

Outcome of Mathieu Meatal-based Flip Flap Technique for Distal Hypospadias: A Retrospective Cohort Study from a Single Tertiary Care Centre, Bhubaneswar, India

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ABSTRACT

Introduction: Several surgical procedures are used for the correction of distal hypospadias. Institutional protocols vary regarding the ideal procedure. The goal of modern hypospadias surgery is to achieve a functionally and cosmetically normal penis. Mathieu described a technique that utilises the perimeatal skin proximally to create a flap for the repair of distal hypospadias. It is a time-tested method with minimal complications.

Aim: To highlight the incidence of complications and the surgical outcomes of distal hypospadias using Mathieu's meatal-based flip flap technique.

Materials and Methods: A retrospective cohort study was conducted in the Department of Paediatric Surgery at a tertiary care hospital at the Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha, India on 55 children aged 2-16 years from January 2021 to August 2024. The study population included children with distal penile hypospadias with or without mild skin-level chordee. Patients underwent surgery using the Mathieu meatal-based flip flap technique. The length of the skin flap was determined by the distance from the meatus to the glans tip, after which a ventral meatal-based skin flap was

incised. The maximum flap length used was 2 cm. The proximal flap was dissected from the underlying urethra, flipped distally, and anastomosed to the distal urethral plate with running subcuticular sutures of 6-0 Polydioxanone. The urethra was stented using an infant feeding tube for eight days, and the dressing with the catheter was removed on postoperative day 9. Postoperative complications were analysed using descriptive statistics of frequency and percentage.

Results: The mean age at the time of urethroplasty was 6.6±3.2 years. Out of 55 patients, 1 (1.8%) developed meatal stenosis, 1 (1.88%) developed a urethrocutaneous fistula, 2 (3.6%) experienced meatal regression, and 3 (5.4%) had glans dehiscence. All patients (and their caregivers) were satisfied with the cosmetic and functional outcomes postoperatively during follow-up.

Conclusion: In present study, Mathieu's meatal-based flip flap urethroplasty resulted in successful outcomes with low complications. Thus, Mathieu's meatal-based flip flap urethroplasty remains a time-tested and effective method for select cases of distal hypospadias.

Keywords: Meatal stenosis, Perimeatal, Urethrocutaneous

INTRODUCTION

Hypospadias is a congenital anomaly characterised by an abnormally placed urethral meatus on the ventral aspect of the phallus, commonly associated with corporal disproportion [1-3]. The surgical management of hypospadias varies according to institutional protocols and depends on the location of the meatus as well as associated anatomical findings, such as the size of the urethral plate, depth of the glanular groove, glans diameter, and so forth. The primary objective is to achieve a functional and cosmetically acceptable penis [4-6]. Total 60 to 70% of all hypospadias cases are distal lesions, with multiple surgical techniques in use for their repair [7,8]. While the field of hypospadias surgery has undergone significant changes, there is no specific technique considered ideal. Different techniques have been adapted to address the expected complications while ensuring functional and cosmetic requirements are met. Tubularised Incised Plate Urethroplasty (TIPS, or the Snodgrass technique) remains one of the most commonly used methods for the repair of distal hypospadias, closely followed by procedures such as Meatal Advancements Granuloplasty Incorporated (MAGPI) and modified Mathieu's urethroplasty [1,2,4-10].

Mathieu originally described his single-stage repair for distal hypospadias in 1932 [1,2,6-8]. Multiple modifications of this

procedure have been developed over the years. The Mathieu technique involves the use of a perimeatal-based flap for the construction of a neourethra with the utilisation of the native urethral plate. It is a versatile method that has stood the test of time for the management of distal hypospadias. With the advent of techniques such as TIPS urethroplasty, the complications feared with Mathieu's urethroplasty have been mitigated, with only a few surgical centers still following the original technique with precision.

The primary drawback of the original Mathieu's urethroplasty is the horizontally oriented and rounded neomeatus, referred to as the "fish mouth meatus," which can give an unsightly cosmetic appearance in some patients [8-10]. Other frequently encountered complications include meatal regression and meatal stenosis, paving the way for modifications of the original technique, such as Multi-camera Augmented Visual Internal SLAM (MAVIS) and Slit-like Adjusted Mathieu (SLAM) techniques [2,8-10].

Several studies describe modifications of the traditional Mathieu's meatal flip-flap urethroplasty and compare these with other methods of distal hypospadias repair concerning complications and outcomes [7-10]. However, there is very limited literature [6,7,9,10] in recent years analysing the outcomes of the traditional method. The rationale for performing the original Mathieu's meatal-based flip-flap urethroplasty is based on the notion that when performed

precisely, while ensuring crucial steps are followed, the outcome can be as successful as with other new methods, with a lesser or equal incidence of postoperative complications.

The identified concerns during the surgical procedure, such as flap length, vascularity, and proper glans wings mobilisation, must be adhered to in order to ensure good functionality. With a standardised protocol, the original method continues to yield good outcomes. In comparison with techniques such as TIPS urethroplasty and modifications of Mathieu's urethroplasty (such as MAVIS and SLAM) in other studies [1,2,6-8,10,11], postoperative outcomes such as meatal stenosis, meatal regression, urethrocutaneous fistula, glans dehiscence, and flap necrosis have a lesser or comparable incidence, provided that the surgical steps are executed with intention.

Therefore, the aim of present study was to identify and highlight the incidence of complications and surgical outcomes in patients who have undergone Mathieu's repair without any modifications, while underscoring the critical steps of the procedure and demonstrating the advantages of continuing to utilise the original method.

MATERIALS AND METHODS

This was a retrospective cohort study of all cases of distal hypospadias that underwent Mathieu's meatal-based flip-flap repair between January 2021 and August 2024 in the Department of Paediatric Surgery at the Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha, India. The time period for data analysis and interpretation was from January 2023 to November 2024. Ethical Committee clearance (IEC) was obtained for the study (Ref no. KIIT/KIMS/IEC/1843/2024).

Inclusion criteria:

- All children aged 2 to 16 years with distal hypospadias and minimal or no chordee who underwent the Mathieu meatal-based flip-flap method.

Exclusion criteria:

- Patients with proximal or mid-penile hypospadias where management involved staged urethroplasty.
- Patients with severe chordee or chordee that is non correctable by degloving.
- Patients with prior failed urethroplasty for distal hypospadias.
- Patients with a thin and hypoplastic urethra, which is not ideal for planning the Mathieu meatal-based flip-flap method.

Sample size calculation: During the review period, 55 children aged 2 to 16 years underwent the Mathieu meatal-based flip-flap method for the management of distal hypospadias, and all cases satisfying the inclusion and exclusion criteria were included in the study.

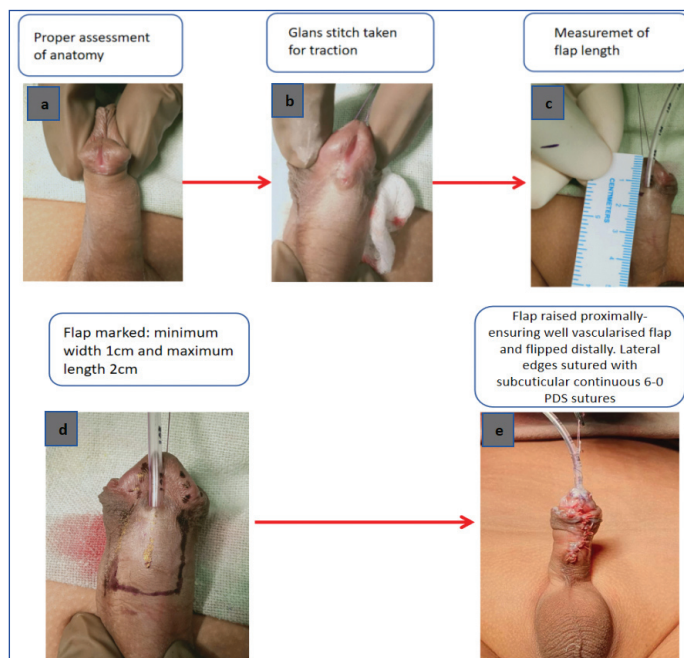
Study Procedure

The case notes were retrieved from the medical records department, along with photographs of the surgical procedure, with due consent from the patient's attendant. Informed consent was obtained from the parents of each patient, explaining the surgery and the inclusion in the study, while ensuring that no personal patient details would be revealed. Patient confidentiality was maintained by securing locked data, accessible only to the surgical and investigative team, with prior permission granted by the Medical Superintendent of the hospital for the study. The required information was extracted accordingly, and the data was entered into a proforma. Postoperative complications, including immediate and long-term follow-ups such as meatal stenosis, urethrocutaneous fistula, flap necrosis, meatal regression, and glans dehiscence, were analysed using descriptive statistics of frequency and percentage. A follow-up period ranging from six months (for the most recently operated patient) to two years was maintained postoperatively, during which a subjective assessment of functional and cosmetic outcomes (of the neomeatus) was conducted.

Postoperatively, functional and cosmetic outcomes were assessed subjectively by analysing:

- The ability to stand and micturate.
- Micturition in a single, good stream.
- No abnormal ventral curvature noted on erection of the penis.
- Satisfaction with the appearance of the urethral meatus.

Surgical procedure followed [1-3,6-8]: The surgical procedure was standardised by all surgeons in the unit/Department, ensuring uniformity, with equal skill levels maintained among the surgeons for the purpose of the surgery and subsequent study. The first step was the assessment of anatomical characteristics and the measurement of flap length and width. The length of the skin flap was determined by the distance from the native hypospadiac meatus to the glans tip, with an equal distance marked from the hypospadiac meatus proximally over the ventral skin of the shaft of the penis. The glans width was measured in each patient. Children with mild chordee (skin-level chordee) had to undergo complete penile degloving for correction. After marking the flap and ensuring a minimum width of 1 cm, the ventral meatal-based skin flap was incised. The maximum flap length used was 2 cm. The proximal flap was dissected from the underlying urethra, ensuring well-vascularised subcutaneous tissue with adequate width. The native urethra was catheterised with an 8Fr infant feeding tube. The lateral edges of the flap were marked with sutures, and thereafter, the flap was flipped distally and anastomosed to the native urethral plate distally with running subcuticular and inverting 6-0 Polydioxanone sutures. Excess prepuceal skin (prepuceal hood) was split midline dorsally (Byar's flap) until the coronal sulcus and was ventrally rotated to cover the neourethra. The remaining phallus skin was sutured circumcoronally to the mucosa around the coronal sulcus. The skin was closed in the midline, ensuring good cosmesis along the midline raphe [Table/Fig-1a-e]. A urethral stent cum catheter using an 8 Fr infant feeding tube was kept in place for eight days, after which the dressing and catheter were removed on postoperative day 9.



[Table/Fig-1a-e]: Steps of Mathieu meatal based flip flap procedure.

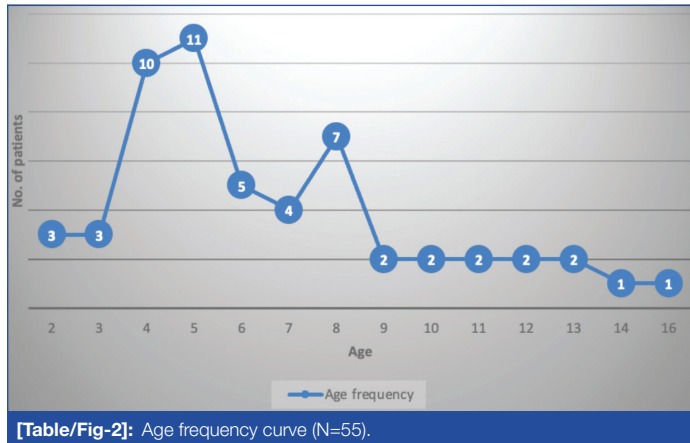
STATISTICAL ANALYSIS

The descriptive statistical analysis was conducted using MS Excel. The data is presented in the form of frequency and percentage for categorical data, and as mean/average for continuous data.

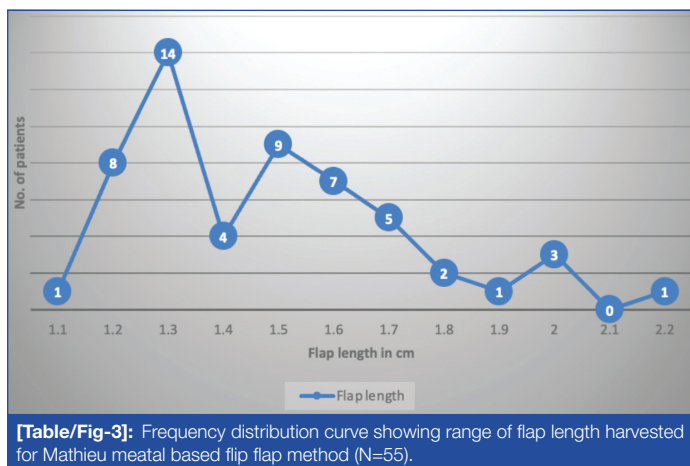
RESULTS

A total of 55 patients were included in present retrospective analysis. The age distribution of the children ranged from 2 to 16 years. The mean age at the time of urethroplasty was 6.6 ± 3.2 years

[Table/Fig-2]. The most common location of the native urethral meatus was at the subcoronal site, with 33 out of 55 patients (60%), while other locations included the coronal sulcus and distal penile (15 and 7 patients, respectively). Twenty-two (40%) patients had mild/skin-level chordee (coronal-4; distal-4; subcoronal-14). The maximum flap length harvested was 2 cm, with a minimum width of all flaps maintained at least 1 cm. The mean flap length harvested in the study population was 1.48±0.24 cm [Table/Fig-3]. The glans width in all patients was more than 10 mm. The urethroplasty dressing was opened on postoperative day 9, along with the removal of the urethral catheter (infant feeding tube).

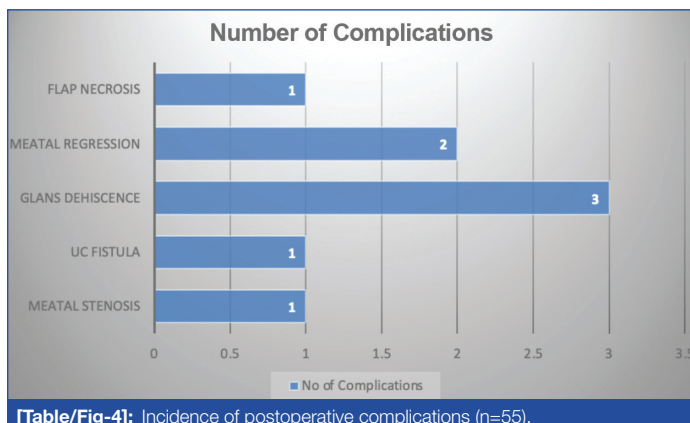


[Table/Fig-2]: Age frequency curve (N=55).

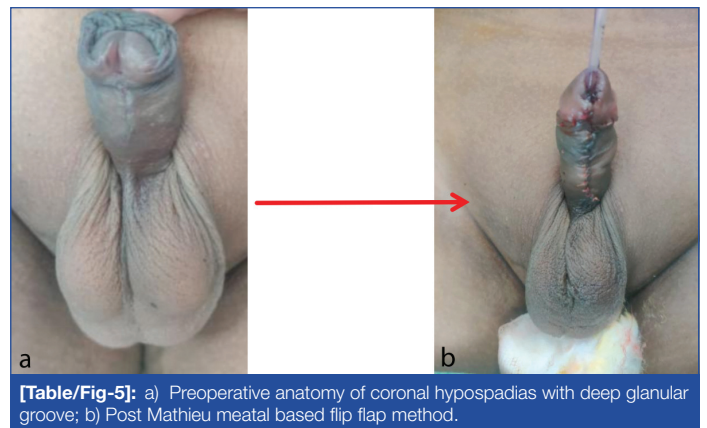


[Table/Fig-3]: Frequency distribution curve showing range of flap length harvested for Mathieu meatal based flip flap method (N=55).

Meatal stenosis was identified in 1 out of 55 (1.8%) patients (coronal hypospadias) [Table/Fig-4]. A urethrocutaneous fistula was noted in 1 out of 55 (1.8%) patients (distal hypospadias) [Table/Fig-5]. This was identified five days post-discharge, which is 14 days postoperatively. The child presented with a good stream of urine from the neomeatus. The child was re-catheterised with a Foley catheter for a period of two weeks for spontaneous healing and was thereafter removed. The child still had a persistent urethrocutaneous fistula and underwent successful repair after six months.



[Table/Fig-4]: Incidence of postoperative complications (n=55).



[Table/Fig-5]: a) Preoperative anatomy of coronal hypospadias with deep glanular groove; b) Post Mathieu meatal based flip flap method.

One out of 55 (1.8%) patients developed flap necrosis, wherein the flap length harvested was 2 cm. Two out of 55 (3.6%) patients developed meatal regression, and three out of 55 (5.4%) patients developed glans dehiscence [Table/Fig-5]. Two out of three patients who had glans dehiscence had a glans width of 11 mm.

No specific subjective scoring system was available in the literature; rather, the above factors were discussed with parents using videos and direct examination. None of the patients had any functional abnormalities. All patients and attendants were satisfied with the cosmesis of the neomeatus [Table/Fig-4,6,7]. All patients, except those who developed postoperative complications, were able to achieve a comfortable voiding schedule in a standing position.



[Table/Fig-6]: a) Preoperative anatomy showing subcoronal meatus and shallow glanular groove; b) Post Mathieu meatal based flip flap procedure.



[Table/Fig-7]: a) 1 year follow up- postoperative appearance of phallus and meatus; b) 2 years follow up- postoperative appearance of phallus and meatus.

DISCUSSION

The present study indicates successful outcomes when using the original Mathieu's meatal-based flip-flap urethroplasty. As demonstrated, the incidence of complications such as meatal stenosis, urethrocutaneous fistula, meatal regression, flap necrosis, and glans dehiscence was lower or comparable to those reported in the literature [1-3, 6-9]. Although new and innovative methods have been developed, along with modifications of original procedures to address complications and improve surgical outcomes, there is no single definitive surgical management defined for hypospadias. Institutional protocols and surgeons' preferences differ based on successful outcomes, and therefore, different methods are followed. In present Institution, the experience with the original Mathieu's flip-flap urethroplasty has been successful, corroborating the outcomes of this study.

When comparing present findings with other studies highlighting Mathieu's urethroplasty and its modifications, author can identify the advantages of the traditional method, especially when ensuring that surgical steps are followed critically.

Qayyum A et al., in 2010, conducted a study on the surgical outcomes of Mathieu's technique in the repair of distal hypospadias. They noted a urethrocutaneous fistula in 14% of their study population (70 patients), meatal stenosis in 7.1%, and total tube disruption in 5.7% [6]. In the original Mathieu's technique, the incidence of urethrocutaneous fistula ranges between 10-30%, and that of meatal stenosis is between 7-30% [1-3]. The present study had comparatively better results, with the incidence of meatal stenosis and urethrocutaneous fistula being far lower than reported in the literature. This could be attributed to present careful selection of patients on whom to perform the Mathieu's procedure, thereby reducing the incidence of commonly seen complications.

One of the major complications in Mathieu's technique is meatal regression. The incidence of this complication in present study was only 3.6%, which is lower in comparison to other studies, where the incidence ranged from 6% to 15% [3-7]. This could be attributable to the maturation of the tip of the neourethra to the glans, thereby preventing its regression.

The incidence of glans dehiscence in present study was 5.4% (3/55 patients), which is considerably lower when compared with other studies [3-5,7,8]. Two out of three patients with glans dehiscence had a glans width of 11 mm. This could have contributed to the development of glans dehiscence due to a possible tight glansplasty. The author advocates for adequate mobilisation of the glans wings, proper measurement of glans width, and careful patient selection criteria to prevent this complication.

Intraoperative assessment and measurement of flap length are crucial, as longer flaps can impair distal blood supply, thereby contributing to flap necrosis. According to a study by Uygur MC et al., as the length of the flap increases, the possibility of blood supply insufficiency also increases; therefore, longer flaps are associated with a higher incidence of fistula formation [7]. Similarly, UI Haq A et al., identified that the success of the Mathieu meatal-based flip flap technique lies in the careful preservation of the vascularisation of the flap and avoidance of overlapping suture lines to produce a watertight closure [8]. In present study patients, the maximum flap length utilised was 2 cm, with a minimum width of 1 cm, so as to ensure a wide and well-vascularised neourethra. The low incidence of flap necrosis (1/55) in present study can possibly be attributed to this crucial step.

Most surgeons advocate the use of a cover or second layer over the tubularised neourethra, utilising either a tunica vaginalis flap or a ventral dartos flap [5,6,9,10]. This is done with the aim of reducing the incidence of fistula formation. In the patients of present study, this approach was not followed, as the second layer creates a bulky cover over the neourethra, making glans wings approximation or glanuloplasty

difficult and increasing the chance of glans dehiscence. Even without the utilisation of a second layer over the neourethra, the incidence of urethrocutaneous fistula in this study was 1.8%, which is much lower than what is documented in the literature (10-30%) [1,3-6].

The incidence of meatal stenosis in present study was 1.8% (1/55 patients). This could be attributed to a narrow urethral plate. Incision of the urethral plate is avoided in present Institute to prevent a higher incidence of meatal stenosis. Despite the development of meatal stenosis, the patient was managed comfortably with dilatation on an outpatient basis using an infant feeding tube. Although Khalil M et al., recommend considering a modification of the original Mathieu technique that includes incision of the urethral plate to reduce meatal stenosis, author do not follow this approach at present center [4]. Present surgical outcomes remain favourable, and the meatal stenosis identified was resolved with dilatation in the Outpatient Department (OPD), thereby reinforcing present preference for the original technique.

A review single-centre study conducted by Minevich E et al., of 202 patients who underwent the original Mathieu meatal-based flip-flap method showed that urethrocutaneous fistulas were noted in only 1% of patients, and meatal stenosis with retraction occurred in 0.5% of patients [9]. This outcome can be corroborated in present study, even with a smaller patient population, which demonstrated a significantly low incidence of postoperative complications.

Although not all present patients achieved the classical slit-like meatus, all parents were satisfied with the cosmetic and functional outcomes, which were assessed subjectively during follow-up. This has been corroborated in studies by Qayyum A et al., Uygur MC et al., and Salako AA et al., wherein the postoperative cosmetic outcomes were satisfactory according to patient and parent records when the original Mathieu meatal-based flip-flap procedure was used [6,7,10].

Multiple modifications of the original Mathieu technique have come into vogue to combat the cosmetic appearance of the fish-mouth neourethral meatus. Techniques such as MAVIS (Mathieu and V incision sutured), described by Boddy SA and Samuel M, and the SLAM, described by Hadidi AT, have been introduced [11,12]. Modified methods have been developed to enhance the outcomes of Mathieu's urethroplasty, utilising modifications pertaining to critical steps to ensure success, such as Hybrid Mathieu's urethroplasty, which uses the urethral plate incision to improve outcomes in patients with small glans [13]. With the advent of these modifications, there are also multiple studies that highlight the advantages of Mathieu's urethroplasty in salvage and redo procedures, demonstrating successful outcomes and a lower incidence of postoperative complications [14,15]. For a better comparison of the original Mathieu procedure with its modifications, more prospective or randomised controlled trials would be required to analyse the outcomes.

In summary, over the years, the Mathieu meatal flip-flap procedure has stood the test of time, and when performed with the right technique and surgical expertise, it can yield excellent outcomes. It is essential to reiterate the importance of institutional protocols and the surgeon's comfort and experience in achieving optimal functional and cosmetic results.

Limitation(s)

Since, the study is retrospective in nature, there was difficulty in conducting a thorough data analysis. The limited sample size restricts the comprehensive analysis of complications and outcomes, thereby limiting comparisons with other studies. There is a need for further prospective randomised controlled trials to compare the outcomes between the original Mathieu meatal-based flip flap method and other modifications to better assess the outcomes.

CONCLUSION(S)

From present study, it was concluded that the outcome of the original Mathieu meatal-based flip-flap technique for distal hypospadias was

favourable in this center. The incidence of postoperative surgical outcomes, such as meatal stenosis, urethrocutaneous fistula, meatal regression, and glans dehiscence, was less than or comparable to the literature. Although not all patients achieved the classical slit-like meatus, the overall functional and cosmetic outcomes were favourable, allowing the child to lead a normal life.

Author can conclude that it is essential to identify patients with favourable anatomical characteristics prior to proceeding with the Mathieu meatal-based flip-flap procedure. Proper measurement of flap length is important to ensure a well-vascularised flap and avoid flap necrosis; otherwise, it is safer to consider other surgical procedures for distal hypospadias. Modifications of the traditional Mathieu procedure can be considered, but in present centre, this would require further evaluation and randomised controlled trials to properly compare the incidence of complications and assess surgical outcomes. Further prospective studies and randomised controlled trials are needed to assess the outcomes when compared with modifications of Mathieu's urethroplasty.

Acknowledgement

The author takes this opportunity to acknowledge the support of study procedure for aiding in collection of data and ensuring safety of the data. Author acknowledge the entire team of Paediatric Surgery, the Operation Theatre (OT) staff and technicians for the success of the surgeries and their support in present publication endeavours. Author acknowledge present patients and their guardians for their support and contribution.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Oct 03, 2024
- Manual Googling: Jan 03, 2025
- iThenticate Software: Jan 14, 2025 (10%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Oct 01, 2024**

Date of Peer Review: **Dec 17, 2024**

Date of Acceptance: **Jan 16, 2025**

Date of Publishing: **Mar 01, 2025**