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The application of the modified Snodgrass technique in hypospadias surgery

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Abstract. – OBJECTIVE: We aimed to explore the effectiveness of the modified tubularized incised plate urethroplasty (Snodgrass Technique) in hypospadias surgery.

PATIENTS AND METHODS: A study was conducted on 50 pediatric patients with hypospadias treated in our hospital from May 2020 to May 2023. The patients were divided into two groups based on the condition of their urethral plate; 22 patients were included in the study group and 28 patients were included in the control group. The control group underwent the traditional Snodgrass technique, while the study group received the modified Snodgrass technique. The two groups were compared in terms of treatment efficacy, preoperative and postoperative 6-month Hypospadias Objective Scoring Evaluation (HOSE) scores, surgical data, and postoperative complications.

RESULTS: The operation time for the study group was longer than that of the control group, and the intraoperative blood loss was less, but the differences were not statistically significant ($p > 0.05$). The success rate of surgery in the study group was 95.45% (21/22), compared to 71.43% (20/28) in the control group, showing a statistically significant difference ($p < 0.05$). The maximum urinary flow rate at 3 and 6 months postoperatively was significantly higher in the study group than in the control group ($p < 0.05$). The time to maximum flow (TQmax) and postvoid residual (PVR) at 3 and 6 months postoperatively were significantly lower in the study group ($p < 0.05$). A total of 3 patients in the cohort developed urethral fistulas, all between 0.10 cm x 0.10 cm and 0.15 cm x 0.15 cm in size. By instructing the patients to apply pressure to the fistula during urination, all fistulas closed between 3 and 6 months postoperatively. The incidence of postoperative complications was 4.55% in the study group and 28.57% in the control group, a difference that was statistically significant ($p < 0.05$).

CONCLUSIONS: The modified Snodgrass technique shows significant therapeutic effectiveness in hypospadias surgery, substantially increasing the success rate and reducing postoperative complications in pediatric patients, making it suitable for widespread application.

Key Words:
Tubularized incised plate urethroplasty, Hypospadias, Complications, Children.

Introduction

Hypospadias is a common congenital malformation of the male reproductive system, with an incidence rate of about 0.3% in newborn males and around 0.2% in China. Recently, evidence[1] have indicated an increasing trend in its incidence rate. Research has found that the primary cause of this disease is the reduced growth and proliferation function of genital fibroblasts, and the lower their proliferative capacity, the more severe the clinical manifestations in children[2]. The characteristic of this disease is the ectopic position of the urethral orifice, with the urethral opening located between the perineum and the urethral orifice. Affected children exhibit symptoms, such as penile chordee and abnormal foreskin. Currently, the only mean of treating this condition is surgical correction of the deformity, aiming to establish a new urethra for normal urination and ensuring a normal appearance of the penis so that the individual can have a normal sexual life in adulthood. The goal is to achieve functional reconstruction while ensuring the penis's morphology and appearance are as normal as possible, reducing the negative emotional impact of later genital reconstructive surgeries on the child[3]. Regarding the choice of surgical method, there is currently no single technique suitable for all types of hypospadias. The Snodgrass technique is known for its simplicity and less complications,

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and its application range is continuously expanding[4]. However, it requires the child to have a well-developed urethral plate. For urethral plates that are poorly developed, measuring 3-4 mm in width, the technique involves preserving the urethral plate and selecting scrotal septal skin as the flap to form the new urethra.

This is known as the modified Snodgrass technique[5]. Our hospital conducted a study on 50 children with hypospadias treated over the past three years. Based on the condition of the children's urethral plates, they were divided into groups to compare the treatment effects of the modified Snodgrass technique and the traditional Snodgrass technique, providing a basis for the clinical treatment of pediatric hypospadias, as detailed below.

Patients and Methods

Patients

This study involved 50 male children with postoperative urethral dehiscence following hypospadias surgery, treated at our hospital from May 2020 to May 2023. Inclusion criteria: (1) patients diagnosed with hypospadias and undergoing first-time surgical treatment; (2) urethral plate > 3 mm, meeting the indications for Snodgrass surgery; (3) informed consent signed by family members, agreeing to participate in this study. Exclusion criteria: (1) severe penile chordee; (2) inability to cooperate with the study and follow-up. This study was approved by the Hospital's Ethics Committee. The children were grouped according to the condition of their urethral plate. Children with a urethral plate of 3-4 mm were included in the study group (n=22), aged 11 months to 2 years, with an average age of (1.55 ± 0.33) years, and urethral dehiscence of 1-3 cm, averaging (1.88 ± 0.38) cm. Children with a urethral plate of 6-8 mm were included in the control group (n=28), aged 11 months to 2 years, with an average age of (1.57 ± 0.31) years, and urethral dehiscence of 1-3 cm, averaging (1.92 ± 0.42) cm. There were no significant differences in general information between the two groups ($p > 0.05$), ensuring comparability between the groups.

Surgical Methods

Preoperative preparation

Professional medical staff from our department explained the surgical procedure and related precautions to the children and their families, providing sufficient support to enhance their understanding of the disease and surgical treatment, alleviating psychological burden, and ensuring the smooth progress of subsequent surgery and follow-up.

Control Group

The urethral plate was preserved at 6-8 mm. A U-shaped incision was made at a position 5-8 mm from the penile coronal groove and 2-3 mm from the external urethral meatus. The inner foreskin was circumferentially incised at 8-10 mm from the coronal groove. Blunt dissection was performed in the superficial layer of Buck's fascia, and the foreskin was degloved to the base of the penis with the excision of fibrous cords. Penile erection was artificially induced to assess for chordee; if present, correction was performed. A longitudinal incision was made in the center of the urethral plate down to the tunica albuginea of the corpus spongiosum, expanding the urethral plate to a width of 12-15 mm to ensure it could wrap around the urethral stent while maintaining a relaxed state, and then sutured. Finally, the dorsal foreskin was used to cover and form the urethra.

Study Group

The Modified Snodgrass Technique was used. A U-shaped incision was made at a position 5-8 mm from the penile coronal groove and 2-3 mm from the external urethral meatus. A catheter was used as a stent for the new urethra and sutured. Depending on the condition of the child's wound, a pedicled scrotal septal skin flap was designed and adjusted to cover the formed urethra, with the distal end fixed at the glans, peripherally aligned, sutured, and bandaged. Postoperatively, the penis was bandaged with elastic dressing. An F6 catheter was left in place without urinary diversion. Routine postoperative dressing changes were performed on the 5th day to observe the healing of the surgical incision. On the 14th day postoperatively, the catheter was removed, and the child was instructed to attempt spontaneous urination.

Observation Indicators

(1) Comparison of intraoperative blood loss and operation time between the two groups; (2) Follow-up for 6 months, with all children in both groups being followed up to evaluate the success rate of the surgery.

Table I. Comparison of surgical data between two groups ($\bar{x} \pm s$).

Group	Number of cases	Intraoperative blood loss (ml)	Operation time (min)
Study Group	22	20.32 ± 2.18	81.39 ±2.78
Control Group	28	21.02 ± 2.11	81.22 ± 2.61
t-value		1.148	0.222
p-value		0.128	0.413

Criteria for Assessing Surgical Success

The new urethral opening is correctly positioned at the tip of the penis, normal penile appearance, absence of downward curvature deformity, thick urinary stream, and ability to urinate while standing. Conversely, failure to meet these criteria was considered surgical failure: referring to the standards of the International Children's Continence Society (ICCS); the average urinary flow rate (Qavc); the maximum urinary flow rate (Qmax); voiding volume (V); time to peak flow (TQmax); flow time (FT); and post-void residual urine volume (PVR) were evaluated preoperatively, 2 weeks postoperatively, 3 months postoperatively, and 6 months postoperatively for both groups. The urinary flow rate was measured using the Chengdu Weixin ZNC961A Intelligent Uroflowmeter (Sichuan Keyi Cheng Technology Co., Ltd., Sichuan, China). Immediately after completing the uroflowmetry, the patient was placed in a supine position, and the PVR was measured using the American Bladder Scan BVI6100 bladder capacity meter. The last criterium for assessing surgical success was to calculate the incidence of postoperative complications in both groups[6].

Statistical Analysis

In this study, SPSS 25.0 (SPSS Corp., Armonk, NY, USA) was used for statistical analysis. For quantitative data, if it conformed to a normal distribution, it was expressed as ($\bar{x} \pm s$). Paired sample *t*-tests were used for within-group comparisons before and after treatment, and independent sample *t*-tests were used for between-group comparisons. If the quantitative data followed a skewed distribution, the median was used, and the Wilcoxon signed-rank test was applied for between-group comparisons. Count data were expressed as percentages (%) and compared between groups using the χ^2 (Chi-square) test. A p-value < 0.05 was considered statistically significant.

Results

Comparison of Surgical Data Between the Two Groups

The operation time for the study group was longer than that for the control group, and the intraoperative blood loss was less than that for the control group. However, these differences were not statistically significant ($p > 0.05$) (Table I).

Comparison of Surgical Success Rates Between the Two Groups

After the follow-up period, the surgical success rate in the study group was 95.45% (21/22), while in the control group, it was 71.43% (20/28). The difference between the two groups was statistically significant ($p < 0.05$) (Table II).

Comparison of Urinary Flow Rates and Residual Urine at Different Time Points Between the Two Groups

There were no significant differences in any of the indicators between the two groups before surgery and 2 weeks after surgery ($p > 0.05$). The study group showed a significantly higher maximum urinary flow rate at 3 and 6 months postoperatively compared to the control group, with a

Table II. Comparison of surgical success rates between two groups.

Group	Number of cases	Number of successful cases	Success rate (%)
Study Group	22	21	95.45
Control Group	28	20	71.43
χ^2 value			4.818
p-value			0.028

statistically significant difference ($p < 0.05$). The time to peak flow (TQmax) and post-void residual urine volume (PVR) were both significantly lower in the study group compared to the control group, with a statistically significant difference ($p < 0.05$) (Table III).

Comparison of Postoperative Complications Between the Two Groups

Among the enrolled children, a total of 3 cases of urethral fistula occurred, with sizes ranging from 0.10 cm x 0.10 cm to 0.15 cm x 0.15 cm. The children were instructed to apply pressure to the fistula during urination, and all fistulas were closed between 3 and 6 months postoperatively. The incidence rates of postoperative complications in the study group and the control group were 4.55% and 28.57%, respectively, showing a statistically significant difference ($p < 0.05$) (Table IV).

The Modified Snodgrass Technique Surgical Procedure

The urethral plate is preserved at a width of 6-8 mm. A U-shaped incision is made between 5-8 mm from the penile coronal groove and 2-3 mm from the external urethral meatus. The inner prepuce is circumferentially incised at a position 8-10 mm from the coronal groove, followed by blunt dissection in the superficial layer of Buck's fascia, and the prepuce is degloved to the base of the penis (Figure 1A). An artificial erection test of the penile corpora cavernosa is conducted to assess the presence of penile curvature. If the curvature is present, dorsal plication correction is performed using a 6-0 Poly thread, elevating the neurovascular bundle before folding (Figure 1B). A catheter is used as a stent for the new urethra and sutured in place (Figure 1C). Depending on the child's wound condition, a pedicled scrotal septal skin flap is designed (Figure 1D). The position of the flap is adjusted to cover the formed urethra (Figure 1E). A postoperative frontal view is reported in Figure 1F.

Discussion

In the treatment of hypospadias (HP), the main challenging issue is the high incidence of postoperative complications, such as urethral stricture, urethral fistula, and complete dehiscence of the new urethra, making the surgical treatment quite difficult[6,7]. The Snodgrass technique is currently widely used in the treatment of HP and has extensive applications in reoperations for failed HP treatments. The urethral plate area, with its dense vascular and nerve distribution, serves as the urethral mucosal tissue. It is closely attached to the corpus spongiosum of the penis. The urethral plate is smooth, regular in appearance, and flexible, making it easy to bend. It is recognized by the academic community as an excellent material for urethral reconstruction[8,9]. Initially, the Snodgrass technique was mainly used for treating hypospadias without penile chordee. The key to the surgery is to longitudinally incise the urethral plate in the midline, wrap it around a stent without tension, and then, suture the urethral plate to form a new urethra. This effectively avoids postoperative circumferential scar formation leading to urethral stricture. With the continuous application and modification of this technique, it has also achieved a high success rate in treating penile and penoscrotal types of hypospadias and has been recognized by most physicians. In this study, the modified Snodgrass technique was used for the children in the study group, preserving the urethral plate fully and selecting scrotal septal skin as the flap to form the new urethra.

The results showed that the operation time for the study group was longer than that for the control group, and the intraoperative blood loss was less for the study group, but these differences were not statistically significant ($p > 0.05$). The success rate of surgery in the study group was 95.45% (21/22), compared to 71.43% (20/28) in the control group, with a statistically significant difference ($p < 0.05$). This is consistent with the findings of Fang et al[10]. The results indicate that the success rate of the modified Snodgrass technique is significantly higher than that of the traditional Snodgrass Technique, and it can reduce the occurrence of urinary fistula and incision infection, offering a considerable advantage. However, there was no significant difference in the incidence of urethral stricture between the two groups, which may be related to the inherently low incidence of postoperative urethral structure. The traditional Snodgrass technique involves forming a new urethra using a pedicled preputial flap, requiring specific foreskin conditions and thus higher demands[11]. In this study, the children in the study group underwent the modified Snodgrass technique, where the urethral plate was preserved and combined with scrotal

Table III. Comparison of urinary flow rates and residual urine at different time points between two groups ($\bar{x} \pm s$).

Item	Preoperative		2 weeks postoperative		3 months postoperative		6 months postoperative	
	Study group	Control group	Study group	Control group	Study group	Control group	Study group	Control group
Qavc (mL/s)	6.15 ± 1.12	6.18 ± 1.15	4.68 ± 1.01	4.65 ± 1.11	6.44 ± 1.14	6.22 ± 1.12	6.88 ± 1.31	6.79 ± 1.14
Qmax (mL/s)	9.78 ± 2.11	9.82 ± 2.13	6.15 ± 1.02	6.18 ± 1.05	8.19 ± 2.05	7.02 ± 2.01*	9.38 ± 2.12	7.88 ± 2.16*
V (mL)	135.68 ± 36.87	134.97 ± 35.94	115.68 ± 25.91	118.05 ± 24.91	136.54 ± 29.58	135.94 ± 25.94	155.94 ± 34.05	156.87 ± 35.91
TQmax (s)	11.05 ± 2.69	11.08 ± 2.58	12.05 ± 2.04	12.07 ± 2.11	9.88 ± 2.06	14.59 ± 2.11*	9.38 ± 2.12	13.59 ± 2.16*
FT (s)	28.59 ± 6.59	29.01 ± 5.94	28.95 ± 5.91	29.05 ± 5.99	35.96 ± 6.11	36.05 ± 6.15	29.84 ± 5.11	29.55 ± 5.16
PVR (mL)	16.88 ± 3.15	16.97 ± 3.25	17.58 ± 4.22	17.96 ± 4.35	16.58 ± 4.22	19.22 ± 4.05*	16.33 ± 4.05	21.05 ± 4.30*

Compared with the study group, *$p < 0.05$.

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

Group	Number of cases	Urethral fistula	Infection	Urethral stricture	Total incidence rate (%)
Study group	22	0 (0.00)	0 (0.00)	1 (4.55)	4.55
Control group	28	3 (10.71)	3 (10.71)	2 (7.14)	28.57
χ^2 value					4.818
p-value					0.028

septal skin to establish a new urethra. This technique has a broader range of application, with no strict requirements on patient age or number of surgeries. It is particularly effective for distal hypospadias, offering a high rate of repair success and significant clinical value[12,13].

Postoperatively at 3 and 6 months, the maximum urinary flow rate in the study group was significantly higher than in the control group, with a statistically significant difference ($p < 0.05$). The time to peak flow (TQmax) and postvoid residual (PVR) were also significantly lower in the study group at these time points, indicating a statistically significant difference ($p < 0.05$). The results show that both groups experienced various degrees of urinary dysfunction post-

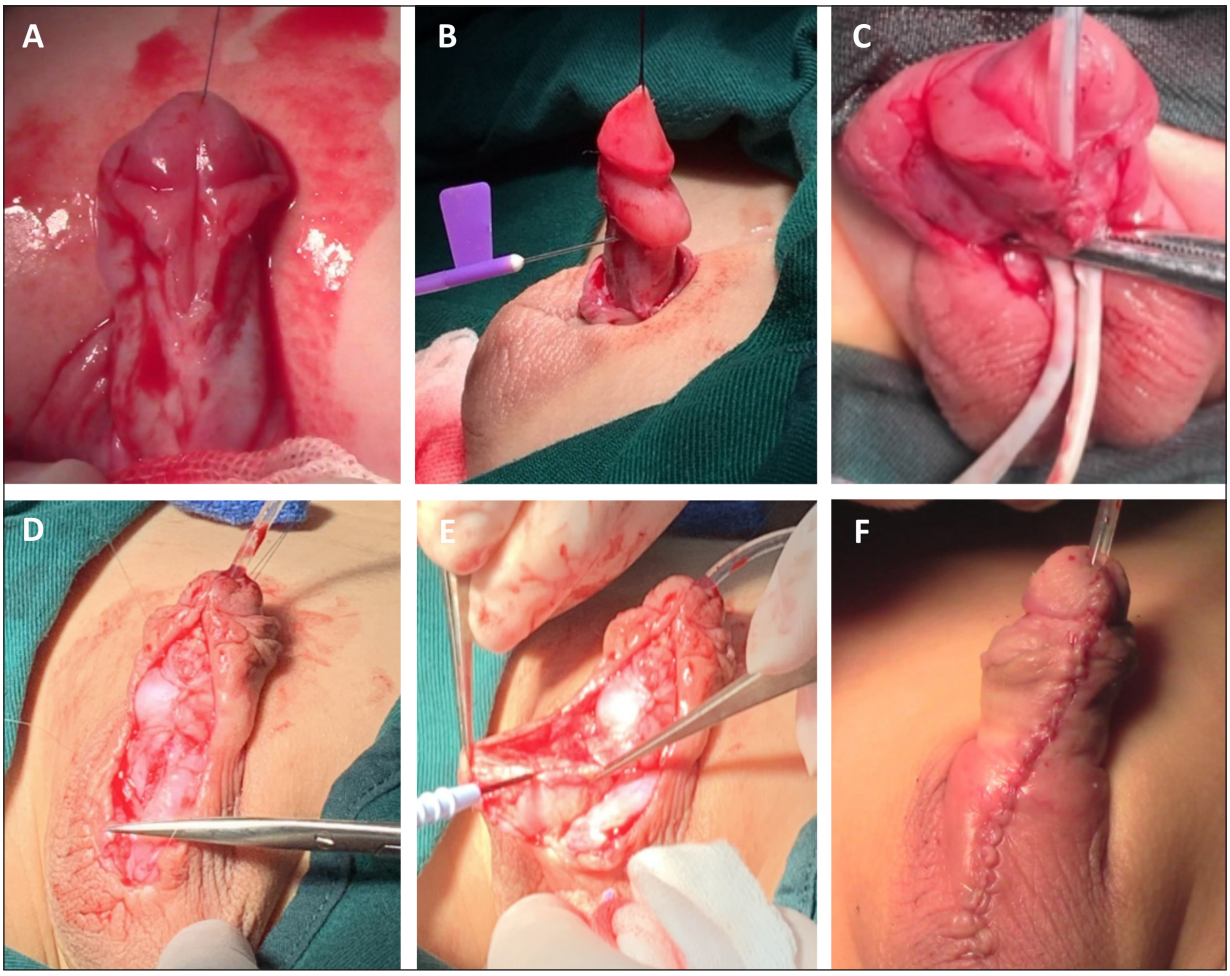

Figure 1. Schematic diagram of the surgical procedure. **A**, The prepuce is degloved to the base of the penis. **B**, The neurovascular bundle is elevated before folding. **C**, A catheter is used as a stent for the new urethra and sutured in place. **D**, Pedicled scrotal septal skin flap is designed. **E**, Flap position adjusted to cover the formed urethra. **F**, Postoperative frontal view.

operatively, indicating some levels of urethral stricture. Studies suggest that urethral stricture most commonly occurs 3 months post-surgery, making it important to measure urinary flow rates at this time point[14,15]. From the results of this study, it is evident that the degree of postoperative urethral stricture in the study group was significantly less than that in the control group. However, there was no significant difference in the data at 2 weeks post-surgery for both groups, possibly because the urethra is in a state of edema, inflammation, and congestion in the early postoperative period, resulting in lower urinary flow rates. Therefore, early postoperative data cannot determine the usual condition of the urethra. In this study, 3 cases of urethral fistula occurred among the enrolled children, all between 0.10 cm x 0.10 cm and 0.15 cm x 0.15 cm in size. By instructing the children to apply pressure to the fistula during urination, all fistulas were closed between 3 and 6 months postoperatively. The incidence rates of postoperative complications in the study and control groups were 4.55% and 28.57%, respectively, showing a statistically significant difference ($p < 0.05$). The reasons for this may include: (1) the modified Snodgrass technique does not require a longitudinal incision, avoiding the process of scar healing; (2) the urethral plate is completely preserved, eliminating the need for circular anastomosis; (3) using the scrotal septum as the new urethra reduces damage to the dorsal foreskin, and the scrotal septal skin flap has good blood supply, leading to faster healing and reduced infection. Through this study, we have summarized several advantages of the modified Snodgrass technique: (1) it has less stringent requirements for the amount of foreskin, causing less damage to the foreskin, suitable for use in children with failed initial surgery or less foreskin; (2) it preserves the complete urethral plate, changing the way the new urethra is formed and avoiding the central longitudinal incision of the urethral plate, meaning no incision is needed inside the new urethra; (3) it preserves the blood vessels in the flap area, maintaining good blood supply and improving postoperative survival rates. However, the modified Snodgrass technique also has some limitations, such as unsuitable for children with severe penile curvature or a short urethral plate. Additionally, the use of scrotal septal skin as the flap[17], due to the presence of hair in some parts, may negatively impact the quality of the child's sexual life in adulthood.

Limitations

The sample size included in this study was not large enough, which may lead to bias in the conclusions. Also, the follow-up period was short, and due to time constraints, this study did not conduct longer-term follow-up. In future research, a larger sample size and extended follow-up period could be used to further analyze the effectiveness of the modified Snodgrass technique.

Conclusions

In summary, the Modified Snodgrass Technique demonstrates significant therapeutic effectiveness in hypospadias surgery, significantly increasing the success rate and reducing postoperative complications in children, making it suitable for widespread application.

Informed Consent

Informed consent was obtained from adult participants included in the study. Written informed consent was obtained from the parents for all patients under 16 years of age. For every personal image presented in the article, we have obtained written consent from the individuals depicted. Upon obtaining consent, we provided each participant with detailed explanations regarding the purpose of the image's use, the extent of its use, and how they would be presented in our research. Additionally, we have ensured that all participants clearly understand that they have the right to withdraw their consent to use their images at any time. To further protect the privacy and rights of the participants, we have also implemented necessary anonymization measures to ensure that individuals cannot be directly identified from the images unless additional explicit consent is obtained. These measures comply with the requirements of the ethics review committee of our institution and internationally recognized ethical standards.

Ethics Approval

This study was approved by the Anhui Provincial Children's Hospital Medical Science Research Ethics Committee [2023 (Ethical Approval) No. 48].

Conflict of Interest

The authors declare no conflicts of interest.

Authors' Contribution

Tao Zhang conducted data analysis and Shan Peng drafted the manuscript; Yongsheng Cao conceived of and designed the project and provided data; Changkun Mao and Wenwen Zhu supervised the research. Qifei Deng participated in patient management and data collection.

Data Availability

Data information is available from the corresponding author.

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