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Hypospadias with its Surgical Management: A Comprehensive Review of Surgical Disease in Children

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ABSTRACT

Hypospadias is one of the most common congenital anomalies affecting the male genital tract, with an estimated prevalence of 1 in 150 to 300 male births worldwide. This comprehensive review examines the current state of knowledge regarding hypospadias epidemiology, classification systems, surgical techniques, outcomes, and complications.A systematic literature search was conducted across PubMed, Google Scholar, and relevant pediatric urology journals from 2015 to 2025. Studies were selected based on relevance to hypospadias surgical management, outcome measures, and evidence quality.The tubularized incised plate (TIP) urethroplasty remains the most widely performed technique for distal hypospadias, with fistula rates ranging from 5-10%. Two-stage repairs, particularly the Bracka technique, demonstrate superior outcomes for proximal hypospadias with success rates of approximately 90%. Overall reoperation rates reach 48.2%, with complications occurring most frequently within the first three months post-surgery. Patient satisfaction rates range from 86-92%, though long-term functional outcomes require further investigation. Modern hypospadias surgery has evolved significantly, with standardized classification systems enabling better patient selection and outcome prediction. Multidisciplinary approaches incorporating preoperative hormonal stimulation, refined surgical techniques, and structured follow-up protocols are essential for optimizing outcomes in this challenging patient population.

Keywords: *Hypospadias; urethroplasty; tubularized incised plate; Bracka repair; pediatric urology; congenital anomalies*

INTRODUCTION

Hypospadias represents one of the most prevalent congenital anomalies affecting the male external genitalia, characterized by the abnormal ventral opening of the urethral meatus, ventral curvature of the penis (chordee), and frequently associated foreskin abnormalities [1]. The condition presents significant surgical challenges, with management requiring a thorough understanding of embryology, anatomy, and the spectrum of available reconstructive techniques [2].

The historical evolution of hypospadias repair spans over a century, from the early meatal advancement procedures to modern tubularized incised plate urethroplasty and two-stage buccal mucosal graft repairs [3]. Contemporary surgical approaches aim to achieve four primary objectives: correction of ventral curvature, creation of a functional neourethra extending to the glans tip, provision of acceptable cosmetic appearance, and preservation of long-term urinary and sexual function [4].

The surgical management of hypospadias has witnessed remarkable advances in recent decades, with the development of standardized classification systems, validated outcome measures, and evidence-based surgical protocols [5]. However, despite these advances, complications remain common, with reoperation rates approaching 50% in some series [6]. This

review provides a comprehensive analysis of current evidence regarding hypospadias epidemiology, classification, surgical techniques, and outcomes to guide clinical practice and future research directions.

2. LITERATURE REVIEW

2.1 Epidemiology and Etiology

Hypospadias occurs with considerable geographic variation in prevalence. Recent population-based studies from the United States report an incidence of 71.6 per 10,000 male births between 2014 and 2018, representing approximately 1 in 125 live male births [7]. European and Asian studies demonstrate lower prevalence rates, with Chinese provincial data reporting 5.53 per 10,000 births from 2014-2023 [8]. Global estimates suggest a prevalence range of 2.1-39.1 per 10,000 births, with increasing temporal trends observed in many regions [9].

The etiology of hypospadias remains multifactorial, involving genetic, endocrine, and environmental factors. Recent systematic reviews of rodent models have identified phthalate exposure as a potential risk factor, with anti-androgenic effects disrupting normal urethral development [10]. Genetic factors account for less than 10% of cases, with mutations in genes including MAMLD1, HSF1, and AR identified in familial cases [11]. MicroRNA dysregulation has also been implicated, with miR-145 affecting embryo attachment and potentially contributing to hypospadias development [12].

Table 1: Worldwide Prevalence of Hypospadias

Region	Prevalence (per 10,000)	Study Period	Reference
United States	71.6-80.0	2014-2018	[7]
Europe (various)	20-40	2010-2020	[9]
China (provincial)	5.53	2014-2023	[8]
Global range	2.1-39.1	Various	[9]
Estimated overall	15-50	Recent	[1]

2.2 Classification Systems

Accurate classification of hypospadias severity is essential for surgical planning and outcome prediction. The traditional anatomical classification based on meatal position (glanular, coronal, distal penile, midshaft, proximal penile, and penoscrotal) has been supplemented by validated scoring systems [13].

The **Glans-Meatus-Shaft (GMS) score**, developed by Holland and colleagues, provides an objective assessment based on three components: glans-urethral plate configuration, meatal position, and shaft curvature. Scores range from 3 (mild) to 12 (severe), with higher scores predicting increased surgical complexity [14].

The **Hypospadias Objective Penile Evaluation (HOPE) score** incorporates six surgically correctable items: meatal position, meatal shape, glans shape, penile skin distribution, penile axis, and penile torsion. External validation studies demonstrate good inter-observer agreement, with Fleiss' kappa values ranging from 0.745 to 0.869 for individual components [15].

The **Hypospadias Objective Scoring Evaluation (HOSE)** score provides a comprehensive assessment of surgical outcomes, with scores ranging from 4-16. Studies report mean postoperative HOSE scores of 14.38, indicating generally favorable outcomes, though individual variation is considerable [16].

2.3 Surgical Techniques

2.3.1 Tubularized Incised Plate (TIP) Urethroplasty

The TIP repair, popularized by Snodgrass in 1994, has become the gold standard for distal and many midshaft hypospadias cases [17]. The technique involves a midline incision of the urethral plate, allowing tubularization without tension. Key technical elements include careful preservation of the urethral plate vascularity, adequate incision depth to allow plate widening, and tension-free closure over a catheter [18].

Contemporary systematic reviews and meta-analyses demonstrate the effectiveness of TIP urethroplasty. A 2024 systematic review and trial sequential analysis comparing TIP with grafted TIP (GTIP) found comparable outcomes, with GTIP showing

advantages in cases with narrow urethral plates [19]. Overall complication rates for TIP range from 7-15% for distal hypospadias, with fistula rates of 5-10% and meatal stenosis occurring in 3-15% of cases [20].

The impact of second-layer coverage on TIP outcomes has been extensively studied. A 2025 systematic review analyzing 40 studies found that single-layer coverage yielded urethrocutaneous fistula rates below 10% in most distal hypospadias cases, while the addition of spongioplasty or other vascularized layers could further reduce fistula formation [21].

2.3.2 Mathieu Meatal-Based Flip-Flap Repair

The Mathieu technique, described in 1932 and modified for modern use, remains a viable option for distal hypospadias with a well-developed urethral plate and adequate meatal tissue [22]. The procedure involves mobilization of a meatal-based flap that is rotated and incorporated into the neourethra.

Recent meta-analyses comparing Mathieu and TIP repairs demonstrate comparable short-term outcomes. A 2019 meta-analysis of distal hypospadias found no significant difference in overall complication rates between the two techniques, though Mathieu repair showed a lower risk of urethral stricture (relative risk 0.42, 95% CI 0.19-0.92) [23]. However, fistula rates are generally higher with Mathieu repair, ranging from 15-20% in some series [24].

2.3.3 MAGPI (Meatal Advancement and Glanuloplasty)

The MAGPI procedure, described by Duckett in 1981, is indicated for glanular and subcoronal hypospadias without significant chordee [25]. The technique involves advanced mobilization of the urethral meatus and glanuloplasty to create a conical glans appearance.

Large series of over 1,000 cases demonstrate the feasibility of MAGPI as an outpatient procedure without catheterization in selected cases [26]. Complication rates are generally low, with meatal stenosis occurring in up to 10% of cases and meatal regression representing the primary long-term concern [27].

2.3.4 Two-Stage Repair (Bracka Technique)

For proximal hypospadias with severe chordee or inadequate urethral plate, the two-stage buccal mucosal graft repair described by Bracka offers distinct advantages [28]. The first stage involves correction of chordee and placement of a buccal mucosa graft on the ventral penile shaft. The second stage, performed 6-12 months later, involves tubularization of the graft to create the neourethra.

Recent studies of the Bracka technique demonstrate excellent outcomes. A 2025 study of 145 cases with follow-up exceeding five years reported functional and cosmetic success in at least 90% of patients according to HOSE and Pediatric Penile Perception Score (PPPS) assessments [29]. Complication rates range from 13-57% across studies, with fistula formation being the most common complication [30].

A 2024 comparative study of modified Koyanagi versus staged Duckett repairs for proximal hypospadias found success rates of 58.82% for the Koyanagi technique versus higher success rates for staged approaches, highlighting the complexity of proximal hypospadias management [31].

2.3.5 Koyanagi Repair

The one-stage Koyanagi repair, developed for severe proximal hypospadias with severe chordee, involves mobilization of the urethral plate with parameatal-based flaps [32]. Contemporary studies report success rates of approximately 58-59% from the first intervention, with penile straightening achieved in all patients [33]. Complications include fistula (36%), meatal stenosis (13%), and partial urethroplasty failure (9%) [33].

A modified Koyanagi technique has shown improved outcomes, with one series reporting a one-time success rate of 87.6% (78/89 patients), with urethral fistula occurring in 12.6% (11/89) of cases [34].

2.4 Preoperative Hormonal Stimulation

Preoperative hormonal stimulation (PHS) with testosterone or dihydrotestosterone has gained acceptance as an adjunct to hypospadias surgery, particularly for patients with small glans size or severe hypospadias [35]. A 2024 study demonstrated that transdermal testosterone was well-tolerated and showed positive impact on the treatment of severe hypospadias, with increases in glans width and penile length observed [36].

A comprehensive systematic review and meta-analysis of preoperative testosterone hormone therapy found that hormonal stimulation can increase penile length by approximately 1.1 cm and glans diameter by 2-3 mm, potentially facilitating surgical reconstruction [37]. However, the impact on complication rates remains debated, with some studies showing reduced fistula formation and others demonstrating no significant difference [38].

2.5 Chordee Correction

Ventral curvature (chordee) is present in approximately 50% of hypospadias cases and requires correction to achieve

functional and cosmetic goals [39]. Multiple techniques exist for chordee correction, including penile plication, dorsal tunica albuginea plication, ventral tunica vaginalis flap coverage, and urethral plate transection [40].

A 2024 scoping review on chordee correction found that ventral tunica vaginalis flap coverage yields success rates of approximately 95-96% in proximal hypospadias with severe chordee [41]. Urethral plate transection has been described for severe proximal cases, though this requires staged reconstruction [42].

2.6 Complications and Their Management

2.6.1 Urethrocutaneous Fistula

Urethrocutaneous fistula represents the most common complication following hypospadias repair, with rates varying from 4-28% depending on the technique and hypospadias severity [43]. Risk factors include poor tissue quality, inadequate vascular coverage of the neourethra, and technical factors including suture line tension [44].

Fistula repair techniques have evolved, with the Perimeteral Advancement and Tension-Free Interposition with Omental flap (PATIO) repair demonstrating success rates of 81% for isolated PATIO repair compared to 44% for standard repair alone [45]. The use of autologous testicular tunica vaginalis grafts for persistent fistulas has reported success rates ranging from 85-100% [46].

Table 2: Complication Rates by Surgical Technique

Technique	Fistula Rate (%)	Stricture Rate (%)	Overall Complication (%)	Reference
TIP (distal)	5-10	2-5	7-15	[20]
TIP (proximal)	15-25	5-10	25-40	[19]
Mathieu	15-20	2-4	15-25	[23]
MAGPI	2-5	5-10	5-10	[27]
Bracka two-stage	10-15	5-10	13-35	[29,30]
Koyanagi	36	13	40+	[33]

2.6.2 Urethral Stricture

Urethral stricture following hypospadias repair represents a challenging complication, with long-term population-based studies demonstrating significant risk [47]. A 2024 study analyzing 23 years of experience found that anterior urethral stricture disease following hypospadias requires careful evaluation and often necessitates urethroplasty rather than endoscopic management [48].

Preferred approaches for hypospadias-related urethral stricture include single-stage dorsal inlay grafts or two-stage labial mucosa reconstruction, with distal strictures often requiring formal urethroplasty [49].

2.6.3 Reoperation and Salvage Repair

The cumulative reoperation rate following hypospadias repair is substantial, with a 2024 study from a tertiary center reporting an overall reoperation rate of 48.2%, with approximately half of the problems detected within the first three months after surgery [6]. The probability of reoperation-free survival was 62% at long-term follow-up [50].

Salvage surgery following failed primary repair presents significant challenges, with complication rates ranging from 5-70% depending on the extent of prior surgery and tissue quality [51]. Safe techniques for redo hypospadias include TIP, Mathieu, urethral mobilization, onlay island flap, and dorsal inlay graft urethroplasty for distal varieties. After second or third repairs, dorsal inlay graft urethroplasty is often preferred [52].

2.7 Long-Term Outcomes and Patient Satisfaction

Long-term functional and cosmetic outcomes following hypospadias repair are increasingly recognized as important measures of surgical success. A 2024 systematic review and meta-analysis of self-reported outcomes in adults with hypospadias found that while patient satisfaction with outcomes remains inadequate in some cases, quality of life is generally equivalent to those without hypospadias [53].

Sexual function outcomes are generally favorable, with approximately 12-16% of individuals experiencing significant erectile dysfunction or sexual dissatisfaction [54]. The Hypospadias Objective Penile Evaluation (HOPE) score in young adults shows an average of 8.75 (±0.97), indicating good aesthetic results [55].

Patient-reported outcome measures (PROMs) are increasingly utilized, with the HOSE, PPPS, and emerging tools such as the Hypospadias-Q and PATH questionnaires providing standardized assessment of sexual, psychological, and urinary domains [56].

3. MATERIALS AND METHODS

This review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines where applicable. A comprehensive literature search was performed using PubMed, Google Scholar, and relevant pediatric urology journals from January 2015 to February 2025.

Search Strategy: The following search terms were employed: "hypospadias," "urethroplasty," "tubularized incised plate," "Bracka repair," "hypospadias complications," "hypospadias outcomes," "hypospadias fistula," "hypospadias reoperation," "preoperative hormonal stimulation," and "hypospadias classification."

Inclusion Criteria: Studies were included if they: (1) reported on hypospadias surgical techniques or outcomes; (2) included pediatric populations (age <18 years); (3) provided quantitative outcome data; (4) were published in peer-reviewed journals; and (5) were written in English.

Exclusion Criteria: Studies were excluded if they: (1) were case reports with fewer than 10 patients; (2) lacked clear outcome definitions; (3) were review articles without original data; or (4) focused exclusively on adult populations.

Data Extraction: Relevant data were extracted regarding study design, patient demographics, hypospadias severity, surgical technique, complication rates, and long-term outcomes.

4.1 Epidemiology and Classification

The literature confirms significant geographic variation in hypospadias prevalence, with the United States reporting the highest rates (71.6-80 per 10,000) and Asian populations demonstrating lower prevalence (5.53 per 10,000 in Chinese provincial data). The Glans-Meatus-Shaft (GMS) and Hypospadias Objective Penile Evaluation (HOPE) scoring systems demonstrate good inter-observer reliability and predictive value for surgical outcomes.

4.2 Surgical Outcomes by Technique

Tubularized Incised Plate (TIP): The most widely performed technique for distal hypospadias, with fistula rates of 5-10% and overall complication rates of 7-15%. For proximal hypospadias, complication rates increase to 25-40%.

Two-Stage Bracka Repair: Demonstrates superior outcomes for proximal hypospadias, with functional and cosmetic success in at least 90% of patients with follow-up exceeding five years. Complication rates range from 13-35%.

Koyanagi Repair: Success rates of approximately 58-59% from the first intervention, with higher complication rates (fistula 36%, meatal stenosis 13%) limiting its application in some centers.

4.3 Complications

The overall reoperation rate following hypospadias repair is 48.2%, with complications occurring most frequently within the first three months. Fistula rates vary significantly by technique, from 2-5% (MAGPI) to 36% (Koyanagi). Urethral stricture and meatal stenosis represent important long-term complications requiring careful follow-up.

4.4 Patient Satisfaction

Patient-reported outcomes demonstrate generally favorable quality of life, with satisfaction rates of 86-92%. However, approximately 12-16% of individuals experience significant sexual dysfunction or cosmetic dissatisfaction, highlighting the need for improved patient selection and counseling.

This comprehensive review demonstrates that hypospadias surgery has evolved significantly over the past two decades, with the development of standardized classification systems, validated outcome measures, and evidence-based surgical protocols. Several key findings warrant discussion.

First, the **tubularized incised plate (TIP) urethroplasty** remains the most widely performed technique for distal and many midshaft hypospadias cases. The technique's popularity stems from its relative technical simplicity, applicability to a wide range of hypospadias severities, and generally favorable outcomes. However, the substantial complication rates, particularly for proximal cases, underscore the importance of careful patient selection and technical refinement. The impact of second-

layer coverage on fistula prevention remains an area of active investigation, with emerging evidence supporting the addition of vascularized tissue layers.

Second, **two-stage repairs**, particularly the Bracka technique using buccal mucosa grafts, have established themselves as the preferred approach for proximal hypospadias with severe chordee or inadequate urethral plate. The 90% success rate reported in contemporary series, with long-term follow-up exceeding five years, demonstrates the durability of this approach. However, the extended treatment duration and need for two separate procedures represent significant drawbacks that must be discussed with families during the informed consent process.

Third, **preoperative hormonal stimulation** has emerged as a valuable adjunct, particularly for patients with small glans size. The demonstrated increases in penile length (approximately 1.1 cm) and glans diameter may facilitate surgical reconstruction and potentially reduce complication rates. However, the optimal timing, dosing, and duration of hormonal stimulation require further investigation through well-designed randomized controlled trials.

Fourth, the **high reoperation rate** (48.2%) following hypospadias repair represents a significant concern for healthcare systems and patients alike. The concentration of complications in the first three months post-surgery suggests opportunities for improved early identification and intervention. Standardized follow-up protocols, including early assessment at 2-4 weeks and structured evaluation at 3 months, may facilitate prompt identification of developing complications.

Fifth, **long-term patient-reported outcomes** demonstrate generally favorable quality of life but highlight ongoing concerns regarding cosmetic appearance and sexual function in a subset of patients. The development and validation of disease-specific patient-reported outcome measures (PROMs) represents an important advance, enabling more comprehensive assessment of surgical success from the patient perspective.

Finally, **emerging technologies** including tissue engineering, stem cell therapies, and 3D bioprinting hold promise for future hypospadias reconstruction. While currently experimental, these approaches may eventually provide solutions for the most complex cases involving significant tissue deficiency or multiple prior failed repairs.

LIMITATIONS

This review is subject to several limitations. First, the heterogeneity of study designs, outcome definitions, and follow-up durations across the included studies precludes formal meta-analysis for many outcomes. Second, publication bias may favor studies reporting favorable outcomes, potentially underestimating complication rates. Third, the rapid evolution of surgical techniques means that long-term outcome data for newer approaches remain limited.

FUTURE DIRECTIONS

Several areas warrant priority for future research:

Randomized controlled trials comparing TIP with grafted TIP and two-stage repairs for proximal hypospadias, with standardized outcome measures and long-term follow-up.

Prospective registries to capture real-world outcomes across diverse clinical settings, facilitating identification of best practices and quality improvement initiatives.

Optimization of preoperative hormonal stimulation protocols, including timing, dosing, and patient selection criteria.

Development and validation of patient-reported outcome measures specifically designed for pediatric and adolescent populations with hypospadias.

Investigation of tissue engineering approaches for complex hypospadias reconstruction, including preclinical and early clinical studies.

5. CONCLUSION

Hypospadias represents one of the most common congenital anomalies requiring surgical correction, with significant implications for patient quality of life and healthcare resource utilization. Modern surgical management requires a thorough understanding of embryology, classification systems, and the spectrum of available reconstructive techniques. The tubularized incised plate urethroplasty remains the gold standard for distal hypospadias, while two-stage buccal mucosal graft repairs demonstrate superior outcomes for proximal cases. Despite advances in surgical technique, complications remain common, with reoperation rates approaching 50%. Multidisciplinary approaches incorporating preoperative hormonal stimulation, refined surgical techniques, structured follow-up protocols, and patient-reported outcome assessment are essential for optimizing outcomes in this challenging patient population. Future research should focus on randomized comparisons of surgical techniques, optimization of preoperative protocols, and development of tissue engineering approaches for the most complex cases

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