

Prospective Comparison of Direct Visual Internal Urethrotomy and Non-transecting Urethroplasty for Short Bulbar Urethral Strictures: One-year Functional and Patient-reported Outcomes

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Research Article

Keywords: Urethral stricture, Bulbar urethral stricture, DVIU, Urethroplasty, Non-transecting urethroplasty, PROM

Posted Date: September 29th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11059660/v1>

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Additional Declarations: No competing interests reported.

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Abstract:***Purpose:***

To compare one-year objective urinary outcomes, patient-reported outcomes, sexual function, recurrence, and patient satisfaction following direct visual internal urethrotomy (DVIU) and non-transecting urethroplasty for short bulbar urethral strictures over 1 year using objective uroflowmetry parameters and validated patient-reported outcome measures.

Methods: A prospective observational non-randomized cohort study was conducted on patients with bulbar urethral strictures ≤ 2 cm in accordance with STROBE statement. Patients were allocated to three groups: DVIU, Non-Transecting Anastomosis (NTA), and Augmented NTA (ANTA). Primary outcome measures included the objective assessment with uroflowmetry and subjective assessment with USS-PROM, IPSS, CLSS, SHIM and MSHQ questionnaires at 3, 6, and 12 months. Outcomes were compared using Friedman and Kruskal Wallis tests.

Results:

Seventy-nine patients were enrolled: 31 underwent Direct Visual Internal Urethrotomy (DVIU), 21 Heineke-Mikulicz /Non-transecting Anastomotic Bulbar Urethroplasty (HM/NTABU), and 27 Augmented Non-Transected Anastomotic Bulbar Urethroplasty (ANTABU). One year objective urinary outcomes favoured urethroplasty. *Urethroplasty groups demonstrated significantly better Q_{max} , USS-PROM, IPSS, and CLSS scores than DVIU ($p < 0.001$), with higher patient satisfaction rates in HM/NTABU (90.48%) and ANTABU (92.59%) compared to DVIU (70.97%) ($p = 0.05$). Quality-of-life outcomes (EQ-5D) were highest in the ANTABU group ($p = 0.038$), whereas DVIU showed better preservation of erectile and ejaculatory function scores ($p = 0.003$ and $p < 0.001$, respectively). Post-void dribbling occurred transiently after urethroplasty and resolved by 6 months. Recurrence at 1 year was highest after DVIU (25%) compared with one recurrence after HM/NTABU and none after ANTABU ($p < 0.001$).*

Conclusions:

Non-transecting urethroplasty techniques demonstrate significantly better 1-year outcomes than DVIU for short-segment, non-traumatic bulbar urethral strictures.

Keywords: Urethral stricture, Bulbar urethral stricture, DVIU, Urethroplasty, Non-transecting urethroplasty, PROM

Total word counts -4825

Introduction:

Approximately 50% of patients diagnosed with anterior urethral strictures present with lesions localized in the bulbar urethra (1). These strictures represent a significant clinical challenge as they often lead to progressive lower

urinary tract symptoms (LUTS) and can severely impact a patient's quality of life. Management options for these patients range from endoscopic Direct Visual Internal Urethrotomy (DVIU) to various open urethroplasty techniques, with the choice of intervention often depending on the specific location and length of the bulbar urethral strictures

While *DVIU* remains a common traditional preference for managing short bulbar strictures, its clinical utility is severely hampered by poor long-term success rates, which often drop to **20–30%** over time. This necessitates a shift toward more durable solutions like *Excision and Primary Anastomotic (EPA) urethroplasty*, which boasts success rates exceeding **90%**; however, EPA is frequently limited by significant morbidity, including a notable incidence of *de novo sexual dysfunction* in up to **14%** of cases, alongside risks of chordee and glans ischemia (2). These limitations have prompted increasing interest in other reconstructive techniques. In contrast, *Non transecting* techniques offer a logical evolution in management by avoiding complete urethral transection and preserving the critical dual blood supply to the corpus spongiosum. These NTA approaches—including *HM*, *NTABU*, and *ANTABU*—aim to preserve urethral vascularity while maintaining high success rates, with reported success rates of over **95%** while simultaneously reducing the risk of sexual dysfunction to approximately **4%**. By transitioning to NTA as a primary intervention, surgeons can achieve durable patency without the technical complications or functional deficits associated with more invasive transecting procedures (3).

There is a lack of extensive evidence directly comparing DVIU, a widely practiced technique, to NTA techniques in terms of both objective outcomes and subjective assessments using validated tools such as the USS PROM questionnaire. Therefore, prospective comparative data evaluating objective urinary outcomes and validated PROMs after DVIU and contemporary non-transecting urethroplasty remain limited. This study compared 1-year objective and subjective outcomes, utilizing uroflowmetry and validated questionnaires (USS-PROM, IPSS, CLSS, SHIM, and MSHQ), between DVIU and non-transecting urethroplasty for short-segment, non-traumatic bulbar urethral strictures.

Methods:

A prospective observational non-randomized cohort study was conducted in a University teaching Hospital between June 2021 and May 2023, enrolling patients diagnosed with non-traumatic bulbar urethral strictures. This prospective study was conducted in accordance with the Declaration of Helsinki, received Institutional Ethics Committee approval, and obtained informed consent from all participants. The protocol was registered with the Clinical Trial Registry of India (CTRI/2022/05/042436) and adheres to the STROBE statement guidelines. The study was designed as a prospective observational cohort rather than a randomized trial because procedural selection depended on patient counselling, surgeon expertise, and intraoperative stricture characteristics that determined suitability for DVIU versus non-transecting urethroplasty techniques.

The inclusion criteria consisted of patients aged >18 years with bulbar urethral strictures measuring ≤ 2 cm in lengths enrolled using a prospective consecutive sampling method. The exclusion criteria included a previous history of urethral surgery, traumatic urethral strictures, active urinary tract infections, malignant urethral strictures, and refusal to provide written informed consent. The sample size was calculated using PASS software based on the primary outcome of recurrence-free success at 1 year. Assuming a clinically significant difference in success rates between DVIU and non-transecting urethroplasty techniques derived from previously published literature (approximately 70% success for DVIU versus 90–95% for urethroplasty), with an alpha error of 0.05 (95 %confidence interval) and power of 80%, the minimum required sample size was estimated to be 60 patients. Statistical significance was defined as a two-sided $p < 0.05$. Normality testing. Shapiro-Wilk test, Median where appropriate were used.

Preoperative evaluation consisted of a dual objective and subjective framework. Objective urinary function was quantified via *uroflowmetry*, focusing on primary flow parameters such as Qmax. Subjective burden was rigorously assessed using the *Urethral Stricture Surgery Patient-Reported Outcome Measure (USS-PROM)*, a validated tool specifically designed to evaluate lower urinary tract symptoms (LUTS) and health-related quality of life (HRQoL) in this population. The USS-PROM assessment integrated four distinct domains: *LUTS Additive Score, Peeling's Voiding Picture Score, LUTS-Specific Quality of Life, Global HRQoL(4)*

Other validated tools used for LUTS assessment included IPSS and CLSS, which Sexual Function was assessed using Sexual Health Inventory for Men (SHIM) for erectile dysfunction, Male Sexual Health Questionnaire (MSHQ) for ejaculatory dysfunction. Management was based on Imaging by Retrograde Urethrogram (RGU), Voiding Cystourethrogram (VCUG) and Cystoscopy by Intraoperative Urethroscopy in all patients.

All procedures in the study population were performed by a single surgeon. The choice of procedure, whether DVIU or NTA (Non Transecting Anastomotic Urethroplasty), was determined preoperatively through a discussion with the patient. However, the specific NTA technique to be performed was decided intraoperatively based on the length of the stricture. Among patients selected for NTA, strictures ≤ 5 mm were managed with Heineke-Mikulicz stricturoplasty (HM), those up to 1 cm underwent NTABU (Non Transecting Anastomotic Bulbar Urethroplasty), and strictures measuring 1–2 cm were treated with ANTABU (Augmented Non Transecting Anastomotic Bulbar

Urethroplasty) (figure I). Heineke-Mikulicz stricturoplasty and NTABU were grouped together for analysis in the remainder of the study, as both represent non-transecting urethroplasty techniques without augmentation, whereas ANTABU involved augmentation with a graft.

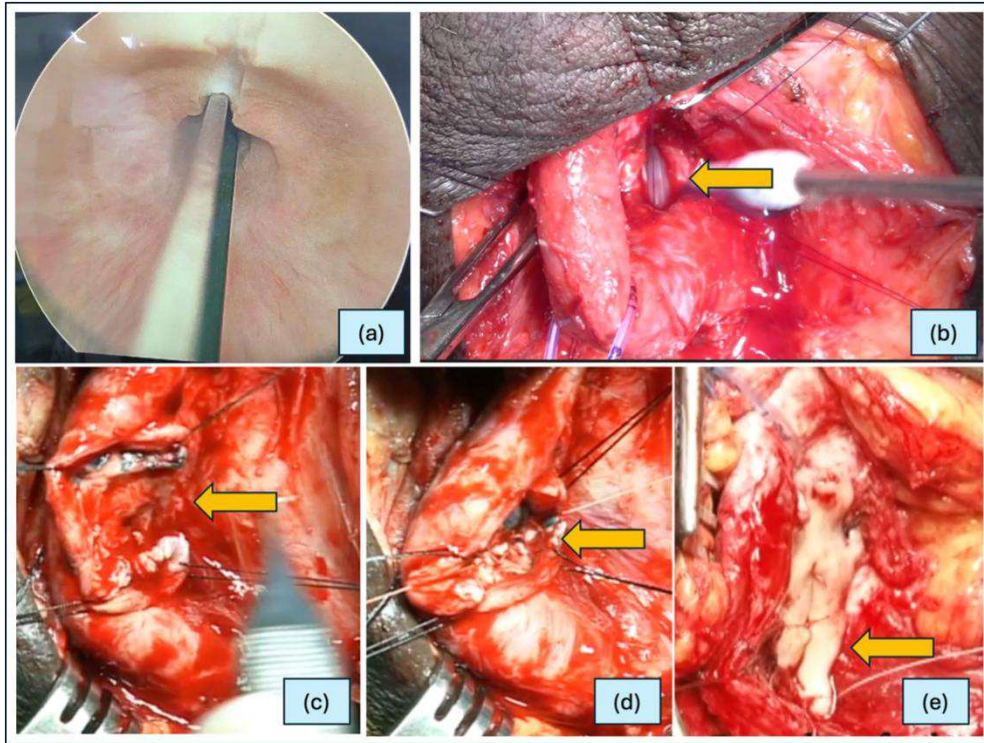


Figure I (original image): (a) DVIU with Sachse Knife at 12'o'clock position; (b) Dorsal urethrotomy (arrow) before being closed horizontally in HM Stricturoplasty; (c) Partial thickness excision of scar (arrow) in NTABU; (d) Mucosa to Mucosa anastomosis (arrow) after partial thickness excision of scar in NTABU; (e) Placement of a dorsal onlay Buccal mucosa graft (arrow) in ANTABU.

DVIU:

Performed at the 12 o'clock position using a 21Fr Karl Storz Sachse optical urethrotome with a straight cold knife, followed by 18Fr Foley catheterization for 2–3 days.

HM stricturoplasty:

Involved performing a vertical dorsal urethrotomy, followed by horizontal closure of the urethra without excising the scarred segment.

NTABU:

Executed via a dorsal urethrotomy, partial thickness excision of the scar, and a mucosa-to-mucosa anastomosis, followed by horizontal closure of the vertical dorsal urethrotomy.

Augmented NTABU (ANTABU)

Involves dorsal urethrotomy and partial-thickness scar excision followed by dorsal onlay buccal mucosa graft (BMG) augmentation.

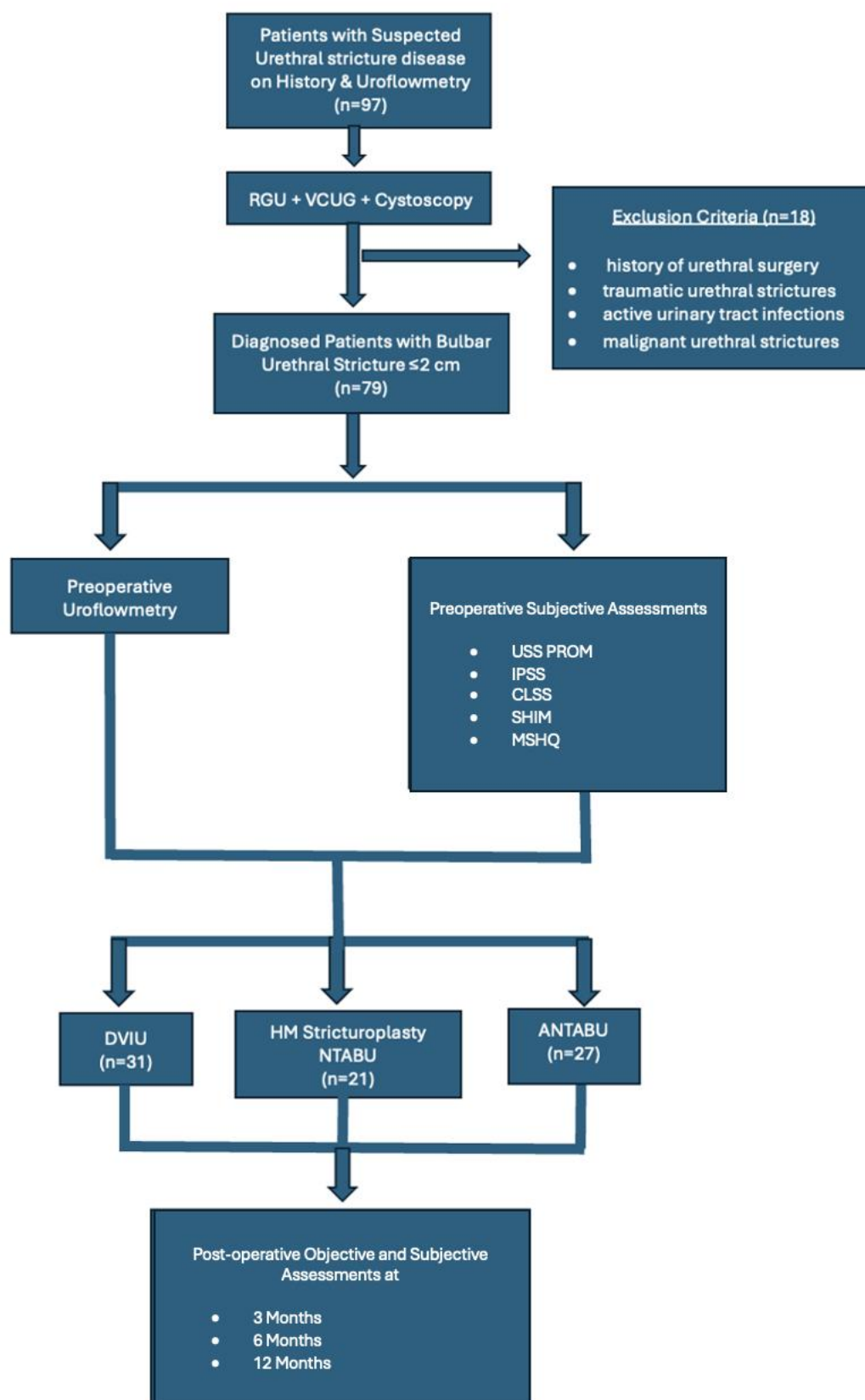
All urethroplasty patients had a 16Fr silastic catheter placed per urethra during surgery, which was removed at the first-month follow-up after 3 - 4 weeks followed by a VCUG.

Outcome variables were predefined prior to analysis. Objective outcomes included maximum urinary flow rate (Qmax) and recurrence-free success at 1 year. Subjective outcomes included LUTS severity, quality of life, sexual function, bother score, and patient satisfaction assessed using validated PROMs. Erectile function and ejaculatory function were assessed using SHIM and MSHQ scores, respectively.

Postoperative follow-up was scheduled at 3, 6 months, and 1 year, during which patients were assessed using uroflowmetry and PROM questionnaires and other validated tools such as IPSS, CLSS, SHIM, and MSHQ (Figure II). Primary outcomes included uroflowmetry(objective) and PROMs'. **Failure** was defined as the development of lower urinary tract symptoms, a follow-up Qmax of <10 mL/s, the inability to pass a 12Fr nephroscope through the reconstructed segment without damaging the urethral mucosa, or the need for any surgical intervention during the follow-up period, such as urethral dilatation, DVIU, or repeat urethroplasty, at any point during the planned follow-up period.

Statistical analysis was done using SPSS Version V27. Descriptive statistics were elaborated in the form of means/standard deviations and medians/IQRs for continuous variables and frequencies and percentages for categorical variables. Statistical analysis of LUTS domain, IPSS, CLSS, EQ 5D, MSHQ-EjF, Erectile function score, Qmax, bother/satisfactory score was done between the three groups using the Friedman test and Kruskal-Wallis Test. Statistical significance was kept at $p < 0.05$. There were no missing data for primary outcome variables at the planned follow-up intervals, and all enrolled patients were included in the final analysis. Multiple comparisons across secondary outcome measures and follow-up intervals were considered exploratory; therefore, no formal adjustment for multiplicity was performed, and results were interpreted cautiously.

As this was a non-randomized observational study, treatment allocation was influenced by surgeon judgment, intraoperative urethrocystoscopy findings, stricture characteristics, and patient preference after counselling. Consequently, patients with tighter or more obliterative strictures were more likely to undergo urethroplasty, introducing a potential selection bias. To reduce procedural variability, all surgeries were performed by a single experienced reconstructive urologist using standardized operative techniques and follow-up protocols.”



Loss to follow-up -0

Figure II (original image): Flow diagram of the study Methodology

Results:

Patients presenting with non-traumatic bulbar urethral strictures ≤ 2 cm were prospectively screened for eligibility between June 2021 and May 2023. After application of inclusion and exclusion criteria and obtaining informed consent, eligible patients were enrolled into the study. Treatment allocation was based on preoperative counselling, surgeon expertise, and intraoperative urethroscopic assessment. Patients underwent either DVIU or non-transecting urethroplasty techniques (HM/NTABU or ANTABU) according to stricture characteristics. All enrolled patients underwent standardized postoperative follow-up at 3 months, 6 months, and 1 year with objective uroflowmetry and validated PROM assessment, including USS-PROM, IPSS, CLSS, SHIM, and MSHQ questionnaires. Outcomes including recurrence, urinary function, sexual function, and patient satisfaction were analysed across the three groups. No patients were lost to follow-up in this study.

A total of 79 patients were enrolled in the study, divided into three groups based on the procedure performed: 31 patients underwent DVIU, 21 underwent NTABU/HM stricturoplasty, and 27 underwent ANTABU. The mean (SD) age of the study population was 54.91 (14.84) years, and the mean (SD) stricture length was 1.43 ± 0.46 cm in the DVIU group, 1.64 ± 0.22 cm in the NTABU/Heineke-Mikulicz group, and 1.91 ± 0.06 cm in the ANTABU group. Detailed descriptive statistics are summarized in Table I.

Although most baseline functional parameters were comparable between groups, significant differences existed in stricture length and baseline LUTS severity, reflecting selective allocation of more complex strictures to urethroplasty groups.

Comparative outcomes between the three groups are summarized in Table II and Supplementary Figure II. At 1-year, objective urinary outcomes were significantly better in the HM/NTABU and ANTABU groups than in the DVIU group, with higher Qmax and lower recurrence rates ($p < 0.001$). Recurrence occurred in 25% of DVIU patients compared with one failure in the HM/NTABU group and no failures in the ANTABU group ($p < 0.001$). Subjective urinary and quality-of-life outcomes were also superior after urethroplasty. HM/NTABU and ANTABU demonstrated significantly greater improvement in USS-PROM LUTS score, Peeling's Voiding Picture Score, Health Status-VAS, IPSS, and CLSS scores compared with DVIU ($p < 0.001$). EuroQol 5-Dimension questionnaire (EQ-5D) quality-of-life scores were highest in the ANTABU group ($p = 0.038$), while patient satisfaction rates were significantly greater in HM/NTABU (90.48%) and ANTABU (92.59%) than in DVIU (70.97%) ($p = 0.05$).

Sexual outcomes favoured DVIU, which demonstrated better preservation of erectile and ejaculatory function scores compared with HM/NTABU and ANTABU ($p = 0.003$ and $p < 0.001$, respectively). Persistent bothersome erectile dysfunction at 1 year was noted in two ANTABU patients and none in the HM/NTABU group. Transient post-void dribbling occurred in 22.2% of ANTABU and 14.2% of HM/NTABU patients, resolving completely by 6 months.

(Supplementary Figure I).

Discussion:

Although DVIU remains a commonly performed treatment for short bulbar urethral strictures, published literature demonstrates highly variable initial success rates and poor long-term durability, with recurrence increasing substantially after repeat procedures (5,6). Various adjunctive strategies, including intermittent self-calibration and intralesional agents, have been investigated to delay recurrence; however, their benefits appear limited and primarily short term (7). Reflecting these concerns, the European Association of Urology (EAU) recommends DVIU or dilation only for selected primary short non-obliterative bulbar strictures and discourages repeated endoscopic procedures when urethroplasty is feasible(8).

Seminal studies on urethroplasty techniques stated excision and primary anastomosis (EPA) as the gold standard for treating short (<2 cm) bulbar urethral strictures, while augmented or substitution urethroplasty with a free graft was regarded as the preferred approach for strictures >2 cm(9).

Excision and primary anastomosis for bulbar urethral strictures demonstrated success rates exceeding 90% at 2-year follow-up(10). It was reported that excision with primary anastomosis is inferior to buccal mucosal graft urethroplasty in the management of short bulbar strictures, with recurrence rates of 7% and 0%, respectively(11). Furthermore, EPA was associated with complications such as chordee and erectile dysfunction, which occurred in 18% of patients(11). Long-term follow-up studies on EPA reported an incidence of 23.3% ejaculatory dysfunction, 1.6% experiencing a cold glans during erection, 11.6% having a glans that was neither full nor swollen during erection, and 18.3% reporting decreased glans sensitivity(12). Most of the studies reported subjective outcomes with adopted questionnaires that were not validated. In present study study used validated USS-PROMs, SHIM and MSHQ, which gives better patient reported outcomes in relation to procedure, were used.

The concept of non-transection of the urethra in his technique of vessel-sparing bulbar urethroplasty was reported by G.H Jordan(13). This technique mobilizes the posterior corpus spongiosum from the perineal body and precise identification of the bulbar arteries to retract them safely out of the surgical field. Subsequently, was modified by avoiding complete mobilization of the posterior corpus spongiosum and identification of the bulbar arteries (14). Instead, it involved progressive paradigm that included a dorsal urethrotomy with options for Heineke-Mikulicz stricturoplasty or NTABU that involved excision of the scarred and obliterated urethral mucosa while preserving the underlying spongiosum, ventral spongioplasty after scar excision and horizontal closure of dorsal urethrotomy. In longer strictures, ANTABU involved augmentation by dorsal placement of Buccal Mucosal Graft after all steps of NTABU were performed. This adaptable approach eliminated the need for complete urethral transection while providing flexibility for management options for different stricture characteristics (14).

Studies comparing non-transecting urethroplasty (NTA) to transecting techniques, such as excision and primary anastomosis (EPA), have shown that NTA techniques achieve comparable outcomes while offering the added benefit of reduced postoperative sexual dysfunction(15,16). Similar paradigm was followed with use of Heineke-Mickulicz stricturoplasty, NTABU and ANTABU in present study.

Our findings demonstrated significantly better Qmax improvements in the NTABU/HM and ANTABU groups compared to the DVIU group at one year.. Objective assessment with uroflowmetry revealed that flow rates were consistently maintained above 15 mL/sec in the urethroplasty groups (NTABU/HM and ANTABU). In contrast, although the DVIU group had a mean maximum flow rate of 17 mL/sec at 6 months, it declined to a mean maximum flow rate of 11 mL/sec at the 1-year follow-up, indicating a progressive reduction in flow over time. These findings were reflected in the success rates observed in our study, with NTABU/HM achieving a success rate of over 95%, ANTABU approaching 100%, and DVIU at 75%, underscoring the clear superiority of the urethroplasty groups over DVIU at 1 year. This demonstrates the durable success rates of Non-transecting techniques over DVIU. Also, the results align with a previous reported objective success rate of 97.7% for NTA at a 13-month follow-up(3).

One multicentric study reported NTA success rates of 97.9%, which were comparable to the 93.8% success rate of transecting techniques(15). Similarly, success rates ranging from 90% to 98.6% for transecting urethroplasty and 81.8% to 100% for non-transecting techniques were reported (15). These findings support the efficacy and reliability of non-transecting urethroplasty techniques for short bulbar strictures.

Success rates in our DVIU group were higher than those reported in previous studies, which could be attributed to careful patient selection. In the present cohort, DVIU was predominantly performed in patients with shorter strictures, as reflected by the lower mean stricture length, and in those with less severe luminal narrowing. Importantly, DVIU was not attempted in cases of obliterative strictures with a luminal Caliber of less than 6 Fr, which likely contributed to the improved outcomes by avoiding technically unsuitable cases. Since the decision was not predefined and was influenced by the surgeon's intraoperative assessment by urethroscopy, this may have contributed to the relatively better outcomes observed in the DVIU group. The success rates of our study, in conjunction with this existing evidence, contribute to the ongoing debate whether NTA techniques be considered the first-line treatment for obliterative or tight short non traumatic bulbar urethral strictures?

Subjective assessment using validated PROMs demonstrated sustained improvement in urinary symptoms and health-related quality of life following HM/NTABU and ANTABU, with significantly better USS-PROM LUTS, Peeling's Voiding Picture Score, Health Status-VAS, IPSS, and CLSS scores compared with DVIU at both 6 months and 1 year. In contrast, although DVIU showed early symptomatic improvement, several subjective parameters deteriorated by 1 year, suggesting less durable symptom control over time. Sexual function outcomes favoured DVIU, which showed better preservation of erectile and ejaculatory function scores than urethroplasty groups on long term followup. Postoperative erectile dysfunction in the urethroplasty cohort was infrequent and improved during follow-up, decreasing from 8.3% postoperatively to 4.1% at 1 year. These findings are consistent with previous retrospective studies reporting relatively low rates of long-term sexual dysfunction after non-transecting urethroplasty (3,14,17). Despite a small increase in transient sexual morbidity, patient-reported outcomes in the urethroplasty groups demonstrated greater overall symptom relief, disease-specific quality of life, and patient satisfaction at 1 year, with satisfaction rates exceeding 90%.

Post-void dribbling was a complication observed exclusively in the HM/NTABU and ANTABU groups in our study. This could be attributed to the division of bulbospongiosus muscle and bulbar urethral mobilization during the procedure of urethroplasty. However, it resolved completely in all patients within six months, confirming it as a short-term complication with no lasting impact. Studies evaluating the impact of sparing of the bulbospongiosus muscle during urethroplasty do not suggest a significant impact of muscle sparing on PMD at early follow up(18).

The strengths of our study include its prospective design, comparable groups and validated PROMs'. This approach not only enhances the robustness of patient-reported outcomes but also lays the foundation for the potential development of a more comprehensive PROM questionnaire tailored specifically for urethral stricture disease in the future.

However, the study is limited by its non-randomized design, single centric, small sample size and potential bias due to the lack of randomization and the intraoperative decision-making by the operating surgeon and propensity matching. Additionally, the absence of intergroup analysis presents an area for further research. A further limitation is technical expertise required for NTA procedures and the treatment allocation influenced by intraoperative findings and surgeon judgment, the study population may not fully represent the spectrum of patients encountered in routine practice, thereby limiting external validity. As the study progresses, we plan to evaluate outcomes over a longer follow-up period to further validate our findings.

Cost-effectiveness studies comparing DVIU and urethroplasty for short bulbar strictures suggest reserving urethroplasty for patients with a single failed initial DVIU attempt(19). However, based on current evidence, NTA urethroplasty techniques demonstrate durable, long-term success and we believe that non-transecting anastomotic (NTA) urethroplasty techniques have the potential to replace DVIU as the preferred first-line approach for managing short-segment, non-traumatic obliterative (<6 Fr) bulbar urethral strictures. Furthermore, they should be considered the standard of care following a single failed DVIU attempt.

Conclusions:

In this prospective observational study, non-transecting urethroplasty was associated with superior urinary function, greater improvement in patient-reported outcomes, and lower recurrence than DVIU at one year. Although DVIU better preserved sexual function, the overall functional and quality-of-life benefits favoured non-transecting reconstruction. Larger multicentre studies with longer follow-up are required to confirm these findings. These findings support consideration of non-transecting urethroplasty as an effective treatment option in appropriately selected patients.

Declaration of Generative AI and AI-assisted technologies in the writing process:

The authors did not use generative AI or AI-assisted technologies in the development of this manuscript.

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Tables:

Table I: Descriptive Statistics of the Study Group	
Clinical Details	Mean $\pm$ SD Median (IQR) Min-Max OR N (%)
Age (Years)	54.91 (14.84) 57 (44.5-66) 23 - 86
Iatrogenic	17 (21.5%)
Inflammatory	2 (2.5%)
Idiopathic	60 (75.9%)
Length of Stricture	1.69 (0.31) 2 (1.5-2) 0.5 - 2
Proximal Bulbar Strictures	43 (54.4%)
Mid Bulbar Strictures	28 (35.4%)
Distal Bulbar Strictures	8 (10.2%)

Table II: Comparative Statistics of the three groups

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Time Point	Group			P value for comparison of the three groups at each of the timepoints (Kruskal Wallis Test)
	DVIU	HM/NTABU	ANTABU	
	Mean (SD)	Mean (SD)	Mean (SD)	
Stricture Length (cm)				
Baseline	1.43 (0.46)	1.64 (0.22)	1.91 (0.06)	0.002
Qmax				
Baseline	5.84 (1.39)	5.67 (1.39)	5.26 (1.29)	0.272
6 Months	17.42 (1.89)	19.95 ± 1.88	19.76 ± 2.09	<0.001
1 year	11.39 (2.57)	20.52 (2.08)	18.21 (4.17)	< 0.001
LUTS Score (USS PROM)				
Baseline	25.23 (2.54)	23.00 (2.97)	22.59 (3.13)	0.002
6 Months	10.58 (1.44)	7.50 (1.32)	6.32 (1.35)	<0.001
1 year	11.34 (2.35)	7.80 (1.24)	6.16 (1.28)	<0.001
Peeling's Voiding Picture Score (USS PROM)				
Baseline	3.46 ± 0.50	3.41 ± 0.56	3.43 ± 0.54	0.838
1 year	2.67 ± 0.73	1.41 ± 0.68	1.34 ± 0.52	<0.001
Health Status - Visual Analogue Scale (USS PROM)				
Baseline	63.61 ± 13.67	60.95 ± 13.67	57.61 ± 13.14	0.14
1 year	76.61 ± 10.63	89.00 ± 5.06	89.36 ± 5.94	<0.001
IPSS				
Baseline	24.32 (2.51)	23.00 (2.76)	23.30 (2.45)	0.193
6 Months	10.60 (2.71)	8.35 ± 1.76	5.36 ± 1.04	<0.001
1 year	15.97 (3.65)	8.15 (1.35)	5.85 (2.27)	<0.001
CLSS				
Baseline	24.68 (1.25)	24.00 (1.22)	24.37 (0.97)	0.087
6 Months	18.60 (2.71)	16.35 ± 1.76	15.36 ± 1.04	<0.001
1 year	16.64 (4.26)	8.38 (1.39)	5.96 (2.3)	<0.001
EQ-5D (USS PROM)				
Baseline	7.10 (0.85)	7.10 (0.94)	6.63 (0.88)	0.108
1 year	6.29 (0.95)	6.62 (0.94)	5.77 (1.03)	0.038
EF				
Baseline	23.56 (1.96)	23.9 (1.97)	24.67 (2.39)	0.34
1 year	21.76 (6.12)	27.81 (1.005)	25.33 (1.24)	0.003
EJ F				

Baseline	14.53 (1.76)	14.61 (1.81)	15.03 (2.09)	0.788
1 year	14.53 (2.83)	17.8 (0.85)	16.33 (1.87)	<0.001
Recurrence				
1 year	8 (25%)	1 (4.7%)	0 (0%)	<0.001

Figures legends:

Figure I (original image): (a) DVIU with Sachse Knife at 12'0'clock position; (b) Dorsal urethrotomy (arrow) before being closed horizontally in HM Stricturoplasty; (c) Partial thickness excision of scar (arrow) in NTABU; (d) Mucosa to Mucosa anastomosis (arrow) after partial thickness excision of scar in NTABU; (e) Placement of a dorsal onlay Buccal mucosa graft(arrow) in ANTABU.

Figure II (original image): Flow diagram of the study Methodology

Supplementary Figure I (original image): Kaplan-Meier Curve depicting the success probability and Time to Failure

Supplementary Figure II (original image): Line graphs showing longitudinal trends in Qmax, USS PROM parameters (LUTS score, Peeling Voiding Picture Score, Health Status - VAS, EQ-5D), EF, EjF, IPSS, and CLSS scores across three treatment groups (DVIU, HM/NTABU, ANTABU) at baseline, 6 months, and 1 year. Each line represents the group-wise mean values across timepoints, illustrating comparative trends and treatment response.

Table Legends:

- **Table I** : Descriptive Statistics of the Study Group
- **Table II** : Comparative Statistics of the three groups

Statements And Declarations:

- The authors have no relevant financial or non-financial interests to disclose.
- The authors have no competing interests to declare that are relevant to the content of this article.
- All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.
- The authors have no financial or proprietary interests in any material discussed in this article.

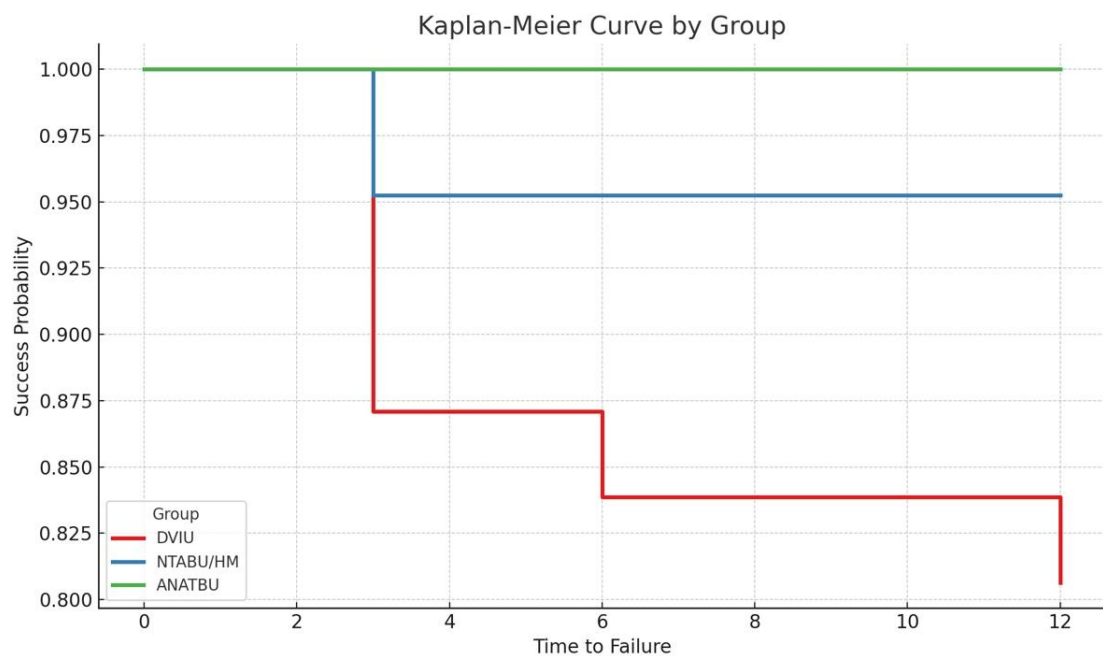
Ethics Approval:

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional ethics committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Institutional ethics committee (DHR Registration No. EC/NEW/INST/2021/1707) under the number IEC2:29/2021. The study was registered with the Clinical Trial Registry of India (CTRI/2022/05/042436) and was compliant with STROBE statement.

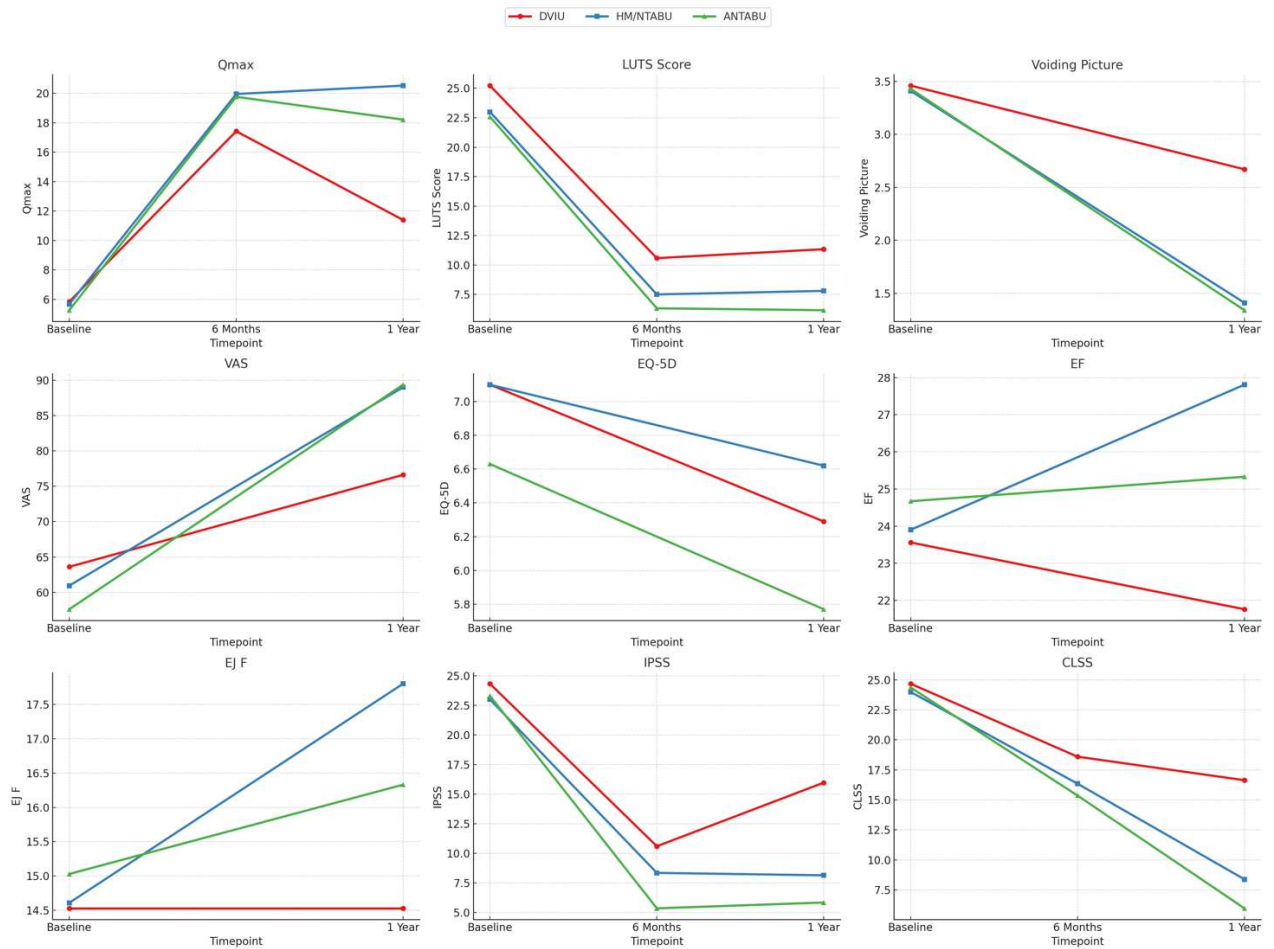
Consent to Participate:

Informed consent was obtained from all individual participants included in the study.

Acknowledgements: None to Disclose.



Supplementary Figure I(original image): Kaplan-Meier Curve depicting the success probability and Time to Failure



Supplementary Figure II (original image): Line graphs showing longitudinal trends in Qmax, USS PROM parameters (LUTS score, Peeling Voiding Picture Score, Health Status - VAS, EQ-5D), EF, EjF, IPSS, and CLSS scores across three treatment groups (DVIU, HM/NTABU, ANTABU) at baseline, 6 months, and 1 year. Each line represents the group-wise mean values across timepoints, illustrating comparative trends and treatment response.