Article

Application of a Multidisciplinary Collaboration Model-Supported Structured Home Care in Reducing Postoperative Complications in Children with Hypospadias

Ann. Ital. Chir., 2026 97, 2: 288–299
https://doi.org/10.62713/aic.4438

Luyan He[1], Qin Zhong[2], Lifen Xiao[1]

[1]Pediatric Department, Ganzhou People's Hospital, 341000 Ganzhou, Jiangxi, China
[2]Department of Urinary Surgery, Ganzhou People's Hospital, 341000 Ganzhou, Jiangxi, China

AIM: Hypospadias is a common congenital anomaly in males and often requires surgical intervention, usually with tubularized incised plate (TIP) urethroplasty. However, postoperative complications such as urethrocutaneous fistula, stenosis, and wound dehiscence remain persistent clinical challenges. Reducing these complications depends not only on surgical approach but also on optimized perioperative and postoperative care pathways, supported by high-quality nursing and timely identification of early warning signs. Therefore, this study aims to investigate the application of multidisciplinary team (MDT) care integrated with a structured home care model in paediatric hypospadias management.

METHODS: This retrospective study compared postsurgical outcomes in children (aged 1–5 years) with distal hypospadias undergoing primary TIP urethroplasty at Ganzhou People's Hospital between June 2022 and August 2024. Study participants were divided into two groups based on care pathway: MDT combined with a structured home care (intervention group) and a conventional nursing care (control group). Key outcomes assessed were complication rates, urodynamic parameters, postoperative pain levels, caregiver anxiety, and cosmetic outcomes (Hypospadias Objective Scoring Evaluation [HOSE] scores).

RESULTS: The intervention group showed significantly shorter surgery times, lower postoperative pain (Children's and Infants' Postoperative Pain Scale [CHIPPS]), reduced parental anxiety (Self-Rating Anxiety Scale [SAS]) (all $p < 0.001$). Compared with the control group, the intervention group demonstrated significantly improved HOSE scores at 12 months postoperatively, indicating superior cosmetic outcomes ($p < 0.001$). At 12 months, the intervention group demonstrated comparatively lower complication rates (14.95% vs. 24.37%), though not statistically significant ($p > 0.05$). Urodynamic parameters, such as corrected maximum and average flow rates (maximum urinary flow rate corrected for voided volume[cQmax] and average urinary flow rate corrected for voided volume [cQave]), showed gradual recovery but remained lower than baseline ($p < 0.05$). Multivariate analysis further confirmed that parental anxiety is an independent predictor of postoperative complications ($p < 0.001$). Mediation analysis revealed that parental anxiety mediated the relationship between care pathway and complication risk ($p < 0.001$).

CONCLUSIONS: The structured home-based nursing model supported by a MDT may be associated with a reduced risk of complications in children after hypospadias repair. This association might be related to improved postoperative pain control and enhanced mental health levels among parents. This model emphasizes collaborative perioperative care and structured support during the postoperative recovery phase. Given that the difference in complication rates has not reached statistical significance, the above results should still be interpreted with caution. Further multi-center studies with larger sample sizes and longer follow-up periods are needed to verify its clinical benefits and elucidate the underlying mechanisms.

Keywords: multidisciplinary team; tubularized incised plate; hypospadias; structured home care; postoperative complications

Introduction

Hypospadias is a frequent congenital anomaly of the male genitourinary tract, affecting approximately 8 per 1000 newborns [1]. Clinically, it is characterized by an ectopic urethral meatus, abnormal foreskin development, and ventral penile curvature, which can impair urinary function and aesthetic outcome and may lead to long-term psychosocial distress [2]. Tubularized incised plate (TIP) urethroplasty is widely used; however, complications such as urethrocutaneous fistula, urethral stenosis, and wound dehiscence persist and are influenced by perioperative management and postoperative care [3]. Overall complication rates range between 20% and 30% [4,5].

Prevention and early detection of postoperative complications rely not solely on the surgical technique, but also on advanced nursing care and the use of accurate assessment metrics. The Hypospadias Objective Scoring Evaluation (HOSE) offers a structural evaluation of meatal position,

Submitted: 7 November 2025 Revised: 27 November 2025 Accepted: 16 December 2025 Published: 9 February 2026
Correspondence to: Lifen Xiao, Pediatric Department, Ganzhou People's Hospital, 341000 Ganzhou, Jiangxi, China (e-mail: 13870750060@163.com).
Editor: Roberto Cirocchi

penile curvature, scarring, and urinary stream quality [6]. In terms of urodynamics, the maximum urinary flow rate (Qmax) is recognized by the International Children's Continence Society (ICCS) as an objective, reproducible, and non-invasive indicator, making it valuable for postoperative monitoring of neourethral performance and potential obstruction [7]. The nomogram-based adjustment proposed by Mattsson and Spångberg helps mitigate volume-related bias in Qmax estimation, which is particularly relevant in young children whose sphincter coordination may still be immature [8]. Additionally, parental knowledge gaps, patterns of information-seeking, and the quality of communication with clinicians can influence decision-making and adherence to follow-up in hypospadias care [9].

Previous studies indicate that structured health education and structured informational interventions can reduce caregiver anxiety and enhance the efficacy of home care [10,11]. Moreover, using home-based audio or video recordings of voiding, or conducting remote follow-up, may alleviate patient anxiety, shorten waiting times, and facilitate earlier identification of abnormal voiding patterns [12]. These findings suggest that a closed-loop "medical–nurse–patient (family)" collaborative model, supported by seamless information exchange, could decrease complication rates and improve functional and aesthetic outcomes.

Multidisciplinary team (MDT) approaches involving paediatric urologists, anesthesia and pain specialists, specialized nurses, psychologists, and wound-care therapists have improved outcomes in other pediatric conditions [13]. Therefore, establishing a paediatric urology MDT and integrating it with a standardized, practical home care pathway, such as pre-discharge education, post-discharge follow-up, an early-warning mechanism, and a "green channel" for rapid access, may improve postoperative care, reduce caregiver anxiety, enhance adherence and pain management, and decrease the risk of complications [14,15].

Nevertheless, evidence remains limited regarding whether an "MDT combined with structured home care" model specifically helps prevent postoperative complications following paediatric hypospadias repair. Therefore, within a setting using a single-procedure (TIP) and single-team, we compared MDT-supported structured home care and conventional nursing care in terms of postoperative outcomes. The primary focus was the incidence of complications at 12 months post-surgery, while secondary endpoints included uroflowmetry measures, HOSE scores, postoperative pain, and caregiver anxiety, aiming to provide clinical evidence to optimize postoperative home care models for children undergoing hypospadias repair.

Methods

Study Design and Enrollment of Study Participants

This single-center, retrospective comparative study included boys aged 1–5 years with distal hypospadias who underwent primary TIP urethroplasty at Ganzhou People's Hospital between June 2022 and August 2024. After standardized preoperative counselling in which both postoperative care pathways were explained in detail, parents or legal guardians chose either the MDT-supported structured home care program (intervention group) or conventional nursing care (control group). Thus, group allocation was based on family preference rather than randomization. To minimize operator-related variability, all procedures were performed by senior paediatric urologists within the same department.

Inclusion criteria for patient selection were as follows: (1) clinically and intraoperatively confirmed distal hypospadias; (2) age 1–5 years at the time of surgery; (3) primary TIP urethroplasty; (4) completion of preoperative and 1-, 6- and 12-month postoperative assessments; and (5) availability of complete clinical and follow-up data in the electronic medical record. Exclusion criteria included: (1) previous hypospadias repair or planned reoperation; (2) systemic diseases likely to affect wound healing or immune function; and (3) inability to retrieve key follow-up data.

The study protocol complied with the Declaration of Helsinki. Consistent with local regulations for retrospective chart reviews using anonymized data, the institutional ethics committee (Ganzhou People's Hospital) waived the requirement for additional approval. Written informed consent for surgery, participation in the MDT home care program, and use of anonymized clinical and follow-up data for research was obtained from the parents or legal guardians of all children.

Surgical Technique and Perioperative Management

Under general anesthesia with the patient in lithotomy position, a U-shaped incision was made extending to the corona. Penile curvature was corrected by degloving, with dorsal plication when needed. The urethral plate was then incised longitudinally and tubularized using 6-0 absorbable suture; the neourethra was covered with a preputial fascial flap, followed by glansplasty. Perioperative measures were standardized across patients, including antibiotic prophylaxis, dressing with Vaseline gauze and an elastic bandage, catheter removal on postoperative day 7–10, and a unified multimodal analgesia regimen. Discharge criteria required an afebrile status, unobstructed urinary flow, and dry wounds demonstrating satisfactory healing.

The integrated care model is illustrated in Fig. 1. The MDT comprised pediatric urologists (surgical decision-making and complication management), anesthesia and pain specialists (development of multimodal analgesia and safety monitoring), specialized urology/pediatric nurses (catheter and wound care, caregiver education, adherence monitoring), wound/ostomy therapists (wound assessment and early detection of infection), child psychology and behavior specialists (Self-Rating Anxiety Scale [SAS] screening and counseling), infection-control staff (antimicrobial strategies), and a follow-up coordinator (remote/clinic schedul-

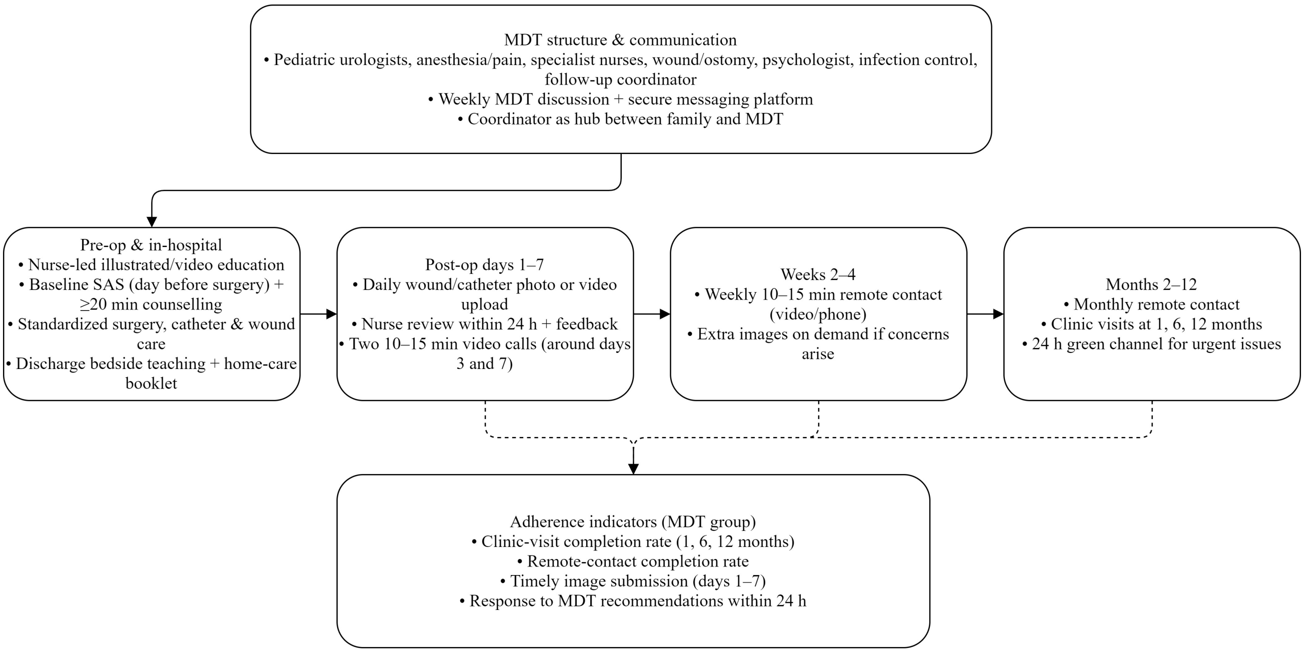

Fig. 1. Integrated MDT-based care model for the perioperative management of pediatric hypospadias. MDT, multidisciplinary team; SAS, Self-Rating Anxiety Scale.

ing and clinic visits and maintenance of follow-up data integrity).

In-Hospital Structured Workflow

In-hospital patient care was performed as follows:

Preoperative Education and Psychological Support

Specialized nurses delivered illustrated and video-based instruction covering procedure steps, recognition of complications, catheter fixation and maintenance, double-diaper technique, and wound monitoring. On the day before the surgical procedure, a psychologist administered the baseline Self-Rating Anxiety Scale (SAS) and provided a face-to-face counseling session (≥20 minutes), explaining coping strategies such as distraction and positive suggestion [16].

Individualized Analgesia

The anesthesia team tailored plans using preventive analgesia plus on-demand dosing guided by Children's and Infants' Postoperative Pain Scale (CHIPPS) [17].

Catheter and Wound Care

Catheter patency was examined daily. Vaseline gauze and an elastic bandage were used, with the first dressing change on postoperative day 1, followed by daily monitoring of urine output and color and examination of the surrounding skin.

Discharge Preparation

A one-to-one bedside demonstration was performed on catheter hygiene, diaper change, wound observation, and recognition of warning signs. Families received a home care booklet containing emergency contacts, a follow-up schedule, complication infographics, and score sheets for HOSE and SAS.

Post-Discharge Structured Home Care (Remote + Clinic)

Nurses conducted daily reviews of catheter and wound status via photo or video during the first postoperative week. Furthermore, clinic follow-up visits were scheduled for 1, 6, and 12 months. Remote support included weekly Question and Answer (Q&A) during month 1, then monthly thereafter. A 24-hour "green channel" enabled rapid access for fever, abnormal urinary stream, bleeding, or pain. The follow-up coordinator monitored adherence and ensured timely data entry.

In the intervention group, adherence was retrospectively assessed based on four predefined indicators: (1) clinic-visit completion rate (proportion of patients attending clinic at 1, 6 and 12 months); (2) remote-contact completion rate (completion of scheduled daily, weekly, and monthly contacts actually); (3) timely image submission (proportion of the postoperative days 1–7 with wound/catheter photo or video uploaded within 24 hours); and (4) response to MDT recommendations (proportion of alerts in which parents/caregivers reported implementing advice within 24 hours).

The control group received conventional education and routine discharge instructions without MDT consultation,

Table 1. Baseline demographic and preoperative clinical characteristics of the study cohort.

Variable	Total (n = 206)	Control (n = 119)	Intervention (n = 87)	Statistic	p
Age (months), M (Q_1, Q_3)	29.35 (19.52, 44.15)	28.90 (17.80, 41.25)	30.30 (20.50, 46.10)	Z = –1.21	0.226
Weight (kg), M (Q_1, Q_3)	13.95 (12.20, 17.50)	13.90 (12.00, 17.00)	14.40 (12.45, 17.95)	Z = –1.16	0.245
Preoperative cQmax, M (Q_1, Q_3)	1.34 (1.19, 1.46)	1.38 (1.12, 1.60)	1.31 (1.24, 1.37)	Z = –1.95	0.051
Preoperative cQave, M (Q_1, Q_3)	0.55 (0.33, 0.76)	0.52 (0.34, 0.76)	0.60 (0.33, 0.80)	Z = –0.75	0.453
Preoperative SAS, M (Q_1, Q_3)	51.00 (49.00, 55.00)	53.00 (51.00, 57.00)	49.00 (47.00, 51.00)	Z = –7.23	<0.001
Type, n (%)				χ^2 = 2.07	0.355
Glanular	95 (46.12)	56 (47.06)	39 (44.83)		
Coronal	54 (26.21)	27 (22.69)	27 (31.03)		
Subcoronal	57 (27.67)	36 (30.25)	21 (24.14)		
Preoperative curve, n (%)				χ^2 = 3.50	0.320
1	58 (28.16)	35 (29.41)	23 (26.44)		
2	22 (10.68)	9 (7.56)	13 (14.94)		
3	103 (50.00)	63 (52.94)	40 (45.98)		
4	23 (11.17)	12 (10.08)	11 (12.64)		

Z, Mann-Whitney test; χ^2, Chi-square test; M, Median; Q_1, 1st Quartile; Q_3, 3st Quartile; cQmax, maximum urinary flow rate corrected for voided volume; cQave, average urinary flow rate corrected for voided volume.

Curve types (International Children's Continence Society [ICCS] classification): 1 = bell-shaped; 2 = staccato; 3 = plateau; 4 = interrupted.

formal psychological intervention, or structured remote follow-up. Surgical and anesthesia pathways were otherwise identical.

Outcomes and Follow-Up

Assessments were performed preoperatively and at 1, 6, and 12 months postoperatively. The primary outcome included the occurrence of any complication within 12 months (stenosis, diverticulum, infection, fistula, or wound dehiscence).

Secondary outcomes were as follows: uroflowmetry under natural voiding, requiring voided volume (VV) $\geq$50 mL. ICCS flow-curve patterns were categorized as bell-shaped, staccato, plateau, and interrupted [7]. To mitigate the effect of VV, corrected parameters were calculated as cQmax $= Qmax/\sqrt{VV}$, cQave $= Qave/\sqrt{VV}$ [8] (Qmax, maximum urinary flow rate; Qave, average urinary flow rate; cQmax, maximum urinary flow rate corrected for voided volume; cQave, average urinary flow rate corrected for voided volume; VV, voided volume); pain: CHIPPS score (0–10), with scores >4 prompting intervention [17]; parental or caregiver anxiety: SAS (20–80), with scores $\geq$50 indicating anxiety; baseline assessment was conducted on the preoperatively [16]; cosmetic and functional outcome: HOSE (0–15), with scores $\geq$12 considered satisfactory; assessed at 12 months by both physician and parents [6].

Data Quality and Missing Data

Data were extracted from the electronic medical record and, when needed, verified through telephone follow-up. For missing data in longitudinal continuous variables assessed at four prespecified time points, we applied the last observation carried forward (LOCF) method as appropriate. LOCF was applied only to functional and scale-based measurements, while outcome variables were not imputed. All assessors underwent calibration training before data collection. Each record was entered independently by two research nurses, and discrepancies were reviewed and resolved by a senior pediatric urologist who was not involved in the original data extraction, thereby ensuring data consistency and accuracy.

Sample Size Considerations

As this is a retrospective cohort study, the sample size was determined by the number of eligible patients enrolled during the study period." Based on previously reported rates of postoperative complications following hypospadias repair (23.7%–30.8%) [4,5], we assessed whether the existing sample size was sufficient to accurately evaluate differences in complication rates between groups. The final cohort included 87 patients in the multidisciplinary team (MDT) group and 119 patients in the conventional treatment group. This enabled us to compare complication rates between groups with sufficient statistical power to detect clinically meaningful differences.

Statistical Analysis

Statistical analyses were conducted in R version 4.3.0 (R Foundation for Statistical Computing, Vienna, Austria), with statistical significance defined at a two-tailed p-value of <0.05. Data normality was assessed using the Kolmogorov–Smirnov test. As most repeated-measures outcomes (cQmax, cQave, SAS and HOSE) showed non-normal, skewed distribution and several scales were ordinal with ceiling effects, parametric repeated-measures Anal-

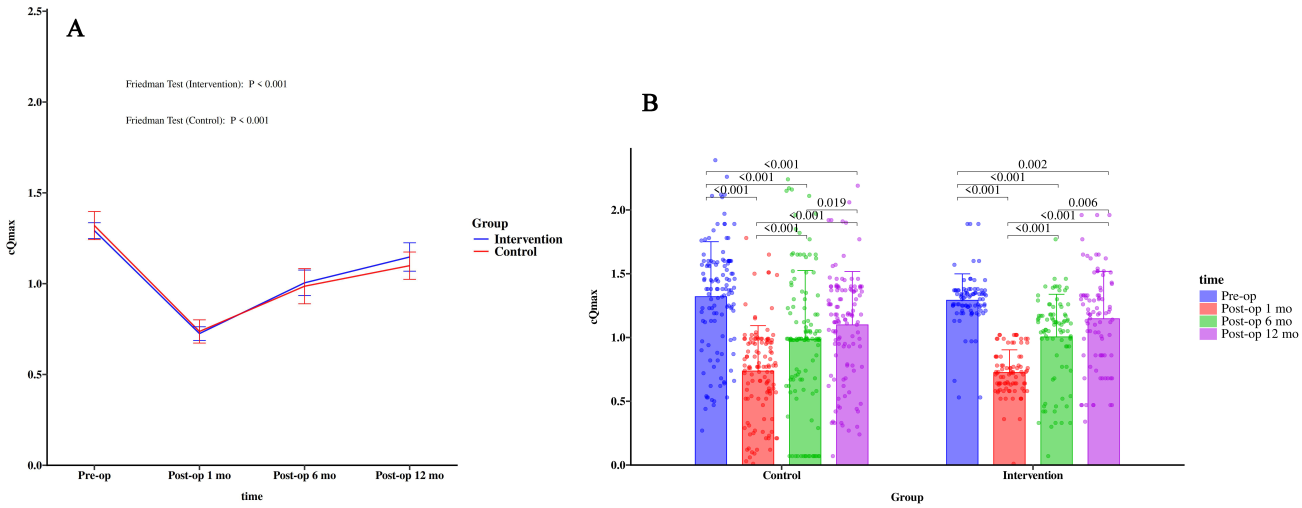

Fig. 2. Maximum urinary flow rate corrected for voided volume (cQmax) over time. (A) Trajectories of 95% confidence interval bands at preoperative, 1-month, 6-month and 12-month follow-up for the control and intervention groups. Global within-group changes over time were tested using Friedman tests. (B) Within-group comparisons between time points using Wilcoxon signed-rank tests with Holm-adjusted *p*-values. mo, month(s).

ysis of Variance (ANOVA) was considered inappropriate. Furthermore, continuous variables were presented as median [Interquartile Range (IQR)] and categorical variables as n (%). Between-group comparisons at each time point were performed using the Wilcoxon rank-sum test for continuous variables and χ^2 or Fisher's exact tests for categorical variables, with Holm adjustment to account for multiple time-point comparisons. However, within-group changes over time were analyzed using Friedman tests, while significant post hoc pairwise Wilcoxon signed-rank tests were applied with Holm correction.

To identify factors associated with the occurrence of any complication at 12 months (yes/no), we established multivariable logistic regression models. Parental SAS score was selected as the primary independent variable of interest because caregiver anxiety is a modifiable factor and was hypothesized to influence treatment adherence and the quality of home-based recovery. Models were adjusted in a stepwise manner for age, weight, hypospadias type, preoperative curvature type, preoperative cQmax/cQave, operative time, and postoperative pain (CHIPPS). Variance inflation factors were <5 across all models, indicating no meaningful multicollinearity. Mediation analyses were performed using the R package mediation with Bayesian estimation to assess whether SAS mediated the association between care pathway (group) and complications, reporting total, direct and indirect effects with 95% credible intervals.

Results

Cohort and Baseline Characteristics

This study enrolled 206 children, including 119 in the control group (57.77%) and 87 in the intervention group (42.23%). Overall adherence was 79.5% in the control group and 90.3% in the intervention group. Although the grouping in this study was not randomised, but rather determined by the families of the paediatric patients themselves, who selected the care pathway after receiving full and informed consent, baseline characteristics such as age, weight, hypospadias type distribution, preoperative cQmax/cQave, and preoperative curve types were comparable between groups (all $p > 0.05$; Table 1). Conversely, preoperative parental SAS scores were substantially higher in the control group than in the intervention group ($p < 0.001$), indicating that families opting for MDT-supported structured home care pathway had lower baseline anxiety entering the perioperative period.

Perioperative and Follow-Up Outcomes

Group-specific perioperative and 12-month outcomes are presented in Table 2. Compared with the control group, the intervention group had shorter operative times (median 1.20 vs. 1.59 h; $p < 0.001$) and lower immediate postoperative pain (CHIPPS 3.00 [2.00–4.00] vs. 5.00 [3.50–6.00]; $p < 0.001$). Furthermore, parental SAS scores were consistently lower in the intervention group at each postoperative time point (1, 6 and 12 months; all $p < 0.001$). Urodynamic parameters (cQmax and cQave) showed an initial decline at 1 month followed by gradual recovery in both groups, with no significant between-group differences at individual time points. Additionally, the distributions of ICCS uroflow curve types also changed over time in a comparable manner between groups. At 12 months, there was no significant difference in the distribution of postoperative complications between the intervention group and the control group ($p = 0.249$).

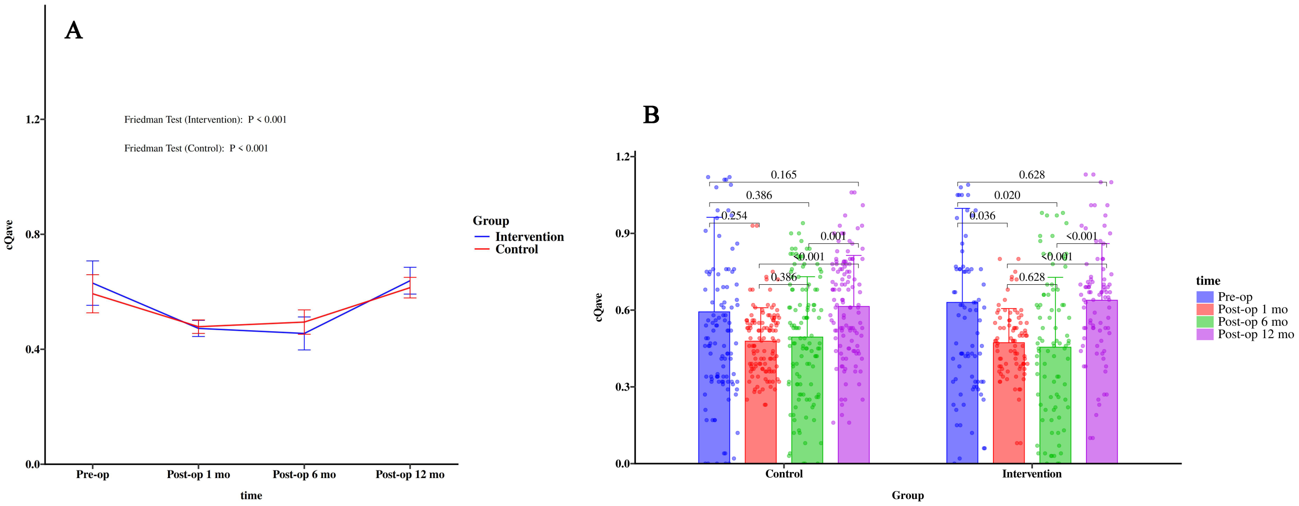

Fig. 3. Average urinary flow rate corrected for voided volume (cQave) over time. (A) Trajectories of 95% confidence interval bands at each time point for both groups. Global within-group changes were analyzed using Friedman tests. (B) Within-group pairwise comparisons between time points based on Wilcoxon signed-rank tests with Holm-adjusted *p*-values.

Repeated-Measures Summaries

Fig. 2A illustrates longitudinal trends in cQmax in both groups from preoperative baseline through 1-month, 6-month, and 12-month postoperative intervals ($p < 0.001$ in each group). cQmax was reduced significantly during the 1-month postoperative assessment and then improved over time gradually. However, cQmax levels at both 6- and 12-months remained substantially below preoperative baseline.

As illustrated in the bar graph in Fig. 2B, within-group comparisons showed statistically significant differences ($p < 0.05$) between the preoperative baseline and each postoperative time point. Furthermore, significant differences ($p < 0.05$) were also observed among postoperative assessments, supporting a pattern of early postoperative decline succeeded by slow, partial or incomplete recovery of cQmax.

The trajectory of cQave in both groups is presented in Fig. 3A. A significant decrease in cQave was observed at 1 month after surgery, and then increased progressively, approaching preoperative levels by 12 months ($p < 0.001$ in each group). As shown in Fig. 3B, within-group pairwise comparisons demonstrated that, in the control group, postoperative cQave values did not differ significantly from the preoperative value ($p > 0.05$). However, the value in 12 months was significantly higher than the values at 1 and 6 months ($p < 0.05$). In the intervention group, cQave at 1 and 6 months after surgery remained significantly lower than the baseline levels ($p < 0.05$). In contrast, the 12-month value showed no significant difference from the preoperative baseline ($p > 0.05$). Significant differences were found when comparing the 12-month value with the 1-month and 6-month assessments ($p < 0.001$).

Results for the SAS score are shown in Fig. 4A. Across all assessment points, the intervention group exhibited consistently lower SAS scores than the control group. In both groups, the SAS score declined at 1 month postoperatively, followed by a significant increase at the 6 and 12-month assessments. Friedman tests indicated significant within-group changes over time (both $p < 0.001$).

As presented in Fig. 4B, pairwise comparisons in the control group revealed that each postoperative SAS score differed significantly from the preoperative baseline score ($p < 0.05$). The score at 1 month was significantly different from those at 6 and 12 months ($p < 0.001$), whereas no significant difference was observed between the 6 and 12-month scores ($p = 0.339$). In the intervention group, SAS scores at 1 and 12 months were significantly different from the preoperative baseline score ($p < 0.05$), but the score at 6 months did not differ ($p = 0.821$). The 1-month score differed significantly from both 6- and 12-month scores ($p < 0.001$). The difference between the 6- and 12-month scores approached but did not reach statistical significance ($p = 0.052$).

The distribution of uroflow curve types is presented in Fig. 5A. The Friedman test assessing global within-group changes yielded $p = 0.104$ in the control group and $p = 0.022$ in the intervention group. Preoperatively, Type 3 was the predominant pattern in both groups. At 1 month postoperatively, the proportion of Type 3 increased further in both groups. By 6 months, Type 3 accounted for 51.3% in the control group and 58.6% in the intervention group. At the 12-month follow-up, a notable rebound in Type 1 patterns was observed in both groups (Control: 36.1%; Intervention: 35.6%), exceeding the preoperative levels. Overall, distribution trends of curve types were comparable between the two groups.

Table 2. Perioperative and 12-month outcomes by care pathway (conventional care vs. MDT-supported structured home care).

Variable	Total (n = 206)	Control (n = 119)	Intervention (n = 87)	Statistic	p
Surgery time (H), M (Q_1, Q_3)	1.40 (1.04, 1.67)	1.59 (1.32, 1.83)	1.20 (0.97, 1.36)	Z = –6.30	<0.001
postoperative CHIPPS, M (Q_1, Q_3)	4.00 (2.00, 5.00)	5.00 (3.50, 6.00)	3.00 (2.00, 4.00)	Z = –6.22	<0.001
Postoperative 12-month HOSEdoc, M (Q_1, Q_3)	14.00 (14.00, 15.00)	15.00 (14.00, 15.00)	14.00 (13.00, 14.00)	Z = –9.39	<0.001
Postoperative 12-month HOSEpar, M (Q_1, Q_3)	13.00 (13.00, 14.00)	13.00 (13.00, 14.00)	13.00 (12.00, 13.00)	Z = –3.41	<0.001
Postoperative 1-month cQmax, M (Q_1, Q_3)	0.73 (0.58, 0.96)	0.77 (0.55, 0.97)	0.72 (0.63, 0.85)	Z = –0.95	0.340
Postoperative 6-month cQmax, M (Q_1, Q_3)	1.04 (0.71, 1.23)	0.99 (0.67, 1.27)	1.10 (0.93, 1.18)	Z = –1.39	0.165
Postoperative 12-month cQmax, M (Q_1, Q_3)	1.18 (0.86, 1.37)	1.17 (0.90, 1.38)	1.19 (0.86, 1.33)	Z = –0.72	0.472
Postoperative 1-month cQave, M (Q_1, Q_3)	0.48 (0.38, 0.56)	0.49 (0.38, 0.56)	0.48 (0.39, 0.55)	Z = –0.17	0.863
Postoperative 6-month cQave, M (Q_1, Q_3)	0.47 (0.27, 0.68)	0.49 (0.31, 0.68)	0.46 (0.24, 0.64)	Z = –1.13	0.259
Postoperative 12-month cQave, M (Q_1, Q_3)	0.64 (0.49, 0.76)	0.62 (0.46, 0.78)	0.66 (0.53, 0.72)	Z = –0.62	0.536
Postoperative 1-month SAS, M (Q_1, Q_3)	44.00 (27.00, 52.75)	51.00 (43.00, 57.50)	31.00 (16.00, 40.50)	Z = –8.50	<0.001
Postoperative 6-month SAS, M (Q_1, Q_3)	55.00 (42.00, 70.00)	60.00 (48.00, 70.00)	51.00 (37.00, 62.50)	Z = –4.08	<0.001
Postoperative 12-month SAS, M (Q_1, Q_3)	53.00 (37.00, 61.00)	61.00 (47.00, 66.00)	43.00 (34.00, 55.50)	Z = –4.72	<0.001
Postoperative 1-month curve, n (%)				χ^2 = 3.87	0.275
1	50 (24.27)	25 (21.01)	25 (28.74)		
2	31 (15.05)	15 (12.61)	16 (18.39)		
3	111 (53.88)	70 (58.82)	41 (47.13)		
4	14 (6.80)	9 (7.56)	5 (5.75)		
Postoperative 6-month curve, n (%)				χ^2 = 3.04	0.386
1	49 (23.79)	31 (26.05)	18 (20.69)		
2	18 (8.74)	13 (10.92)	5 (5.75)		
3	112 (54.37)	61 (51.26)	51 (58.62)		
4	27 (13.11)	14 (11.76)	13 (14.94)		
Postoperative 12-month curve, n (%)				χ^2 = 4.74	0.192
1	74 (35.92)	43 (36.13)	31 (35.63)		
2	13 (6.31)	11 (9.24)	2 (2.30)		
3	110 (53.40)	61 (51.26)	49 (56.32)		
4	9 (4.37)	4 (3.36)	5 (5.75)		
Complication, n (%)				-	0.249
0	164 (79.61)	90 (75.63)	74 (85.06)		
1	4 (1.94)	4 (3.36)	0 (0.00)		
2	3 (1.46)	3 (2.52)	0 (0.00)		
3	11 (5.34)	6 (5.04)	5 (5.75)		
4	23 (11.17)	15 (12.61)	8 (9.20)		
5	1 (0.49)	1 (0.84)	0 (0.00)		

Z, Mann-Whitney test; χ^2, Chi-square test; -, Fisher exact; M, Median; Q_1, 1st Quartile; Q_3, 3st Quartile; CHIPPS, Children's and Infants' Postoperative Pain Scale; HOSE, Hypospadias Objective Scoring Evaluation; doc, Doctor; par, Parents.

Curve types (ICCS classification): 1 = bell-shaped; 2 = staccato; 3 = plateau; 4 = interrupted; Complication: 0 = none; 1 = stenosis; 2 = diverticulum; 3 = infection; 4 = fistula; 5 = dehiscence.

As presented in Fig. 5B, pairwise analysis in the control group demonstrated no significant differences between preoperative and postoperative distribution at any time point ($p > 0.05$). In the intervention group, a significant difference was observed only between the 1-month and 6-month postoperative assessments ($p < 0.05$), with no other pairwise comparison achieving statistical significance (all $p > 0.05$).

Multivariable Analysis

After multivariable adjustment, parental anxiety assessed through SAS remained an independent predictor of postoperative complications (Model 3). Specifically, each 1-point increase in the parental SAS score was associated with 82% higher odds of experiencing a postoperative complication (Odds Ratio [OR] 1.82; 95% Confidence Interval [CI] 1.48–2.24; $p < 0.001$), suggesting a strong positive association between higher caregiver anxiety and adverse surgical outcomes (Table 3).

Mediation Analysis

Mediation analysis revealed that SAS significantly mediated the association between care group and postoperative complications. The estimated indirect effect was –0.15

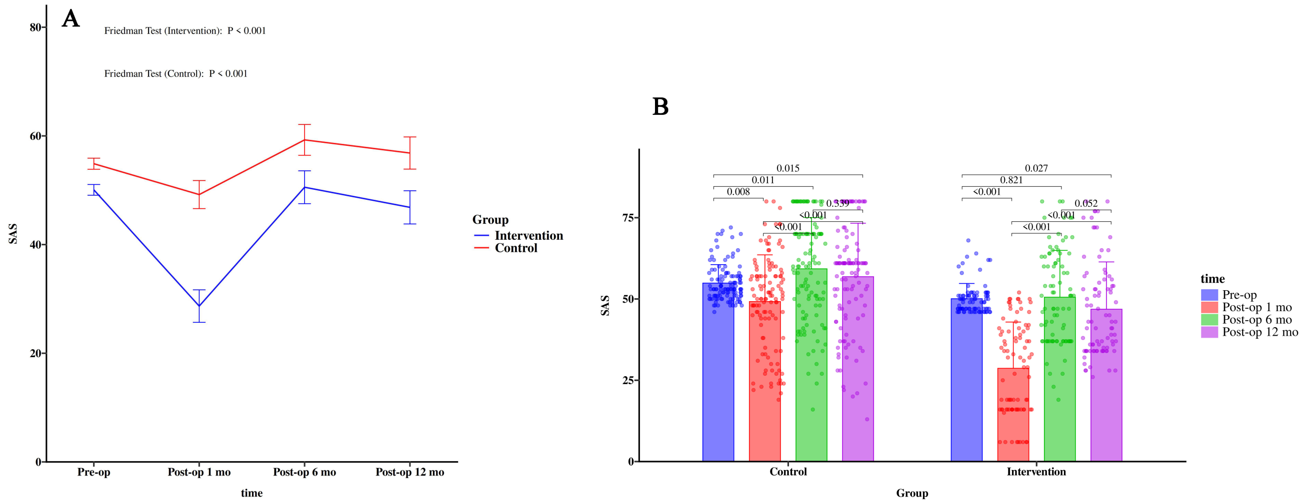

Fig. 4. Parental SAS trajectories over time. (A) Trajectories of 95% confidence interval bands for the control and intervention groups at preoperative, 1-, 6- and 12-month postoperative assessments. Global within-group changes were analyzed using Friedman tests. (B) Within-group pairwise comparisons using Wilcoxon signed-rank tests with Holm correction.

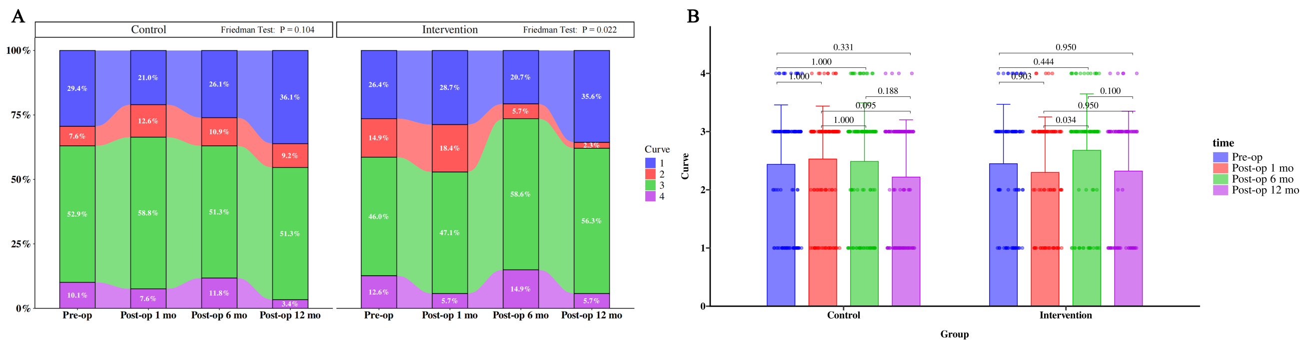

Fig. 5. ICCS flow-curve type distributions over time. (A) Stacked bar plots showing the proportion of each ICCS flow-curve type at preoperative, 1-, 6- and 12-month postoperative assessments in the control and intervention groups. Colors represent curve types as follows: Type 1 (bell-shaped), Type 2 (staccato), Type 3 (plateau), and Type 4 (interrupted). Global within-group changes in the distribution of curve types were examined with Friedman tests. (B) Within-group pairwise comparisons using Wilcoxon signed-rank tests with Holm correction.

(95% credible interval –0.26 to –0.09; $p < 0.001$). However, the direct impact of the group assignment was not statistically significant (Table 4).

Discussion

Within a single-center setting using a uniform surgical technique (TIP urethroplasty), this study compared an MDT-supported structured home care model with conventional nursing for children undergoing distal hypospadias repair. Baseline indicators, including age, weight, urodynamic indices, and uroflowmetry curve types, were comparable between groups. However, the intervention group demonstrated better perioperative performance, including shorter operative duration, lower postoperative pain scores (CHIPPS), and consistently reduced parental anxiety (SAS) both before and after surgery. These improvements may be attributed to the more standardized perioperative preparation and enhanced intraoperative coordination facilitated by the MDT model. HOSE scores, assessed by both physicians and parents, were slightly lower but remained within the satisfactory range, suggesting potential benefits of MDT care in perioperative optimization. Although the 12-month complication rate was lower in the intervention group compared to the control group (14.95% vs. 24.37%, $p = 0.249$), the difference did not achieve statistical significance. However, logistic regression analysis confirmed parental anxiety as an independent predictor of complications (OR = 1.82, 95% CI: 1.48–2.24), and mediation analysis revealed a substantial indirect effect of SAS on the association between care pathway and complication risk (indirect effect –0.15, $p < 0.001$). These findings indicate that structured care pathways may mitigate psychological burden, enhance adherence, and thereby indirectly reduce the risk of postoperative complications.

Dynamic changes in urodynamic parameters formed a key secondary outcome. Both the cQmax and cQave declined

Table 3. Multivariable logistic regression for any complication at 12 months (Models 1–3).

Variable	Model 1		Model 2		Model 3	
	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
SAS	1.52 (1.34–1.73)	<0.001	1.54 (1.35–1.75)	<0.001	1.82 (1.48–2.24)	<0.001

OR, Odds Ratio; CI, Confidence Interval.

Model 1: Crude.

Model 2: Adjust: Age (months), Weight (kg).

Model 3: Adjust: Group, Type, Preoperative_Curve, Age (months), Weight (kg), Preoperative_cQmax, Preoperative_cQave, surgery_time (h), CHIPPS.

Table 4. Mediation analysis (Bayesian) of SAS in the pathway from group to complications.

Effect	Estimate	Lower	Upper	β (95% CI)	*p*	Mediation
Total	–0.08	–0.17	0.06	–0.08 (–0.17~0.06)	0.200	100.00
Direct	0.07	–0.05	0.17	0.07 (–0.05~0.17)	0.360	–56.63
Indirect	–0.15	–0.26	–0.09	–0.15 (–0.26~–0.09)	<0.001	156.63
Group → SAS		–4.57	–1.37	–2.97 (–4.57~–1.37)	<0.001	-
Group → Complication		–0.72	2.47	0.87 (–0.72~2.47)	0.284	-
SAS → Complication		0.39	0.81	0.60 (0.39~0.81)	<0.001	-

SE, Standard Error.

Adjusted: Type, Preoperative_Curve, Age (months), Weight (kg), Preoperative_cQmax, Preoperative_cQave, surgery time, CHIPPS.

significantly after surgery and then gradually improved over time, but remained below baseline at 12 months. This pattern aligns with findings by Wolffenbuttel *et al*. [18], who reported persistently reduced flow rates at 3–6 months after TIP repair. Early postoperative flow restriction may reflect urethral edema, scar formation, or transient sphincter dysfunction associated with surgical manipulation [19]. In the present cohort, a rapid improvement in cQave was observed in the intervention group, which may be attributed to more standardized incision and wound management and targeted antimicrobial guidance delivered by MDT wound-care specialists, potentially minimizing inflammatory interference with urethral patency.

Flow-curve analysis indicated that Type 3 (plateau) was the dominant postoperative pattern in both groups, whereas Type 1 (bell-shaped) increased significantly by 12 months. This shift reflects progressive structural remodeling and functional adaptation of the reconstructed urethra. Consistent with previous findings [20,21], uroflow curve patterns can serve as early indicators of obstruction and may be clinically useful for follow-up. Nonetheless, the persistently reduced cQmax suggests incomplete functional recovery of peak flow, potentially due to residual sphincter discoordination after urethral plate incision. Future studies should assess adjunctive interventions, including bioengineered scaffolds, to promote faster urethral regeneration and improve long-term flow dynamics [22].

The trajectory of parental or caregiver anxiety differed between groups over the follow-up period. The intervention group consistently exhibited lower SAS scores than the control group at all postoperative time points, with the most pronounced between-group difference observed at 1 month postoperatively (31.00 vs. 51.00, $p < 0.001$). While this disparity partly reflects the lower baseline anxiety in the intervention group, structured pre-discharge education and psychological support may have contributed to this pattern. However, we acknowledge that the non-randomized design precludes definitive causal attribution. Karaburun *et al*. [11] reported similar reductions in anxiety following audiovisual education, with parental preoperative anxiety decreasing from 57.65 to 44.82.

Although the SAS score increased modestly at 6–12 months, possibly in response to secondary concerns such as infection or fistula, the intervention group maintained lower anxiety levels than controls. In contrast, SAS scores in the control group increased significantly from 1 to 6 months (60.00 vs. 51.00, $p < 0.001$). Components of the intervention, such as post-discharge teleconsultation, remote review of wound and catheter images, and a 24-hour "green channel" for urgent access, likely improved reassurance and continuity of care [23].

The observation that SAS independently predicted complications (adjusted OR = 1.82) reinforces caregiver anxiety as a key modifiable risk factor, potentially through reduced vigilance or delayed reporting of early warning signs. Mediation analysis further confirmed the indirect role of SAS (β_indirect = –0.15), consistent with Everhart *et al*. [24], who demonstrated that anxiety can reduce treatment adherence by decreasing self-efficacy and increasing perceived barriers. Parental psychological status can also influence the child's mental well-being. Mechanistically, anxiety may impair wound healing through neuroendocrine and immune dysregulation, including altered cortisol secretion and delayed resolution of inflammation [25]. Increased anxiety may also reduce adherence to wound-care recommendations and delay clinical consultation when early signs of complications arise [26].

Notably, preoperative SAS scores were already lower in the MDT group than in the control group. This likely reflects self-selection of families who were more receptive to intensive counselling and the immediate effect of structured preoperative psychological support provided by the MDT. Although multivariable models adjusted for key baseline variables, residual confounding and selection bias cannot be completely excluded. Therefore, the observed mediation pathway linking the care pathway, SAS, and complications should be interpreted as associative rather than strictly causal.

At the 12-month post-operative assessment, the median HOSE score assessed by clinicians was 14.00, and the median HOSE score assessed by parents was 13.00, consistent with previous findings reported by Borkar *et al*. [27]. Although both groups achieved acceptable cosmetic and functional outcomes, the intervention group's slightly lower scores may be partially related to their shorter surgical duration (1.20 vs. 1.59 hours, $p < 0.001$), which could reduce tissue trauma and subsequent scarring risk. This interpretation is supported by Adler *et al*. [28], who reported that longer operative time is associated with a higher risk of postoperative complications. Parental-assessed HOSE scores were slightly lower than physician ratings, echoing the psychosocial perceptions reported by Haid *et al*. [29], where hypospadias repair itself imposed a substantial emotional burden on caregivers. Moreover, improved postoperative pain control in the intervention group (lower CHIPPS 3.00 vs. 5.00, $p < 0.001$) highlights the advantage of individualized multimodal analgesia combined with behavioral interventions such as positive suggestion.

Clinically, these findings provide evidence that integrating MDT coordination with a structured home care can enhance postoperative management after TIP repair in children. This model not only optimizes clinical resource utilization but also leverages remote communication and caregiver education, thereby reducing anxiety and improving adherence, which ultimately influence recovery and surgical outcomes.

Despite encouraging findings, several limitations to the study should be acknowledged before interpreting these observations. First, the retrospective, preference-based group allocation inherently carries selection bias, as evidenced by significant baseline differences in parental anxiety levels (SAS scores) despite the comparability of other clinical variables. Consequently, any causal interpretation of the role of caregiver anxiety in study outcomes should be approached with caution. Second, the single-center design and moderate sample size (n = 206) restrict external generalizability. Third, although current guidelines recommend hypospadias repair between 6–18 months of age [30], our cohort included children aged 1–5 years to ensure reliable uroflow assessment, potentially limiting extrapolation to infants. Fourth, the 12-month follow-up may not capture late-presenting complications; Lucas *et al*. [31] reported that only 47% of complications occur within the first postoperative year. Additionally, because allocation was non-randomized, the mediation findings should be interpreted as associative rather than causal. Finally, the observed complication rate was lower than projected, which may have reduced statistical power to detect a significant between-group difference.

Conclusions

In this single-center cohort of boys undergoing distal TIP urethroplasty, MDT-supported structured home care was linked to shorter operative time, reduced postoperative pain, and consistently lower parental anxiety compared with conventional nursing care. Although the overall 12-month complication rate did not differ significantly between groups, parental anxiety emerged as an independent predictor of complications and showed a substantial indirect mediating effect in the relationship between care pathway and complication risk. These results support integrating MDT-based structured home care into pediatric hypospadias management and underscore caregiver psychological state as a potential target for complication prevention. Further prospective, multicenter studies with extended follow-up are needed to validate these findings and optimize home-based postoperative management strategies.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

LYH and QZ designed the research study. LYH and LFX performed the research. QZ and LFX analyzed the data. LYH drafted this article. All authors contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

As a retrospective analysis protecting patient privacy and causing no harm, this study was exempt from ethical approval by Ganzhou People's Hospital per local regulations. The study conformed to the provisions of the Declaration of Helsinki. Written informed consent for surgery, participation in the MDT home care program, and use of anonymized clinical and follow-up data for research was obtained from the parents or legal guardians of all children.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

References

[1] Lavoie C, Chun B, Au M, Do C, Baker Z, Cortessis V, *et al*. Comparing the incidence of hypospadias across the United States: A contemporary analysis. Journal of Pediatric Urology. 2025; 21: 627–632. https://doi.org/10.1016/j.jpurol.2025.01.002.

[2] Zhang Y, Jia H, Fan J, Wang J, Liu J, Yang C, *et al*. Mono-2-ethylhexyl phthalate-induced downregulation of MMP11 in foreskin fibroblasts contributes to the pathogenesis of hypospadias. Ecotoxicology and Environmental Safety. 2024; 284: 116988. https://doi.org/10.1016/j.ecoenv.2024.116988.

[3] Xu Y, He Y, Wang H, Wu X, Liu Z, Du G, *et al*. Widening of narrow urethral plates with lateral skin in TIP hypospadias repair: single center series. BMC Surgery. 2024; 24: 104. https://doi.org/10.1186/s12893-024-02400-8.

[4] Fang Y, Sun N, Song H, Zhang W, Tang Y, Huang L, *et al*. A multicenter study on surgical procedure selection and risk factor analysis of postoperative complications after TIP and Duckett hypospadias repair. BMC Urology. 2022; 22: 131. https://doi.org/10.1186/s12894-022-01051-2.

[5] Fang Y, Yang D, Sun N, Song H, Zhang W, Tang Y, *et al*. Development of a clinical prediction model for postoperative complications following tubularized incised plate urethroplasty: a multicenter study. Pediatric Surgery International. 2025; 41: 106. https://doi.org/10.1007/s00383-025-06009-7.

[6] Jonuzi A, Zvizdić Z, Milišić E, Kulovac B, Mešić A, Vranić S. Assessment of postoperative cosmetic outcomes of distal form hypospadias repair with the Hypospadias Objective Scoring Evaluation (HOSE). Medicinski Glasnik. 2022; 19: 10.17392/1482-22. https://doi.org/10.17392/1482-22.

[7] Austin PF, Bauer SB, Bower W, Chase J, Franco I, Hoebeke P, *et al*. The standardization of terminology of lower urinary tract function in children and adolescents: Update report from the standardization committee of the International Children's Continence Society. Neurourology and Urodynamics. 2016; 35: 471–481. https://doi.org/10.1002/nau.22751.

[8] Mattsson S, Spångberg A. Flow rate nomograms in 7- to 16-year-old healthy children. Neurourology and Urodynamics. 1994; 13: 267–280. https://doi.org/10.1002/1520-6777(1994)13:3<267::aid-nau1930130309>3.0.co;2-k.

[9] Snodgrass P, Snodgrass W, Bush N. Parental Concerns of Boys with Hypospadias. Research and Reports in Urology. 2021; 13: 73–77. https://doi.org/10.2147/RRU.S285626.

[10] Dellafiore F, Arrigoni C, Nania T, Caruso R, Baroni I, Vangone I, *et al*. The impact of COVID-19 pandemic on family caregivers' mental health: a rapid systematic review of the current evidence. Acta Bio-Medica: Atenei Parmensis. 2022; 93: e2022154. https://doi.org/10.23750/abm.v93iS2.12979.

[11] Karaburun MC, Akıncı A, Kubilay E, Özkaya MF, Soygür YT, Burgu B. The impact of audiovisual information on parental anxiety levels prior to hypospadias surgery: A prospective single center cohort study. Journal of Pediatric Urology. 2024; 20: 746.e1–746.e7. https://doi.org/10.1016/j.jpurol.2024.06.012.

[12] Türk E, Güven A, Karaca F, Edirne Y, Karaca I. Using the parents' video camera for the follow-up of children who have undergone hypospadias surgery decreases hospital anxiety of children. Journal of Pediatric Surgery. 2013; 48: 2332–2335. https://doi.org/10.1016/j.jpedsurg.2013.04.012.

[13] Kothari R, Donner JR, Balakrishnan K, Hartman G, Pediatric Thyroid Program Workgroup:, Alazraki A, *et al*. Composition and Priorities of Multidisciplinary Pediatric Thyroid Programs: A Consensus Statement. Thyroid. 2025; 35: 346–356. https://doi.org/10.1089/thy.2024.0496.

[14] Bakel LA, Waynik IY, Starmer AJ, Berkwitt AK, Ziniel SI. Clinical Pathways Programs in Children's Hospitals. Pediatrics. 2024; 154: e2023065553. https://doi.org/10.1542/peds.2023-065553.

[15] Lin E, Noritz G. Home Health Care of Children, Adolescents and Young Adults With Complex Medical Needs: Clinical Report. Pediatrics. 2025; 156: e2025073171. https://doi.org/10.1542/peds.2025-073171.

[16] Zung WW. A rating instrument for anxiety disorders. Psychosomatics. 1971; 12: 371–379. https://doi.org/10.1016/S0033-3182(71)71479-0.

[17] von Baeyer CL, Pasero C. What nurses' work-arounds tell us about pain assessment. International Journal of Nursing Studies. 2017; 67: A1–A2. https://doi.org/10.1016/j.ijnurstu.2016.10.001.

[18] Wolffenbuttel KP, Wondergem N, Hoefnagels JJS, Dieleman GC, Pel JJM, Passchier BTWD, *et al*. Abnormal urine flow in boys with distal hypospadias before and after correction. The Journal of Urology. 2006; 176: 1733–1736; discussion 1736–1737. https://doi.org/10.1016/S0022-5347(06)00614-8.

[19] de Rooij FPW, van der Sluis WB, Ronkes BL, Steensma TD, Al-Tamimi M, van Moorselaar RJA, *et al*. Comparison of surgical outcomes and urinary functioning after phalloplasty with versus without urethral lengthening in transgender men. International Journal of Transgender Health. 2022; 24: 487–498. https://doi.org/10.1080/26895269.2022.2110548.

[20] Jojoa-Acosta M, Bahillo A, Arjona L, Lorenzo RM, Canelón E. Comparison of three classifiers in detection of obstruction of the lower urinary tract using recorded sounds of voiding. Computers in Biology and Medicine. 2025; 193: 110337. https://doi.org/10.1016/j.compbiomed.2025.110337.

[21] Smith C, Godbole P. Is Routine Uroflowmetry Necessary following Hypospadias Repair? International Archives of Urology and Complication. 2018; 4: 038. https://doi.org/10.23937/2469-5742/1510038.

[22] Wan X, Yao H, Wei Z, Gao D, Zheng D, Xu B, *et al*. Heterogeneous porous hypoxia-mimicking scaffolds propel urethral reconstruction by promoting angiogenesis and regulating inflammation. Biomaterials. 2025; 314: 122833. https://doi.org/10.1016/j.biomaterials.2024.122833.

[23] Inan AA, Ekim A. The Effect of Discharge Planning on Parents' Anxiety and Coping Difficulties in Hypospadias Repair Surgery. Journal of Perianesthesia Nursing. 2025; 40: 1307–1315. https://doi.org/10.1016/j.jopan.2025.01.027.

[24] Everhart RS, Saavedra MT, Ford CR, Gibson SL, Reid F, Muther EF, *et al*. Mental health and adherence in CF: Self-efficacy and perceived barriers as mediators. Journal of Cystic Fibrosis. 2025; 24: 334–340. https://doi.org/10.1016/j.jcf.2025.02.016.

[25] Walburn J, Vedhara K, Hankins M, Rixon L, Weinman J. Psychological stress and wound healing in humans: a systematic review and meta-analysis. Journal of Psychosomatic Research. 2009; 67: 253–271. https://doi.org/10.1016/j.jpsychores.2009.04.002.

[26] Fava GA, Cosci F, Sonino N, Guidi J. Understanding Health Attitudes and Behavior. The American Journal of Medicine. 2023; 136: 252–259. https://doi.org/10.1016/j.amjmed.2022.10.019.

[27] Borkar N, Tiwari C, Nair A, Mohanty D, Sinha CK, Mahajan JK. Tubularized incised plate urethroplasty and grafted tubularized incised plate urethroplasty: systematic review, meta-analysis and trial sequential analysis. World Journal of Pediatric Surgery. 2024; 7: e000707. https://doi.org/10.1136/wjps-2023-000707.

[28] Adler AC, Chandrakantan A, Lee AD, Koh CJ, Janzen NK, Austin PF. Effect of Caudal vs. Penile Block on the Incidence of Hypospadias Complications Following Primary Repairs: A Retrospective Cohort Study. The Journal of Urology. 2021; 205: 1454–1459.

https://doi.org/10.1097/JU.0000000000001448.

[29] Haid B, Becker T, Koen M, Berger C, Strasser C, Roesch J, *et al*. Penile appearance after hypospadias correction from a parent's point of view: Comparison of the hypospadias objective penile evaluation score and parents penile perception score. Journal of Pediatric Urology. 2016; 12: 33.e1–33.e7. https://doi.org/10.1016/j.jpurol.2015.10.010.

[30] Chen KY, Kennady EH, Rapp DE, Smith RP, Corbett ST, Ortiz NM. Long-term Complications of Hypospadias Repair. Current Sexual Health Reports. 2022; 14: 128–134. https://doi.org/10.1007/s11930-022-00336-9.

[31] Lucas J, Hightower T, Weiss DA, Van Batavia J, Coelho S, Srinivasan AK, *et al*. Time to Complication Detection after Primary Pediatric Hypospadias Repair: A Large, Single Center, Retrospective Cohort Analysis. The Journal of Urology. 2020; 204: 338–344. https://doi.org/10.1097/JU.0000000000000762.