urethral defect, postoperative urethral fistula, urethral stricture, urethral diverticulum, glans dehiscence, recurrent curvature, urine flow rate, and cost.

After the operation, patients were followed up through outpatient clinics, online platforms, and telephone interviews. Urethral stricture was diagnosed through a combination of clinical symptoms (e.g., weak urinary stream, straining), uroflowmetry (maximum flow rate < 5 mL/s with plateau-shaped curve), and confirmatory imaging (retrograde urethrogram or urethral ultrasound).[15] Uroflowmetry was performed in accordance with the International Children's Continence Society (ICCS) standards [18].

Surgical approach

Modified Duckett urethroplasty

A U-shaped incision was made around the urethral meatus (Fig. 1A). The penile skin was circumferentially incised 5 mm below the coronal sulcus and degloved to the scrotal level in the avascular plane of the Buck's fascia. Subsequently, the fibrous contracture tissue was removed, and an artificial erection test was performed to determine whether the urethral plate was transected (curvature > 30°).

An inverted V-shaped incision was made to transect the plate (Fig. 1B). The lowest point of the incision was approximately 1.5 cm below the coronal sulcus, forming a collar-shaped urethral plate structure. Following this, the urethral plate was dissected from the superficial layer of the corpora cavernosa. An incision was made on the ventral midline of the glans, and the glans apex was moved dorsally (Fig. 1C). The glans wings were dissected off the corporeal body to the 3 and 9 o'clock positions in the plane between the corpora and the glans stroma. The edges and Excessive spongiosum tissue were trimmed, focusing on the medial and distal sides of the glans, and the volume of the glans spongiosum was reduced (Fig. 1D). Dorsal midline plication of the albuginea was performed to correct the penile curvature (Fig. 1E). The dysplastic urethra was then split by 1 cm to form a long bevel-shaped urethral plate. The urethral plate was anchored to the corporeal body (Fig. 1F).

The skin was marked for neourethra with a width of 1.5–1.7 cm, and a length of 3–4.5 cm according to the urethral defect (Fig. 1G). An incision was made along the marks just into the subcutaneous tissue, and the flap pedicle was separated down to the base of the penis in the plane between the inner plate and dorsal skin. The island flap was rotated by 90° and transferred to the ventral side of the penis, then tubularized around the catheter with a running suture from the proximal to the distal end (Fig. 1H). The new tube was sutured to the distal end of the original urethra, ensuring the suture line lay deep against the corpora cavernosa. The distal end of the flap was fixed to the tip of the glans by using a single stitch. The proximal end of the flap was tailored to include a long bevel. The flap was anastomosed with the urethra in a long bevel shape (Fig. 1I).

The bilateral wings were closed with interrupted sutures to form the glans; the length from the first suture point to the glans apex was 1.1 cm, ensuring no tension (Fig. 1J). The bilateral collar-shaped structures were closed using interrupted sutures to cover the neourethra (Fig. 1K). The distal end of the neourethra was trimmed and sutured to the new meatus to form a split.

The prepuce was divided dorsally and transferred ventrally, and the penoscrotal angle was reconstructed. The neourethra was covered with subcutaneous tissue, and ventral skin closed with interrupted sutures (Fig. 1L). The penis was dressed with sterilized gauze and an elastic bandage.

Byar's two-stage procedure

First stage

A coronal sulcus incision degloved the penis, followed by chordee excision. Artificial erection testing guided dorsal plication if curvature persisted. The glans was split midline, wings mobilized, and dorsal

prepuce divided and transferred ventrally to cover the glans and shaft.

Second stage (6 months later)

A U-shaped perimeatal incision extended distally. A 10-F stent was placed. Neourethral closure (7 – 0 polyglactin) and preputial flap coverage were performed, followed by glanuloplasty and skin closure.[19, 20]

Statistical analysis

Preoperative indicators and postoperative complications were compared between the two groups. A *t*-test or Mann-Whitney U test was performed for continuous variables, and a chi-square test or the Fisher exact probability method was performed for categorical variables. All statistical analyses were performed with a two-sided significance level of 0.05 using SPSS software (version 26.0; IBM Corp., Armonk, NY, USA).

Ethics approval

This study was approved by the Ethics Committees of the Sichuan Provincial People's Hospital (No. 2020152) and Shenzhen Children's Hospital (No. 202210802).

Results

Patient demography

A total of 120 patients underwent modified Duckett urethroplasty, and 143 patients underwent Byar's two-stage procedure. The urethral defects were 3.4 ± 0.5 cm (range: 2.0–4.8 cm) and 3.5 ± 0.6 cm (range: 2.3–5.0 cm) in the modified group and two-stage group. There were no statistically significant differences between the groups in terms of age, urethral defects, penile curvature, glans width or hypospadias type (Table 1).

Table 1
Demography and postoperative outcomes of modified group and two-stage group

Variable	Modified group	Two-stage group	P
Number of cases	120	143	
Age (month)	35.0±13.0	37.6±17.4	0.186
Urethral defect (cm)	3.4±0.5	3.5±0.6	0.331
Penile curvature (°)	58.2 ± 15.5	60.3 ± 17.1	0.297
Glans width (mm)	12.7 ± 1.8	12.4 ± 1.9	0.190
Hypospadias type			0.059
Proximal penile	38	34	
Penoscrotal	10	28	
Scrotal	66	73	
Perineal	6	8	
Follow up (month)	28.1(24 ~ 44)	28.4(24 ~ 38)	0.794
Success rate	88.3%	73.4%	0.003
Total complication	14(11.7%)	38(26.6%)	0.003
Fistula	9(7.5%)	21(14.7%)	0.068
Urethral stricture	0(0%)	10(7.0%)	0.009
Diverticulum	0(0%)	4(2.8%)	0.180
Glans dehiscence	5(4.2%)	3(2.1%)	0.540
Recurrent curvature	0	0	
Reoperation	9	36	0.001
Maximum flow rate	9.4±3.0	5.7±2.3	0.001
Cost(RMB)	14483.2±1643.2	26378.2±3365.6	0.001

Postoperative outcomes

The follow-up was 24–44 months. Complications occurred in 52 patients: 14 in the modified group and 38 in the two-stage group (Table 1). The complication rates in the modified group were significantly lower than those in the two-stage group (11.7% vs. 26.6%, $P=0.003$). The modified group achieved optimal cosmesis with a slit-like meatus and fluent urinary stream, and the parents were satisfied with it (Fig. 2).

There were 30 patients with urethral fistulas, including nine in the modified group and 21 in the two-stage group. There were 10 and four cases of urethral strictures and diverticula, respectively, all in the two-stage group. There were eight cases of glans dehiscence: five in the modified group and three in the two-stage group. The urethral stricture rate was markedly lower in the modified group than in the two-stage group (0% vs. 7.0%, $P=.009$). In total, 45 patients underwent reoperation, and all achieved successful results. Glans dehiscence occurred in eight patients, with minimal voiding impairment, and only one patient (in the two-stage group) underwent repeat surgery at the request of the parents.

The maximum urine flow rate was higher in the modified group than in the two-stage group (9.4 ± 3.0 ml/s vs. 5.7 ± 2.3 ml/s, $P=.001$). The modified group had lower costs than the two-stage group (14483.2 ± 1643.2 RMB vs. 26378.2 ± 3365.6 RMB, $P=.001$).

Discussion

Our study demonstrated that the modified Duckett urethroplasty for proximal hypospadias had encouraging outcomes, with a low complication rate of 11.7% and no urethral stricture, demonstrating superiority over Byar's two-stage repair. In this modified procedure, a spacious outflow tract, long bevel anastomosis, and collar-shaped structure below the coronal sulcus effectively reduce urethral strictures and postoperative complications.

The optimal procedures for proximal hypospadias remain controversial. Most surgeons recommend two-stage repair for its low complication rate and short learning curve [16, 17]. However, some studies report persistently high complication rates [3, 14]. Conversely, others prefer one-stage repair and have attempted to modify the Duckett urethroplasty. Wang et al. advocated preserving the distal urethral plate with long-bevel anastomosis [21]. Lyu et al. proposed using an in situ urethral plate with upper and lower wedge sutures [14]. Overall, these modifications improved outcomes, but urethral stricture rates remained high.

Urethral strictures after hypospadias repair mainly occur at the glans meatus, coronal meatus, or the junction of the neourethra and native urethra [15, 22]. Wang reported that among 169 patients with urethral stricture postoperatively, 80 involved the meatus, and 87 the anastomosis connection urethra [23]. Xiao et al. reported coronal meatal strictures in 5 of 8 patients [22]. Therefore, we propose that urethral strictures primarily result from the compression of the glans spongiosum and anastomotic stenosis. Thus, the neourethra requires a spacious outflow tract within the glans, and long-bevel anastomosis, to ensure fluent urine flow.

Our novel technique modifications comprise three key aspects:

(1) Construction of a spacious outflow tract via: 1) Dissection and full separation of bilateral glans wings were dissected and fully separated at the 3 and 9 o'clock positions. 2) Glans volume reduction by trimming excessive spongiosum tissue to obtain flat and fully expanded wings bilaterally (Fig. 3). 3)

During glans reconstruction, the first glans wing suture was positioned 1.1 cm from the glans apex (Fig. 1J).

(2) Long-bevel anastomosis of urethra. The main steps were preservation of the original urethral plate and ventral splitting of the proximal urethra. The residual proximal urethral plate measured 1–1.5 cm. Subsequently, the flap tube's proximal end was anastomosed to the urethra using a long bevel line to minimize stenosis risk (Fig. 1I).

(3) The collar-shaped urethral plate structure. The urethral plate was incised in an inverted V-shape 1 cm below the coronal sulcus (Fig. 1B), following which the collar-shaped structure was obtained to cover the neourethra.

Through these modifications, a spacious outflow tract and long-bevel anastomosis were created, augmenting the neourethral lumen and reducing compression by the glans corpus spongiosum. In our cohort, no urethral strictures occurred, with a maximum urinary flow rate of 9.4 mL/s—exceeding prior reports [24]. Moreover, our stricture rate was significantly lower than those in previous studies. Wang et al. documented 9.7% strictures in proximal hypospadias [25]. Chen et al. reported a 9.20% incidence [26]. We preserve the original urethral plate in long-bevel anastomosis, since preserving the urethral plate in anastomosis can provide support and blood supply to the neourethra and reduce strictures [14].

The coronal sulcus is known to be relatively weak and is a common site of urethral fistula development. This well-vascularized urethral plate protects the neourethra, lowering fistula incidence. Preserving the urethral plate below the coronal sulcus has been reported to reduce the urethral fistula in the coronal sulcus [21]. Our fistula rate was lower than rates reported for proximal hypospadias [5].

A meta-analysis revealed that the overall complication rates were 32% and 34% for Onlay urethroplasty and Duckett tubularized flap urethroplasty, respectively [3]. The success rate of the modified procedure was higher than that reported previously. In addition, compared with the Byar two-stage repair, the one-stage modified Duckett urethroplasty has a shorter treatment duration and lower hospitalization costs. Therefore, this modified Duckett urethroplasty could be recommended to treat proximal hypospadias more widely.

However, there are some points to be noted regarding this modified technique. First, for hypospadias with long urethral defects, the preputial flap is too long to obtain sufficient blood supply, which may lead to an ischemic neourethra and increased complications. Thus, this method is not recommended for hypospadias with a urethral defect > 5 cm. Fang et al. reported that the length of the preputial island flap was a risk factor for complications after the Duckett urethroplasty [5]. Moreover, this procedure should be performed with caution for hypospadias with dysplastic prepuces.

This study had some limitations. First, it was a retrospective, non-randomized study. This study's non-randomized design, driven by surgeon expertise and institutional learning curves, may introduce

selection bias. Second, the follow-up period in this study was relatively short. Thus, long-term follow-up is required.

Conclusion

The modified Duckett urethroplasty, with a spacious outflow tract and long bevel anastomosis, can prevent urethral strictures and markedly reduce postoperative complications in proximal hypospadias. The modified Duckett urethroplasty could be recommended to treat proximal hypospadias widely.

Declarations

Ethical approval and consent to participate

This study received Institutional Review Board approval of the Sichuan Provincial People's Hospital (IRB No. 2020152) and Shenzhen Children's Hospital (IRB No. 202210802). Due to the retrospective nature of the study and anonymization of data, the requirement for informed consent was waived by the ethics committee.

Clinical trial number

not applicable.

Consent for publication

Written informed consent for publication was obtained from all the participants.

Competing interests

The authors declare that they have no conflicts of interest.

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Author Contribution

Yunman Tang and Zhilin Yang were involved in the project administration, performing the surgical procedures, investigation, methodology, data analysis, writing original draft, review and editing of the manuscript. Xuejun Wang and Shoulin Li helped in the execution of experiments, data analysis and critical reviewing and editing of the manuscript. Yu Mao and Tiejun Zhang were involved in sample

collection, critical review and editing of manuscript. Daorui Qin and Guanglun Zhou were involved in the supervision, critical review and editing of the manuscript. Bo Yang and Jianchun Yin were involved in conceptualization and designing, supervision, data analysis. Wanhua Xu was involved in performing the surgical procedures.

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Data Availability

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

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Figures

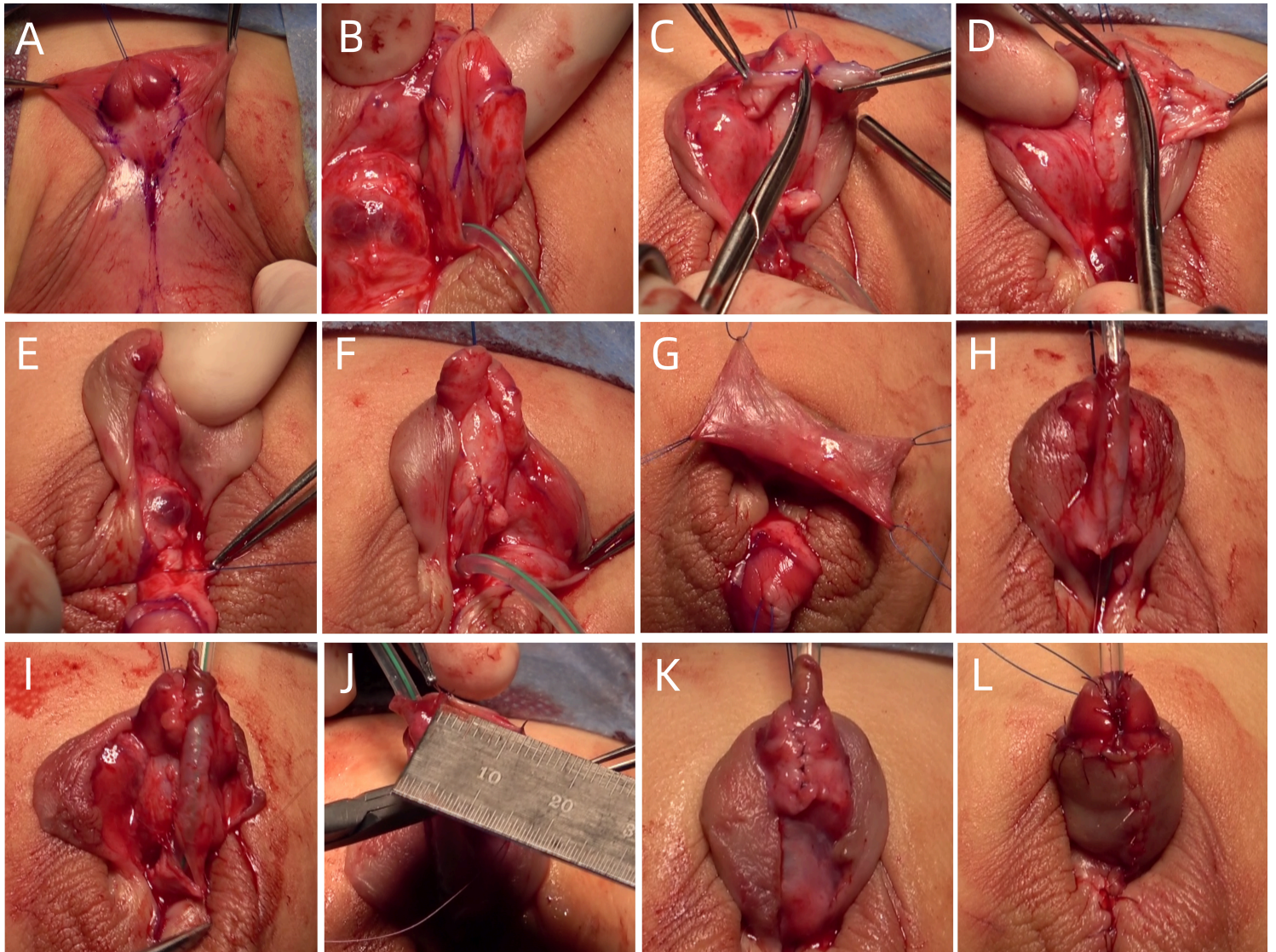


Figure 1

Surgical procedure of modified Duckett urethroplasty. (A) A U-shaped incision was made around the urethral meatus and circumferentially below the coronal sulcus. (B) Inverted V-shaped incision transecting the urethral plate. (C) An incision was made on the ventral midline of the glans. (D) The excessive spongiosum tissue were trimmed, and the volume of the glans spongiosum was reduced. (E) Dorsal midline plication of tunica albuginea correcting penile curvature. (F) Urethral plate anchored to corpora cavernosa. (G) Dorsal prepuce inner surface spread with four stay sutures. (H) The flap was tubularized around the catheter with a running suture from the proximal to the distal end. (I) Long-bevel anastomosis between flap and urethra. (J) The bilateral wings were closed; the length from the first suture point to the glans apex was 1.1 cm. (K) The bilateral collar-shaped structures were closed to cover the neourethra. (L) Ventral skin closed with interrupted sutures (final appearance).

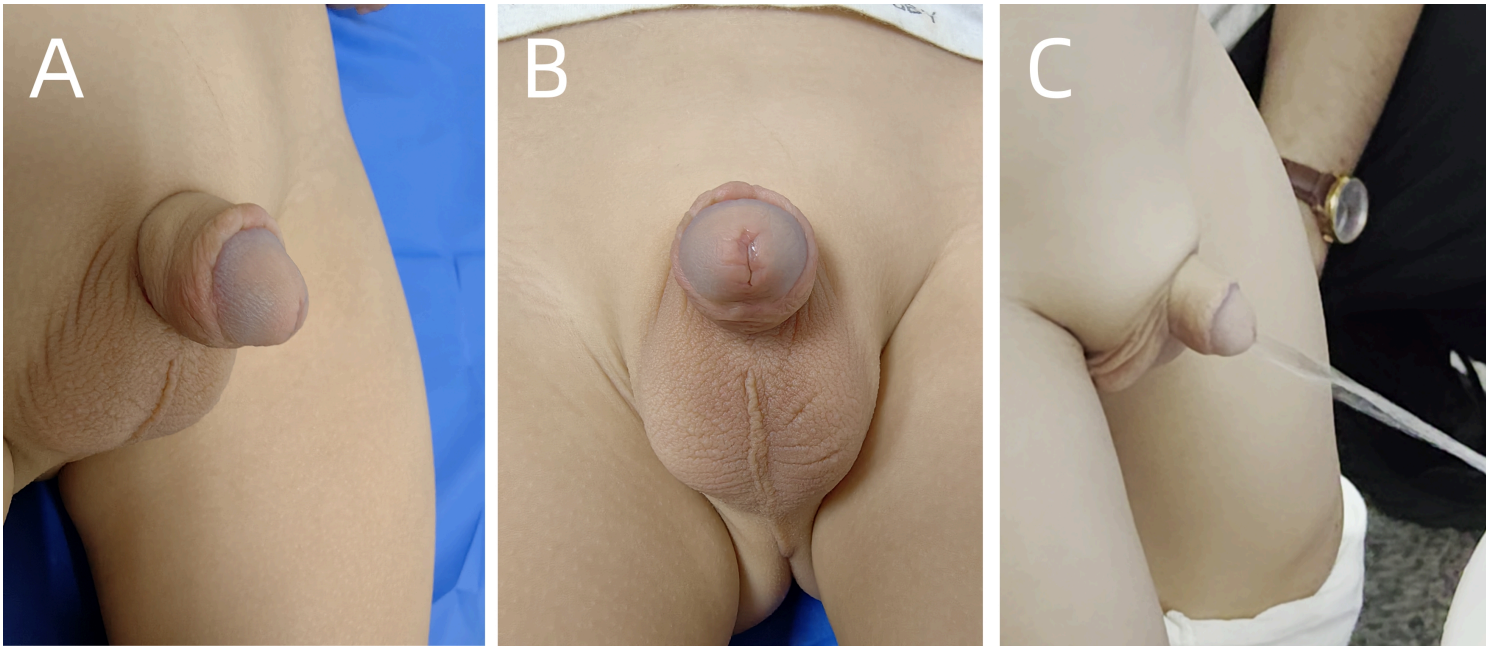


Figure 2

Cosmetic appearance after modified Duckett urethroplasty. (A) The lateral appearance of penis. (B) The frontal appearance of penis, with slit-like meatus. (C) Fluent urine stream.

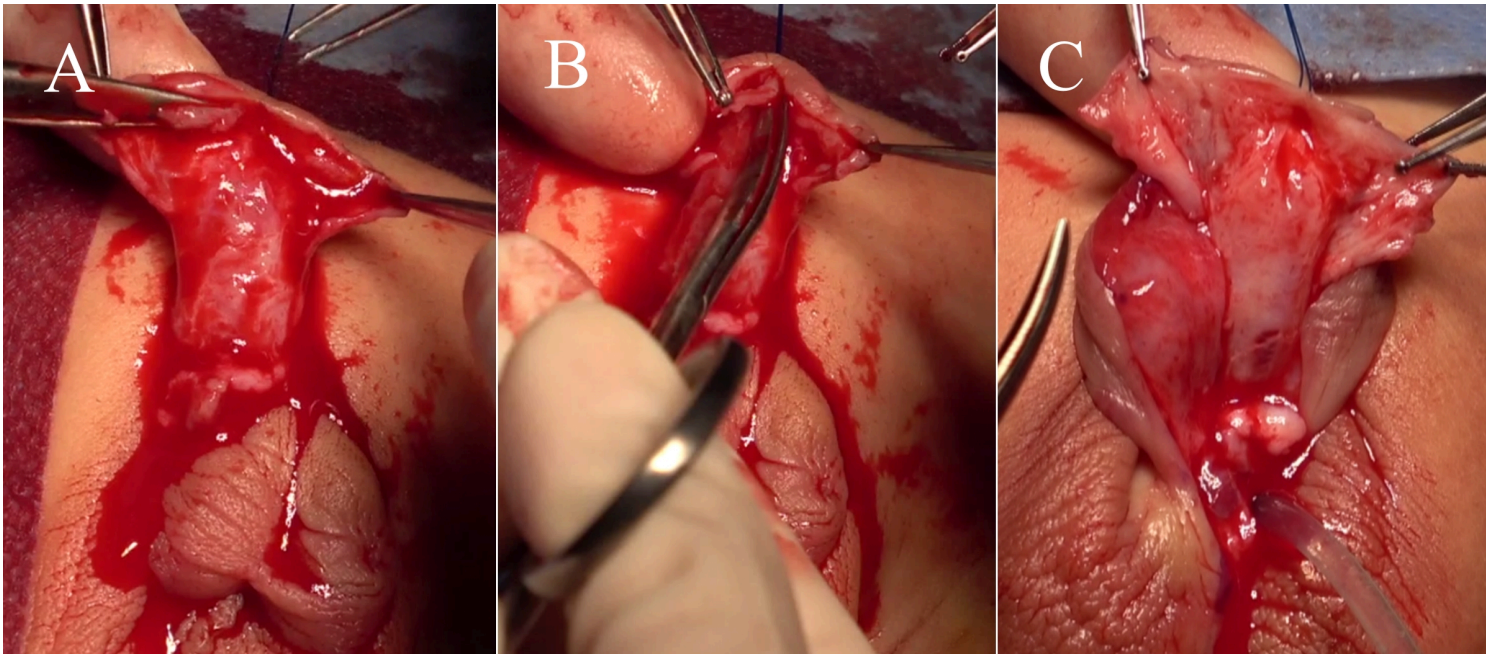


Figure 3

Glans volume reduction technique. (A) Trimming of excessive spongiosum tissue (right glans wing). (B) Trimming of excessive spongiosum tissue (left glans wing). (C) Bilateral glans wings were fully expanded and the Glans spongiosum volume was reduced.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [ModifiedDuckettprocedureanonymous.mov](#)