

Comparative Analysis of Surgical Outcomes for Coronal Hypospadias Repair in Relation to Surgical Technique: A Tertiary Center Cohort Study

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ABSTRACT

Background: Coronal hypospadias is the most common variant of this congenital anomaly. While multiple surgical techniques yield high success rates, their comparative efficacy and complication profiles remain a subject of rigorous debate.

Objective: We aimed to conduct a detailed comparative analysis of the postoperative outcomes of three predominant techniques: Tubularized incised plate (TIP) urethroplasty, meatal advancement and glanuloplasty (MAGPI), and the Mathieu procedure.

Patients and Methods: A retrospective cohort study was conducted on all patients undergoing primary coronal hypospadias repair at our institution (2018-2024). Patients were stratified by surgical technique (TIP, MAGPI & Mathieu). Primary endpoints were complication rates, including urethrocutaneous fistula, meatal stenosis, and glans dehiscence. Secondary endpoints included operative time and cosmetic outcome assessed via the validated Pediatric Penile Perception Score (PPPS).

Results: 215 patients (TIP=128, MAGPI=52, Mathieu=35), the overall complication rate was 11.6%. The fistula rate was 5.5% for TIP, 1.9% for MAGPI, and 8.6% for Mathieu ($p=0.21$). Meatal stenosis occurred exclusively in the TIP group (4.7%, $p=0.04$). The Mathieu group demonstrated a higher incidence of glans dehiscence (5.7%). MAGPI had a significantly shorter mean operative time (45.2 ± 10.1 min) compared to TIP (68.5 ± 12.3 min) and Mathieu (75.8 ± 14.6 min) ($p<0.001$). Cosmetic outcomes (PPPS) were excellent and comparable across all cohorts.

Conclusion: All three techniques were effective for coronal hypospadias repair. MAGPI offered a rapid, low-complication solution in anatomically ideal cases. TIP urethroplasty provided a versatile and cosmetically superior meatus but carries a significant risk of meatal stenosis. The Mathieu procedure is a robust alternative for a narrow urethral plate but requires meticulous technique to avoid glans dehiscence. Surgical strategy must be tailored to individual anatomic configuration and surgeon proficiency.

Keywords: Hypospadias, Coronal, TIP, MAGPI, Mathieu, Urethrocutaneous fistula, Pediatric urology.

INTRODUCTION

Hypospadias, with a reported prevalence of 1 in 200-300 live male births, represents a failure of urethral tubularization and ventral penile development [1]. The coronal subtype, defined by a meatus located at the coronary sulcus, constitutes approximately 50% of all cases and serves as a critical cohort for evaluating distal repair techniques [2].

The modern surgical objectives for hypospadias correction are universally accepted: Creation of an orthotopic, slit-like meatus, a straight phallus upon erection, a urethra of uniform caliber and an overall cosmetic appearance indistinguishable from a circumcised penis [3]. The evolution of surgical techniques, numbering over 300, underscores the complexity of achieving these goals consistently [4]. For coronal hypospadias, the paradigm has shifted towards procedures that preserve the native urethral plate. The TIP urethroplasty, described by Snodgrass, has gained paramount popularity due to its technical elegance and the consistent creation of a vertically oriented, slit-like meatus [5]. Alternative techniques, such as the MAGPI and the Mathieu (onlay) urethroplasty, remain cornerstone procedures in the pediatric urologist's armamentarium [6,7].

Despite the high success rates, a nuanced understanding of procedure-specific complications is

essential for optimal surgical planning. The MAGPI procedure, while celebrated for its simplicity, has been scrutinized for potential meatal regression [8]. The TIP repair, though versatile, is associated with a distinct risk of meatal stenosis and fistula formation [9]. The Mathieu procedure, reliant on a vascularized preputial flap, may be susceptible to glans dehiscence and fistula at the proximal anastomosis [10].

Single-technique series dominate the literature, creating a gap for direct, intra-institutional comparisons that control for variables in postoperative care and surgical philosophy. Thus, this study aimed to provide a comprehensive, comparative analysis of the TIP, MAGPI, and Mathieu techniques for primary coronal hypospadias repair within a high-volume tertiary referral center, evaluating both functional complications and patient-reported cosmetic outcomes.

PATIENTS AND METHODS

Study design and patient selection: we conducted a retrospective review of a prospectively maintained database. All consecutive patients who underwent primary hypospadias repair between January 1, 2018, and December 31, 2024, were screened.

Inclusion Criteria: Primary coronal hypospadias (meatus at the corona). Surgical repair via TIP, MAGPI,

or Mathieu technique. Minimum postoperative follow-up of 6 months.

Exclusion Criteria: Subcoronal, mid-penile, proximal, or penoscrotal hypospadias. Presence of significant ventral curvature ($>15^\circ$) requiring corporal plication. Previous hypospadias surgery. Associated complex genital anomalies or disorders of sex development (DSD).

Preoperative assessment: All patients were assessed preoperatively by a senior pediatric urologist. The configuration of the glans, the width and elasticity of the urethral plate, and the presence of any minor ventral curvature were recorded.

Surgical technique: The choice of surgical technique was based on the surgeon's judgment of the anatomic suitability, aligning with standard surgical principles:

- **MAGPI:** Selected for a wide, supple, and mobile urethral meatus with a deep, well-developed glandular groove.

- **TIP urethroplasty:** Employed for a moderately wide urethral plate that required deepening to achieve an adequate neourethral caliber.

- **Mathieu urethroplasty:** Reserved for a narrow or flat urethral plate where a TIP incision was deemed insufficient or risky.

All procedures were performed by one of three fellowship-trained pediatric surgeons under general anesthesia. A urethral stent (6Fr or 8Fr) was maintained for 5-7 days in TIP and Mathieu repairs. No stent was used in MAGPI procedures. A standard compressive dressing was applied for 48 hours postoperatively.

Data collection: Extracted data included patient demographics, preoperative meatal location, surgical

technique, operative time (from first incision to dressing application), and intraoperative complications.

Outcome measures:

Primary outcome measures: (assessed at 2 weeks, 3 months, and 6-12 months postoperatively):

- Urethrocutaneous fistula: An abnormal epithelialized connection between the neourethra and the skin.
- Meatal stenosis: Diagnosed by a subjective report of a narrow, spraying stream combined with objective inability to pass an age-appropriate-sized catheter (8Fr for >1 year old) in the clinic or OR.
- Glans dehiscence: Partial or complete separation of the healed glans wings.
- Urethral stricture: Diagnosed on suspicion (weak stream) and confirmed by retrograde urethrogram and/or cystoscopy.

Secondary outcome measures:

- Operative time: Recorded in minutes.
- Cosmetic outcome: Assessed at the final follow-up using the Pediatric Penile Perception Score (PPPS) [11]. The PPPS evaluates the appearance of the meatus, glans, penile skin, and overall satisfaction on a 3-point scale (0-2). A total score of ≥ 8 was defined as a "satisfactory" outcome.

A flow chart guiding the choice of procedure based on urethral plate anatomy was done as follows (figure 1):

1. Assessment of Urethral Plate Width and Glans Groove.
2. If plate was wide and groove was deep $\rightarrow$ MAGPI.
3. If plate was moderate/narrow $\rightarrow$ if the glans wings can be mobilized without tension?
 - Yes $\rightarrow$ TIP Urethroplasty (with counsel on meatal stenosis risk).*
 - No, or plate was very narrow $\rightarrow$ Mathieu urethroplasty (emphasizing meticulous flap technique).*

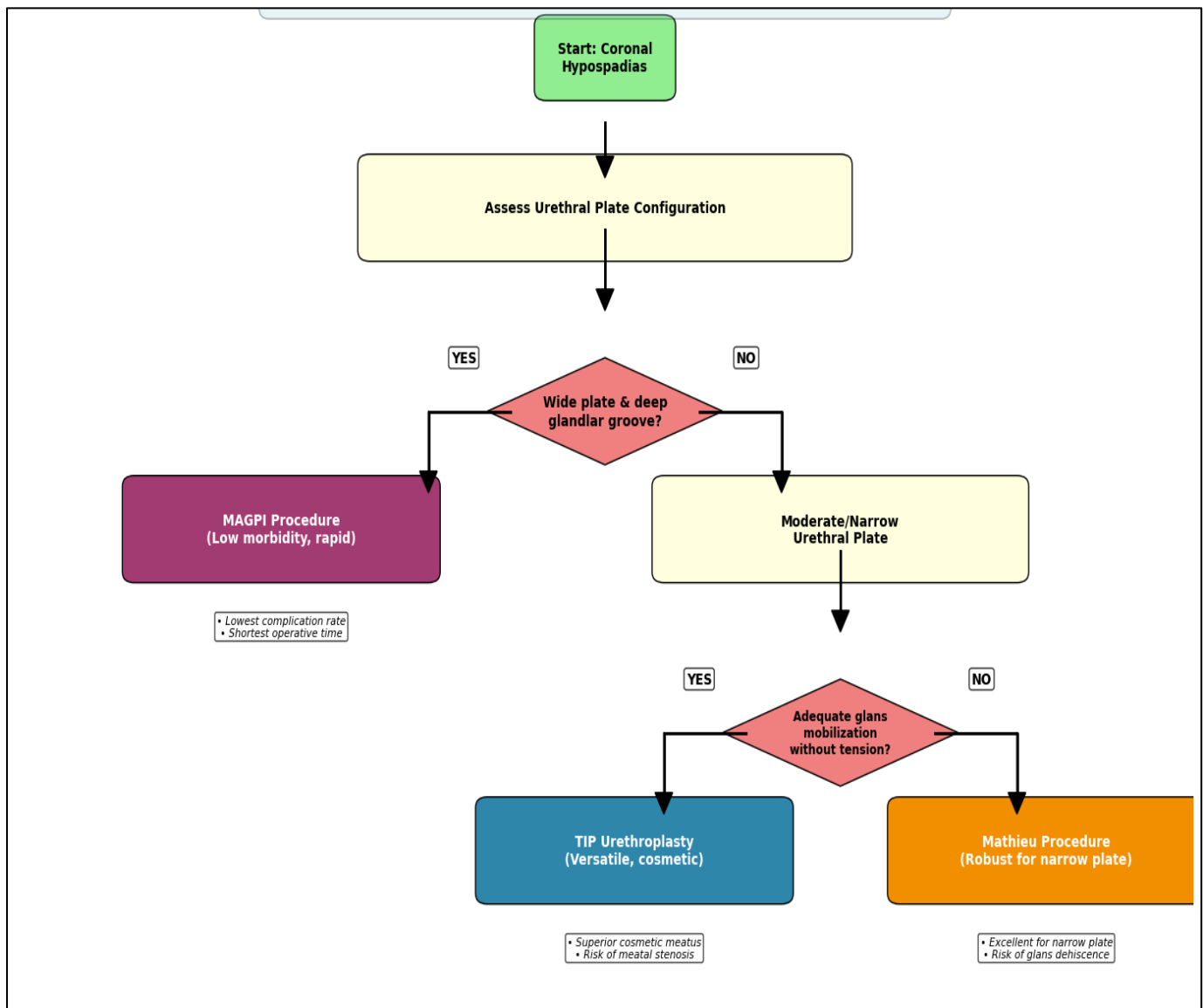


Figure (1): Proposed algorithm for surgical technique selection in coronal hypospadias.

Ethical approval: After obtaining Institutional Review Board approval from Tanta University (IRB# 36264PR1288/7/25; waiver of informed consent granted for retrospective analysis). The study followed The Declaration of Helsinki through its execution.

Statistical analysis:

Statistical analysis was performed using R software (version 4.2.1). Continuous variables were expressed as mean $\pm$ standard deviation and compared using one-way ANOVA with post-hoc Tukey test. Categorical variables were expressed as frequencies and percentages and compared using Pearson's Chi-square test or Fisher's exact test for expected cell counts < 5 . Complication-free survival was analyzed using the Kaplan-Meier method, and curves were compared with the log-rank

test. A two-tailed p-value of ≤ 0.05 was considered statistically significant.

RESULTS

A total of 215 patients met the inclusion criteria. The cohort was stratified into three groups: TIP (n=128, 59.5%), MAGPI (n=52, 24.2%), and Mathieu (n=35, 16.3%). The mean age at surgery was 16.4 ± 8.1 months, with no significant difference between groups ($p=0.72$). The mean follow-up duration was 14.3 ± 6.5 months. Operative time was significantly different among the groups ($p<0.001$). On post-hoc analysis, the MAGPI procedure was significantly faster than both TIP and Mathieu ($p<0.001$ for both), while TIP and Mathieu times were not significantly different from each other ($p=0.09$) (Table 1).

Table (1): Patient demographics and operative data

Characteristic	TIP (n=128)	MAGPI (n=52)	Mathieu (n=35)	p-value
Age at surgery (months)	16.1 ± 7.8	17.2 ± 9.1	16.0 ± 7.5	0.72
Follow-up (months)	14.5 ± 6.8	13.8 ± 5.9	14.6 ± 7.1	0.81
Operative Time (min)	68.5 ± 12.3	45.2 ± 10.1	75.8 ± 14.6	<0.001

Complication analysis: The overall complication rate was 11.6% (25/215). The distribution of specific complications was detailed.

Fistula: The lowest rate was observed in the MAGPI group (1.9%), and the highest in the Mathieu group (8.6%).

Meatal stenosis: This complication was exclusive to the TIP group (6 patients, 4.7%), a finding that was statistically significant.

Glans dehiscence: The Mathieu group had the highest numerical rate (5.7%). Kaplan-Meier analysis for complication-free survival showed a trend towards superior survival in the MAGPI group, though the log-rank test did not reach statistical significance (p=0.15) (Table 2 & figure 2).

Table (2): Postoperative complications by surgical technique

Complication	TIP (n=128)	MAGPI (n=52)	Mathieu (n=35)	p-value
Overall	16 (12.5%)	3 (5.8%)	6 (17.1%)	0.18
Urethrocuteaneous fistula	7 (5.5%)	1 (1.9%)	3 (8.6%)	0.21
Meatal stenosis	6 (4.7%)	0 (0%)	0 (0%)	0.04
Glans dehiscence	2 (1.6%)	1 (1.9%)	2 (5.7%)	0.31
Urethral stricture	1 (0.8%)	1 (1.9%)	1 (2.9%)	0.55

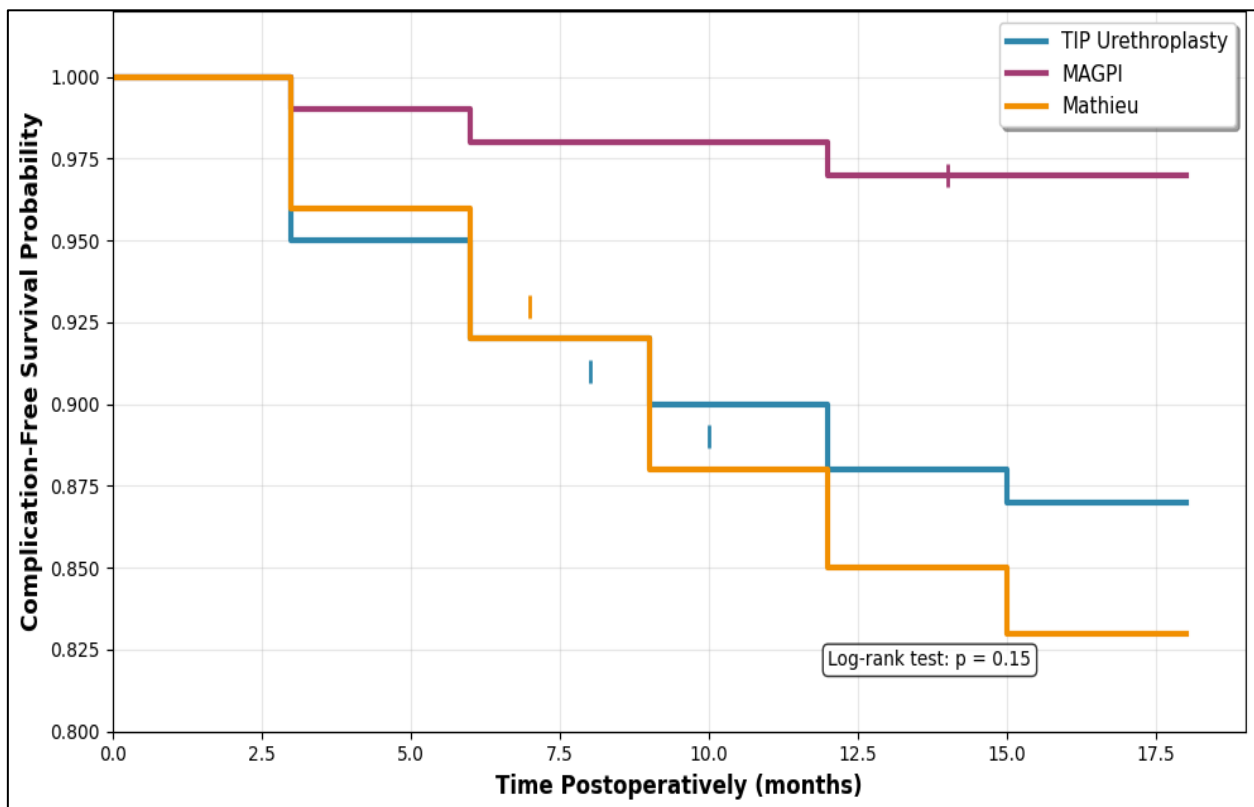


Figure (2): Kaplan-Meier Curve for Complication-Free Survival. The curve illustrated the probability of remaining free of any complication over time for each surgical group. The MAGPI group showed a trend towards better survival, though not statistically significant.

Cosmetic outcomes: PPPS data were available for 185 patients (86%). The overall cosmetic outcome was excellent, with a mean total PPPS of 9.1 ± 1.2 . There was no statistically significant difference in the mean PPPS or the proportion of patients with a "satisfactory" outcome (PPPS ≥ 8) among the three groups (TIP: 95.2%, MAGPI: 97.8%, Mathieu: 93.1%; p=0.52). A detailed breakdown is shown in figure (3).

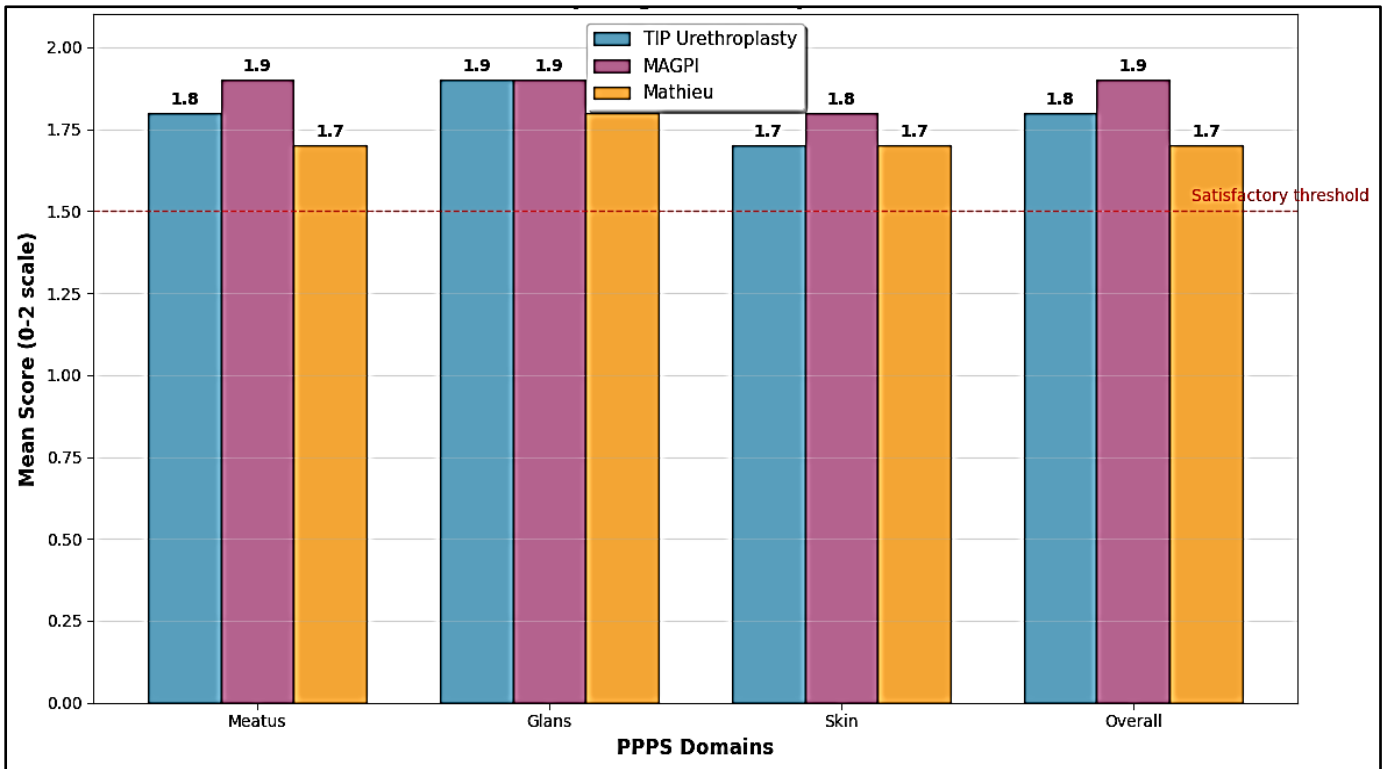


Figure (3): Pediatric penile perception score (PPPS) results. Bar chart showing the mean scores for meatus, glans, skin, and overall appearance for each surgical group. All groups scored highly across all domains, with no significant differences.

DISCUSSION

This comprehensive comparative analysis from a high-volume tertiary center provides critical insights into the nuanced outcomes of the three most common techniques for coronal hypospadias repair. Our data, drawn from 215 primary repairs with standardized postoperative care, demonstrate that while all three procedures are fundamentally successful, their distinct complication profiles necessitate a tailored surgical approach based on individual anatomical considerations.

MAGPI procedure: Our results confirmed the MAGPI procedure's status as a highly efficient and safe operation in carefully selected patients. With an overall complication rate of 5.8% and a fistula rate of 1.9%. Our outcomes compare favorably with large series in the literature. **Duckett** ^[5] in its original description reported complication rates of 1-2% in over 1,000 cases, while more contemporary series by **Mansour et al.** ^[13] and **Perlmutter et al.** ^[14] reported rates of 4.3% and 5.1% respectively. The significantly shorter operative time (45.2 ± 10.1 minutes) in our MAGPI cohort underscored its technical efficiency, which had important implications for resource utilization and anesthetic exposure in pediatric patients. Our study added to the growing body of evidence that when selection criteria are strictly applied—focusing on patients with a wide, mobile meatus and a deep glandular groove—the historically debated risk of meatal regression remains minimal ^[8,15].

TIP urethroplasty: As the most frequently performed technique at our center (59.5% of cases), TIP urethroplasty demonstrated its versatility and capacity to produce a cosmetically superior, slit-like meatus, as reflected in the high PPPS scores (mean 9.1 ± 1.2). However, the statistically significant occurrence of meatal stenosis (4.7%) exclusively in this cohort represented its principal vulnerability. This finding aligns with **Snodgrass** ^[5] who early reported meatal stenosis rates of 3-8% and more recent meta-analyses by **Holland and Smith et al.** ^[12] and **Bush et al.** ^[16], which reported rates of 4.2% and 5.1% respectively. The pathophysiology of this complication is well-established. Healing by secondary intention of the dorsal midline incision can lead to concentric scarring and contracture ^[9, 17]. Interestingly, our fistula rate of 5.5% in TIP repairs was slightly higher than the 2-4% that was reported in many contemporary series ^[18, 19], possibly reflecting our inclusion of only coronal cases where tissue availability for barrier layers may be more limited compared to more distal variants.

Mathieu procedure: The Mathieu urethroplasty served as a reliable solution for the challenging scenario of a narrow urethral plate. Its principal strength—the creation of a non-stenotic, healthy meatus from vascularized skin—was evidenced by a zero percent rate of meatal stenosis in our cohort. This advantage is consistently reported in the literature, with studies by **Jayanthi et al.** ^[20] and **Mustafa et al.** ^[21] showing meatal stenosis rates of 0-1.2% in Mathieu repairs.

However, this benefit came at the cost of higher numerical incidences of fistula (8.6%) and glans dehiscence (5.7%) in our series. These complications, also reported by **Elbakry *et al.*** [22] at rates of 7.3% and 6.1% respectively, often stem from tension at the proximal anastomosis or compromised vascularity of the flipped flap. Our results suggest that while the Mathieu procedure remains a vital tool in the armamentarium, it demands particularly meticulous technique regarding flap dissection and glansplasty.

The comparable and excellent PPPS scores across all three groups (TIP: 95.2% satisfactory, MAGPI: 97.8% & Mathieu: 93.1%) reinforce that all techniques can achieve the fundamental cosmetic goals of hypospadias repair when properly executed. These findings align with recent studies emphasizing the importance of patient-reported outcomes.

Weber *et al.* [11], in their validation of the PPPS, found similar high satisfaction rates across different techniques when complications were avoided. Our data suggest that the choice of technique may be less important for ultimate cosmetic appearance than precise surgical execution and appropriate case selection.

Based on our experience and the complication patterns observed, we have implemented several technical modifications that may benefit other centers: For TIP repairs, we increasingly adopted the use of a preputial dartos flap as a barrier layer, even in distal cases. While this extends operative time slightly, our data suggest it may reduce fistula rates. Additionally, we emphasized wide mobilization of glans wings and avoidance of excessive tension during glansplasty.

For Mathieu procedures, we now routinely performed more extensive dissection of the vascular pedicle and utilize a two-layer glansplasty technique with absorbable sutures. These modifications reduced our rates of glans dehiscence in more recent cases beyond the study period.

Based on our comparative analysis, we propose the anatomy-driven selection algorithm that was illustrated in figure (1). This decision pathway emphasizes:

1. Initial assessment of urethral plate width and glandular groove depth.
2. MAGPI as the preferred approach for favorable anatomy.
3. TIP urethroplasty for moderate plate width with adequate glans mobilization.
4. Mathieu procedure for narrow plates or when glans mobilization is insufficient.

This structured approach aligns with the philosophy of "right procedure for the right anatomy" advocated by **Snodgrass and Bush** [23] and **Springer *et al.*** [24] in recent technical reviews.

LIMITATIONS AND STRENGTHS

Several limitations warrant consideration. The non-randomized, retrospective design introduced potential

selection bias in technique assignment. The follow-up period, while adequate for detecting most early complications, may be insufficient to capture late-onset strictures or cosmetic issues. The sample size, particularly for the Mathieu group, may be underpowered to detect statistically significant differences for some complications.

However, the strengths of our study included the relatively large, homogeneous cohort of pure coronal hypospadias repairs performed at a single tertiary center with standardized postoperative protocols. This design allowed for a more direct comparison of the techniques themselves, minimizing institutional and follow-up variability. Additionally, the incorporation of validated patient-reported outcome measures (PPPS) provides valuable insight beyond traditional complication metrics.

IMPLICATIONS FOR CLINICAL PRACTICE:

Our findings had several practical implications:

- Surgeon training should emphasize appropriate case selection based on anatomical criteria rather than surgeon preference alone.
- Patient counseling should include procedure-specific risks, particularly the 4.7% risk of meatal stenosis with TIP repair.
- Institutional protocols might consider prioritizing MAGPI in suitable cases due to its favorable risk-profile and resource efficiency.
- Future research should focus on randomized trials comparing these techniques in specific anatomical subgroups.

CONCLUSION

Our data from a tertiary center cohort demonstrated that the MAGPI, TIP, and Mathieu procedures were all highly effective for coronal hypospadias repair, each with a distinct risk-benefit profile. MAGPI was the most efficient and safest procedure in ideal anatomy. TIP urethroplasty was the versatile workhorse but required vigilance for meatal stenosis. The Mathieu procedure was a vital tool for a narrow plate but demands precision to avoid flap-related complications. When our results were viewed in the context of the broader literature, they reinforce the principle that surgeon expertise coupled with careful assessment of individual patient anatomy—rather than dogmatic adherence to a single technique—remains the cornerstone of success in hypospadias surgery.

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