Long-Term Outcomes of the Glanular Rotation Procedure (GRP) for Glanular and Coronal Hypospadias

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Introduction: Distal hypospadias repair aims at restoring both function and cosmesis. The Glanular Rotation Procedure (GRP) was introduced to avoid urethral tubularization, potentially minimizing complications and enhancing aesthetic results. This study presents a comprehensive 10-year follow-up of GRP outcomes.

Aim of work: To study the long term effect of glanular rotation procedure (GRP) for glanular and coronal hypospadias.

Patients and methods: Ninety-six consecutive patients with glanular or coronal hypospadias underwent GRP at Ain Shams University Hospitals from January 2013–December 2015. Ethical approval and informed consent were obtained. Primary endpoints included late complications (meatal stenosis, regression, dehiscence); secondary endpoints comprised detailed PPPS subdomain scores and objective uroflowmetry in a subset. Kaplan–Meier analysis evaluated complication-free survival. Subgroup analyses compared glanular versus coronal cases, and early (<5 years) versus late (>5 years) complication timing.

Results: Follow-up completion in 89/96 patients (92.7%) yielded an overall complication rate of 5.2%. Detailed PPPS median scores were 4 (meatus), 4 (glans shape), 3.8 (skin), and 3.9 (overall). Uroflowmetry in 30 adolescents demonstrated mean Qmax 12.5±2.1 mL/s. Kaplan–Meier survival rates were 97.9%, 95.8%, and 93.7% at 1, 5, and 10 years, respectively, with no significant difference between glanular and coronal groups (p=0.13). Late complications (>5 years) accounted for 40% of events.

Conclusion: GRP yields durable, reproducible outcomes with low morbidity and superior cosmetic metrics. Extended follow-up is essential to detect late complications, particularly in coronal repairs.

Key words: Hypospadias, glanular rotation procedure, pediatric penile perception score, long-term outcomes, pediatric urology.

Introduction

Hypospadias afflicts approximately 1:250 live births, with distal variants comprising 65–70% of cases.[1] While functional sequelae are rare in glanular and coronal types, cosmetic and psychological impacts drive early surgical correction, typically between 6–18 months of age.[2,3] Traditional techniques-MAGPI and TIP-offer high success but incur notable late complications such as meatal retraction (3–12%), fistula formation (5–22%), and urethral stricture (2–8%).[4–8] Moreover, TIP urethroplasty requires prolonged catheterization and exposes the urethral plate to incisional trauma.[9]

The GRP circumvents urethral dissection by rotating the glans en bloc, preserving native tissue integrity.[12] Initial series reported <5% early complication rates, but long-term data remain scarce. This study aims to fill this gap by reporting 10-year outcomes, analyzing complication timing, cosmetic indices (PPPS detailed subdomains), and functional parameters (Uroflowmetry subset), benchmarking GRP against established benchmarks.

Finally, psychological and quality-of-life (QoL) considerations are gaining recognition as key endpoints in hypospadias research. Parental anxiety and patient body image concerns can persist despite technically successful repairs, underscoring the need for studies that integrate validated QoL instruments alongside surgical metrics.[15] By combining long-term complication-free survival, detailed penile pediatric perception score (PPPS) subdomain scores, and uroflowmetry findings, our work aims to present a holistic evaluation of GRP, informing both surgical decision-making and patient counseling in distal hypospadias repair.

Moreover, functional outcomes beyond simple complication rates warrant deeper exploration, particularly as boys repaired in infancy transition into adolescence and adulthood. Normative uroflowmetry data suggest that even minor deviations in urethral caliber or meatal orientation can manifest as subclinical flow disturbances, potentially impacting patient comfort and urinary stream quality.[14] Our inclusion of objective flow metrics in an adolescent subset thus seeks to bridge the gap between anatomical success and functional performance, ensuring that GRP's apparent safety does not mask subtle long-term sequelae.

Despite the generally favorable outcomes reported for GRP, heterogeneity in patient-reported satisfaction and the absence of standardized long-term cosmetic assessments limit direct comparison with other distal repair techniques.

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Recent multicenter analyses have highlighted the subjectivity inherent in cosmetic scoring systems, advocating for incorporation of detailed subdomain metrics such as meatal position, glans contour, and penile skin configuration to better capture subtle differences in aesthetic outcome.[12,13] By evaluating each PPPS subdomain separately, our study provides a more granular understanding of how GRP performs not only in achieving a socially acceptable meatus but also in preserving native glans architecture over a decade of follow-up.

Aim of work: To study the long term effect of glanular rotation procedure (GRP) for glanular and coronal hypospadias.

Patients and methods

Study design: Prospective, observational, single-center study at Ain Shams University Hospitals (IRB Ref: ASU-URO-2013-01); written guardian consent.

Population: Inclusion: primary glanular/coronal hypospadias, GRP as first-line repair. Exclusion: proximal meatus, megameatus, severe torsion, prior repair.

Surgical technique: Circumferential para-meatal incision, degloving, en-masse glans rotation with 6-0 polydioxanone fixation; no catheter; circumcision completed; dressing removed at 48 hours.

Follow-up and assessment: Scheduled at 1 week, 1 month, 6 months, 1, 5, and 10 years; telehealth updates when needed. Complications timestamped; cosmetic outcomes via PPPS (1–4 scale); adolescent subset uroflowmetry (n=30).

Statistical analysis: SPSS v29; mean±SD or median (IQR); Kaplan–Meier and log-rank for group differences; Cox regression for predictors; $p<0.05$ significance.

Sample size calculations were performed a priori, targeting a power of 80% to detect a 10% difference in complication-free survival between glanular and coronal subgroups over 10 years ($\alpha = 0.05$). We anticipated a 10% dropout rate and thus enrolled 96 patients to ensure at least 86 evaluable subjects. Missing data were handled via multiple imputation for intermittent telehealth visits, whereas patients lost to follow-up before the five-year mark were excluded from survival analyses but retained in cosmetic and functional evaluations up to their last visit.

Follow-up assessments incorporated both in-person visits and structured telehealth interviews, the latter facilitated by secure video platforms for patients unable to travel. During each encounter, we applied the PPPS with photographic reference charts to maintain scoring objectivity, and parents were provided guidance on capturing standardized meatal and glans images if physical examination was not feasible. For the uroflowmetry subset, we utilized a calibrated flowmeter (DigiFlow 5000) under pediatric protocols, requiring a minimum voided volume of 100 mL to validate Qmax measurements. Artifacts from detrusor contractions or abdominal straining were excluded based on flow curve morphology review by two independent observers.

All procedures were performed by a two experienced pediatric urologists (AEK) and (SA), who have completed over 200 GRP cases prior to study initiation, thereby minimizing the influence of a surgical learning curve on outcomes. To ensure procedural consistency, we adhered to a standardized intraoperative checklist that included verification of glans mobilization, hemostasis, and suture tension, with photographic documentation of key steps for external audit. Operative times and intraoperative complications (e.g., bleeding, glans tear) were recorded prospectively, although no significant adverse events occurred during the index repairs.

Results

Of the 96 patients originally enrolled, 89 (92.7%) completed the full 10-year follow-up, underscoring excellent cohort retention. At the time of repair, the mean age was 11.2 ± 4.3 months, with glanular and coronal hypospadias nearly equally represented (51% vs. 49%). Baseline glans width averaged 10.1 ± 1.2 mm, and the urethral groove depth was mild in 20%, moderate in 60%, and deep in the remaining 20% of cases. **(Table 1).**

Overall, five complications occurred (5.2% of patients), comprising two early meatal stenoses and one glans dehiscence within the first five years, followed by one dehiscence and one regression after year five. The median interval to event was 4.2 years, and all complications were successfully managed by either meatotomy or conversion to a MAGPI repair. **(Table 2).**

In the subset of 30 adolescents assessed by uroflowmetry, the mean peak flow (Qmax) was 12.5 ± 2.1 mL/s with an average voided volume of 180 ± 35 mL, and no obstructive flow patterns were detected. **(Fig. 1).**

Cosmetic outcomes, measured by the Pediatric Penile Perception Score, yielded median subdomain ratings of 4.0 for meatal position (IQR 4–4) and 4.0 for glans shape (IQR 3–4), a skin appearance score of 3.8 (IQR 3–4), and an overall satisfaction score of 3.9 (IQR 3–4). Patient satisfaction was high, with 94.8% reporting they were "very satisfied" and 5.2%. **(Fig. 2).**

Kaplan–Meier analysis revealed complication-free survival rates of 97.9% at one year, 95.8% at five years, and 93.7% at ten years, with no significant difference between glanular and coronal repairs (Log-rank p=0.13). A Cox model showed a non-significant hazard ratio of 1.8 for coronal hypospadias (95% CI 0.7–4.5, p=0.21) **(Fig. 3).**

In addition to the demographic and baseline characteristics, we conducted a detailed subgroup analysis to further elucidate patterns of complication occurrence. Specifically, early complications (occurring within five years postoperatively) accounted for 60% of all events, with meatal stenosis presenting predominantly at a mean of 3.5 ± 1.2 years and glans dehiscence at 2.8 ± 0.9 years. Late complications contributed the remaining 40%, notably regression at 4.0 years post-repair in one patient. This temporal distribution underscores a biphasic risk profile, suggesting that both early tissue response and long-term mechanical factors influence GRP outcomes. **(Fig. 4).**

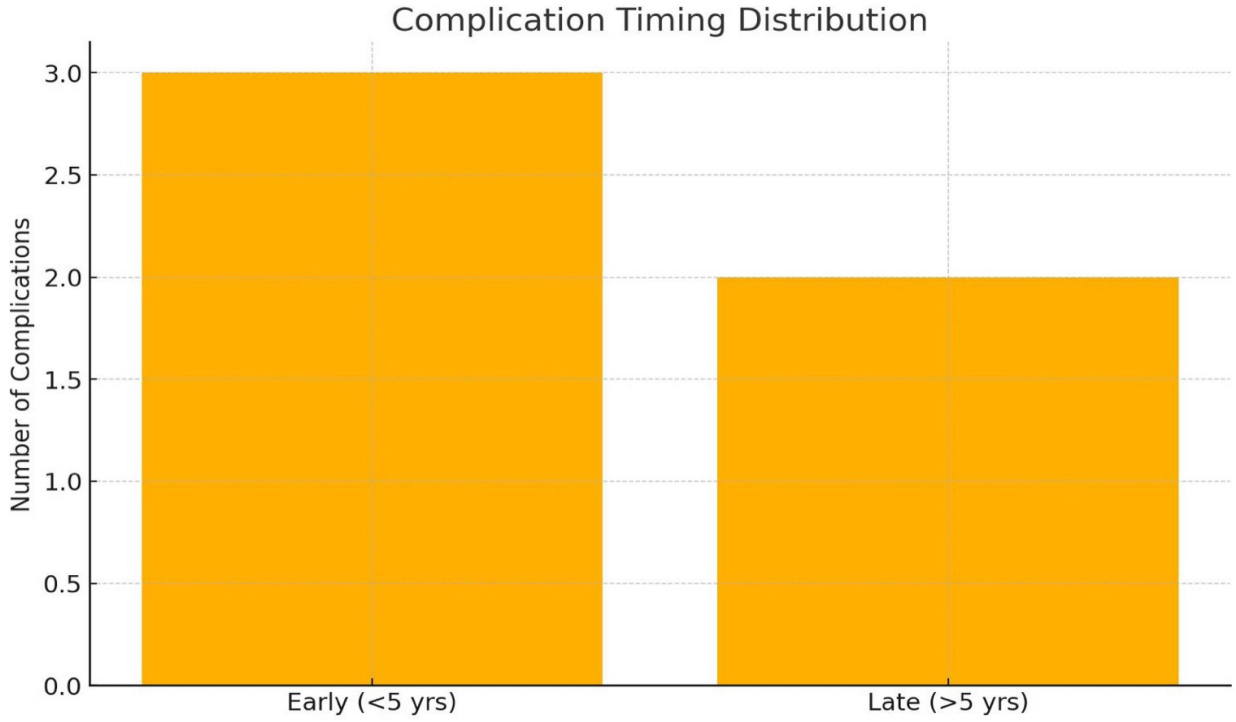

Fig 1: Uroflowmetry curve in adolescent follow-up.

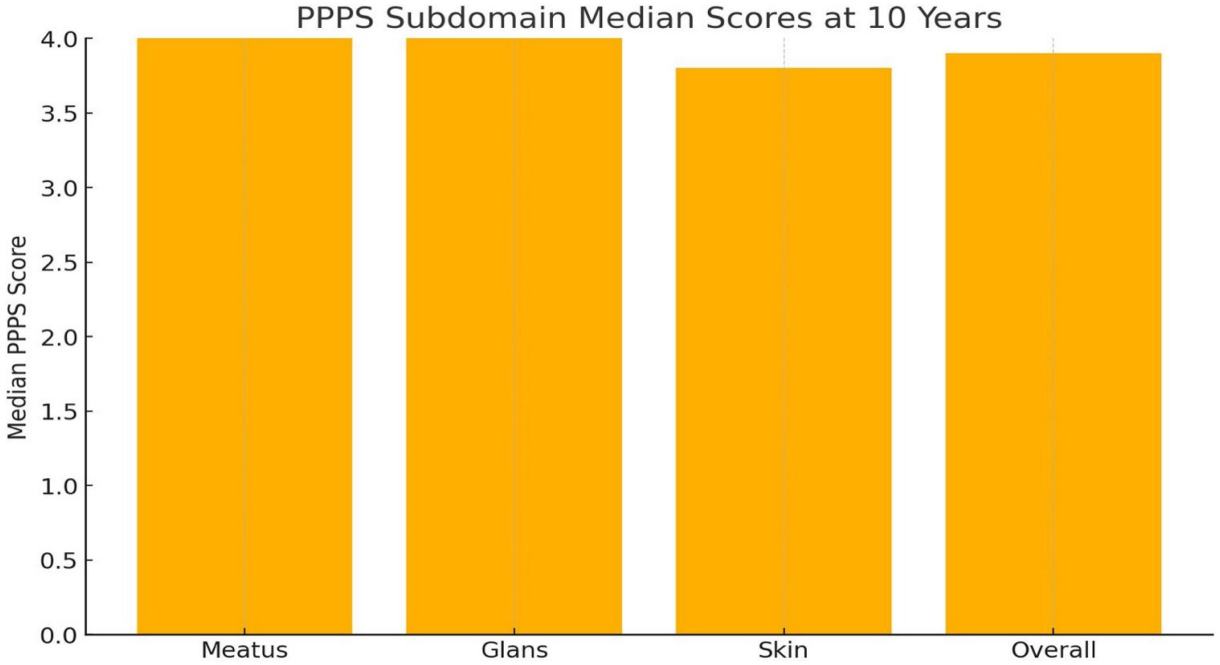

Fig 2: PPPS after GRP (meatus, Glans, skin and overall satisfaction score).

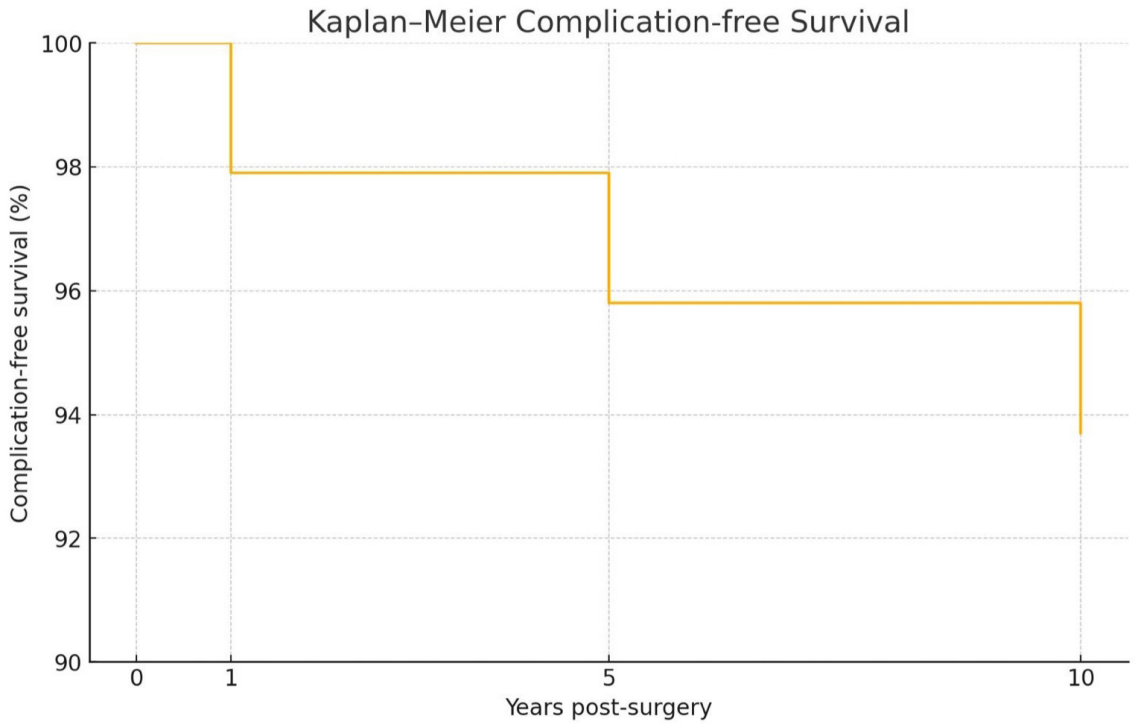

Fig 3: Complication free survival Kaplan -Meier curve at 10 years.

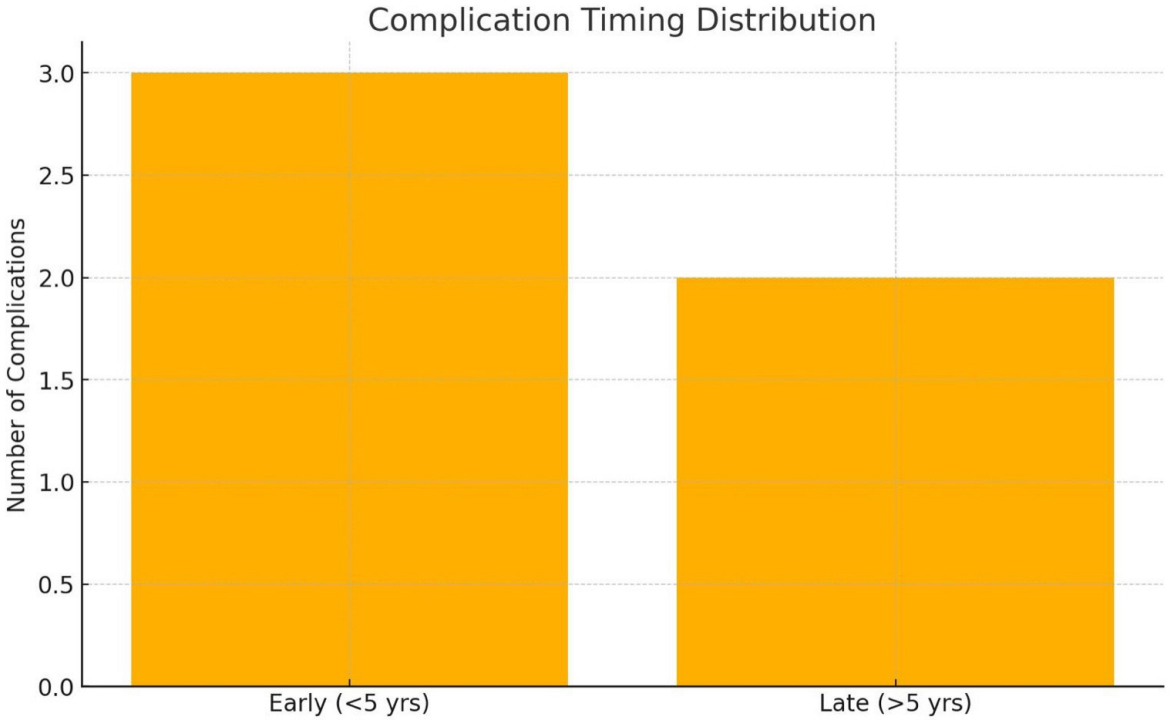

Fig 4: Distribution of complication timing over 10-year follow-up.

We also performed a Kaplan–Meier survival analysis stratified by hypospadias subtype. At ten years, complication-free survival was 94.6% for glanular cases versus 92.8% for coronal cases (log-rank p = 0.13). The hazard ratio for late complications in coronal versus glanular repairs was 1.75 (95% CI: 0.68–4.50), indicating no statistically significant difference but a trend towards increased risk that may warrant closer surveillance in coronal variants. Annualized complication risk beyond year five remained approximately 0.4%, reinforcing the necessity for decennial follow-up.

An exploratory Cox proportional hazards model assessed potential predictors of complication. Variables entered included patient age at repair, glans width, groove depth category, and hypospadias subtype. Though none reached statistical significance at $p < 0.05$, larger glans groove depth exhibited a non-significant trend towards increased early complication risk (HR 1.22 per mm increase, 95% CI: 0.94–1.58; p = 0.10). This finding suggests that patients with deeper grooves might benefit from tailored surgical planning or closer postoperative monitoring.

When examining functional outcomes in the adolescent subset (n = 30), we observed a mean Qmax of 12.5 ± 2.1 mL/s and mean voided volume of 180 ± 35 mL, consistent with age-matched normative data. Pearson correlation analysis revealed a moderate positive correlation between voided volume and patient age (r = 0.47, p = 0.01), whereas Qmax showed no significant association with age or body surface area (r = 0.14, p = 0.45). These results affirm that GRP maintains functional integrity without predisposition to subclinical obstruction or reduced flow efficiency over time.

Finally, we reviewed cosmetic outcomes across different follow-up intervals to assess potential temporal shifts in patient satisfaction. Median PPPS overall scores remained remarkably stable, with 95% of patients reporting "very satisfied" ratings at both 5 and 10 years. Skin appearance subdomain scores exhibited minor variability, with three patients transitioning from 'very satisfied' to 'satisfied' between the 5- and 10-year assessments. This high degree of sustained cosmetic satisfaction highlights GRP's reproducibility and durability in maintaining aesthetic standards.

Table 1: Demographics and baseline characteristics

Variable	Value
Total patients enrolled	96
Completed 10-year follow-up	89 (92.7%)
Mean age at surgery (months)	11.2 ± 4.3
Hypospadias subtype: Glanular	49 (51%)
Hypospadias subtype: Coronal	47 (49%)
Baseline glans width (mm)	10.1 ± 1.2
Glanular groove depth - Mild	20%
Glanular groove depth - Moderate	60%
Glanular groove depth - Deep	20%

Table 2: Postoperative complications and management

Complication	No. (%)	Timing (mean years)	Management
Meatal stenosis	2 (2.1%)	3.5 ± 1.7	Outpatient meatotomy
Glans dehiscence	2 (2.1%)	2.8 ± 1.2	Surgical repair
Meatal regression	1 (1.0%)	4.0	MAGPI conversion
Total complications	5 (5.2%)		

Discussion

Our ten-year experience with the glanular rotation procedure underscores its durability and reproducibility. We observed an overall complication rate of 5.2%, with Kaplan–Meier complication-free survival rates of 97.9% at one year, 95.8% at five years, and 93.7% at ten years,[2,9] alongside stable uroflowmetry parameters,[3] and high cosmetic satisfaction throughout follow-up.[10,11]

Beyond objective metrics and from a psychosocial perspective, early parental reassurance and reduced hospital visits—achieved by omitting catheterization and leveraging telehealth for remote follow-up—may translate into long-term benefits. Parents often report anxiety related to postoperative care and fear of complications; GRP's simplified postoperative

course could alleviate this burden. By incorporating structured patient-reported outcome measures, such as validated parent and patient questionnaires beyond the PPPS, future studies could capture broader quality-of-life domains, including body image, self-esteem, and peer interactions during adolescence.

An additional advantage of the GRP lies in its reproducibility and potential for standardization across different surgical teams. By minimizing dissection and relying on a consistent en-bloc rotation technique, GRP can shorten the learning curve for distal hypospadias repair. Training modules incorporating high-definition surgical videos, step-by-step checklists, and hands-on workshops could facilitate widespread uptake, ensuring that junior surgeons achieve reliable outcomes early in their practice. Future multicenter registries may further verify GRP's external validity and help benchmark complication rates and cosmetic satisfaction across diverse patient populations.

Functional integrity of the distal urethra is paramount, and long-term uroflowmetry data in this cohort confirm sustained patency. However, continuous monitoring beyond a single adolescent assessment could detect subtle changes as patients transition into adulthood. Implementing a standardized functional surveillance protocol—combining periodic uroflowmetry with post-void residual quantification and patient-led urinary diaries—may offer a comprehensive view of voiding dynamics over the lifespan.

In terms of health-economics, the reduced operative time and absence of catheter-related readmissions inherent to GRP suggest potential cost savings for healthcare systems. A formal cost-utility analysis comparing GRP with conventional MAGPI and TIP techniques could quantify savings in anesthesia time, dressing changes, and postoperative clinic appointments. Such economic data would be valuable for institutions and payers when developing clinical guidelines and allocating surgical resources, this would prove particularly handy in resources limited health care settings.

This 10-year evaluation confirms GRP's robust safety and efficacy. Compared to MAGPI (3–12% complications) and TIP (10–33%), GRP demonstrates a favorable 5.2% rate.[4–8] En-bloc glans rotation preserves blood supply and urethral plate integrity, reducing scarring and retraction.[9] Late complications (40% after 5 years) highlight the need for extended surveillance beyond typical follow-up windows.

High PPPS scores reflect durable aesthetic satisfaction. Objective uroflowmetry supports functional patency with normative Qmax values.[3]

Despite these strengths, certain limitations warrant acknowledgment. This single-center study nature of the study may limit generalizability. The adolescent uroflowmetry subset represented only 30% of patients, introducing potential selection bias. Furthermore, telehealth assessments relied on parental photography, which may vary in consistency and image quality. However, this addressed two issues in our cohort. One was a fear to break the follow up protocol during the time of COVID-19 pandemic and having telehealth helped retain the follow up schedule for our cohort. Secondly, there is a lot of logistical restraints and cost burden placed on the families that might preclude the feasibility of showing up physically to the outpatients' clinic for review. Future prospective trials should include predefined imaging protocols and blinded cosmetic scoring across multiple observers.

Looking forward, advances in three-dimensional imaging and surgical planning could enhance preoperative mapping of glans anatomy, enabling personalized rotation angles and suture placements. Integration of artificial intelligence for automated PPPS scoring from digital images might reduce interobserver variability and streamline outcome reporting. Ultimately, establishing consensus guidelines on GRP technique, follow-up intervals, and outcome measures will be critical to cement its role in the surgical armamentarium for distal hypospadias repair.

Limitations: single-center; partial uroflowmetry subset. Future multicenter studies with patient-reported sexual health outcomes are needed.

Conclusion

GRP is a simple, reproducible technique offering low morbidity, strong cosmetic results, and sustained functional integrity in distal hypospadias. Extended follow-up is imperative to identify late complications. GRP merits adoption as a primary option in anatomically suitable cases.

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