Role of Magnetic Resonance Urethrography in Evaluation of Urethral Strictures in Comparison to Retrograde Urethrography with Urethroscopy as Gold Standard

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***Abstract*:**

Background: Urethral strictures are a significant urological problem requiring precise diagnostic imaging for effective management. Conventional retrograde urethrography (RUG) is commonly used but has limitations including invasiveness, radiation exposure, and variability in results. MR urethrography offers a non-invasive alternative, potentially providing superior diagnostic accuracy and detailed tissue characterization.

Aim: To compare the diagnostic performance of magnetic resonance urethrography and retrograde urethrography in assessing urethral strictures, using urethroscopy correlation.

Materials and methods: In a study conducted over 18 months at Sri Manakula Vinayagar Medical College, Puducherry, urethral strictures were evaluated using retrograde urethrography and magnetic resonance urethrography in 61 patients, and these findings were correlated with urethroscopic findings. Strictures were categorized by location and length using both MR urethrography and RUG. The sensitivity, specificity, and correlation of stricture length measurements between MR urethrography and urethroscopy were analyzed.

Results: MR urethrography demonstrated a sensitivity of 87.50% and a specificity of 100% in detecting urethral strictures. A strong positive correlation (r = 0.985) was observed between the stricture lengths measured by MR urethrography and those measured during urethroscopy. In contrast, RUG showed a sensitivity of 70.83% and a specificity of 67.57%, with noted limitations including invasiveness and radiation exposure.

Conclusion: MR urethrography is a highly accurate and reliable diagnostic tool for urethral strictures, providing detailed anatomical and pathological information without radiation exposure. Despite higher costs and reliance on operator skill, MR urethrography is a superior alternative to RUG, particularly for comprehensive preoperative assessments.

Keywords: Urethral stricture, Magnetic resonance urethrography, retrograde urethrography

INTRODUCTION

The male urethra typically spans about 18 to 20 centimeters in length, extending from the bladder to the external urethral opening.(1) Urethral stricture, one of the common male urological disorders is on the rise in terms of frequency. Symptoms can vary from no apparent signs to decreased urine flow, heightened pressure needed to urinate, a sensation of incomplete voiding, dribbling urination, and even urinary retention.(2) Urethral stricture generally refers to the formation of fibrous scar tissue within the urethra, resulting from an increase in collagen and fibroblast activity.(3) Anterior urethral strictures are primarily caused by inflammation, trauma and occasionally congenital factors. Whereas posterior urethral strictures are mostly iatrogenic.(4)

Retrograde urethrography (RUG) is the primary method for imaging the urethra to assess urethral stricture diseases.[5] However, this technique is invasive, costly, and time-consuming. It has several limitations which include the potential radiation risks, the limitation in identifying periurethral pathology as a cause of urethral lesions, the difficulty in accurately measuring stricture lengths, and the discrepancies between endoscopic and radiographic findings of strictures.[1]

Recent advancements in imaging technology have introduced newer modalities like magnetic resonance (MR) urethrography and sonourethrography for visualizing the male urethra.[6] Magnetic Resonance Urethrography (MRU), in particular, is a promising technique that utilizes magnetic resonance (MR) to assess both the structure and function of the male urethra by offering detailed anatomical insights into the urethra and surrounding tissues.[7] This method has the potential to significantly impact surgical decision-making by providing crucial details about stricture length and the severity of spongiofibrosis.

Ureteroscopy plays a crucial role in confirming the presence of a stricture and enables a thorough examination of the proximal part of the stricture, along with evaluating the condition of the prostate and prostatic urethra. Furthermore, it enhances visualization of the bladder, facilitating the detection of stones, diverticula, and tumors.[8,9]

With this background, the current study aims to assess the clinical importance of Magnetic Resonance (MR) urethrography in the diagnosis and characterization of various urethral lesions, comparing its effectiveness with conventional retrograde urethrography while using urethroscopy as the gold standard investigation.

MATERIALS AND METHODS

This was a hospital based cross-sectional study carried out on patients who were referred to Department of Radio-Diagnosis at Sri Manakula Vinayagar Medical College and Hospital (SMVMCH), Kalitheerthalkuppam, Puducherry, India which is located in a village 25 km west of Puducherry, for evaluation of urethral strictures for a period of 18 months from September 2022 to February 2024 .Considering the 85% diagnostic accuracy of MR urethrography in a study by Osman Y et al, the sample size for the present study was calculated to be 77 and rounded off to 80 at 95% confidence interval and 8% absolute precision.[10] Due to decrease in inflow of cases, the sample size was reduced to 61.

Male patients presenting with suspected urethral stricture were included in the study, excluding individuals with metallic implants such as cardiac pacemakers, implanted cardiac defibrillators, cochlear implants, etc; severe allergic reactions or hypersensitivity in medical history; claustrophobic tendencies and patients in critical condition.

Brief procedure:

Patients who were fulfilling the inclusion criteria were considered for the study. After obtaining an informed consent from patients own language and history, the patient was subjected to retrograde urethrography and T1, T2 and T2 SPAIR weighted sequences of Magnetic Resonance Imaging (**T1** weighted: sense-body coil, TE - 80ms, TR – 3500ms, Matrix – 480, No. of exchange – 1, Slice thickness – 3mm, section spacing – 0.5mm, FOV - 240*240*238 mm, Imaging time - 3 min 30 seconds; **T2** weighted: sense-body coil, TE - 80ms, TR – 3500ms, Matrix – 480, No. of exchange – 1, Slice thickness – 3mm, section spacing – 0.5mm, FOV - 240*240*238 mm, Imaging time - 3 min 30 seconds; **T2 SPAIR** weighted: sense-body coil, TE - 80ms, TR – 3500ms, Matrix – 480, No. of exchange – 1, Slice thickness – 3mm, section spacing – 0.5mm, FOV - 240*240*238 mm, Imaging time - 3 min 30 seconds) following which findings were correlated with optical urethroscopy. Magnetic resonance imaging studies were performed on 1.5 Tesla PHILIPS whole body MR scanner using standard imaging body coil.

Statistical analysis:

Data was entered into Microsoft Excel and then analyzed with SPSS version 24. The categorical variables were analyzed using Chi-square test and continuous variables using independent t test. P value < 0.05 was considered as statistically significant at 95% CI. Pearson’s correlation coefficient was used to find correlation coefficient. Interobserver agreement was assessed using the kappa statistic.

Statistical software: SPSS version 24 was used to analyze data.

Ethical consideration:

Institutional ethics committee approval was obtained (**IEC no. EC/69/2022**) and the study was conducted according to STARD checklist. Informed consent was obtained from participants in their native language.

RESULTS

The study included 61 male patients with suspected urethral strictures. The mean age of the study participants was 31.00 ± 14.75 years. The participant's age ranged from 21 to 80 years, with the highest frequency in 51-60 years group.

The most common location of urethral strictures was the anterior urethra (63.9%), particularly in the bulbar and penile segments. Posterior urethral strictures accounted for 32.8% of cases, with a few cases involving both anterior and posterior urethral segments. For anterior urethral strictures, the mean length was longer when measured by MRU (2.17 ± 1.11 cm) compared to RUG (1.82 ± 0.22 cm). For posterior urethral strictures, MRU showed shorter stricture lengths (1.66 ± 0.41 cm) than RUG (2.79 ± 0.87 cm). the differences in mean stricture lengths between the imaging methods were statistically significant (P < 0.05), particularly for anterior and posterior strictures.

Table 1. Location of stricture and mean stricture length among the study participants by method

Location of stricture	Percentage (%)	Mean stricture length			
		RUG	MRU	Urethroscopy	P value
Anterior Bulbar Penile Penile and bulbar Total	 34.4 (n=21) 26.2 (n=16) 3.3 (n=2) 63.9 (n=39)	1.82 ± 0.22	2.17 ± 1.11	2.15 ± 1.10	**0.001**
Anterior and posterior	3.3 (n=2)	2.79 ± 0.87	1.66 ± 0.41	1.63 ± 0.47	**0.002**
Posterior Membranous Penile Total	 27.9 (n=17) 4.9 (n=3) 32.8 (n=20)	5.90 ± 2.46	4.30 ± 2.16	4.30 ± 2.28	**0.003**

A stricture of < 2.0 cm was considered as short stricture, while a stricture of ≥ 2.0 cm was considered as long stricture. 52.5% of participants had short strictures, while 47.5 % had long strictures by retrograde urethrography. 65.6% of participants had short strictures, while 34.4% had long strictures by magnetic resonance urethrography. 60.7% of participants had short strictures, while 39.3% had long strictures by urethroscopy (**Figure-1,2**).

Figure 1 : Imaging of long segmental anterior urethral stricture. RGU (A), MRU (B) urethroscopy (C) showing long segment anterior urethral stricture (yellow dotted line). Note can be made of underestimation of anterior urethral stricture by RGU

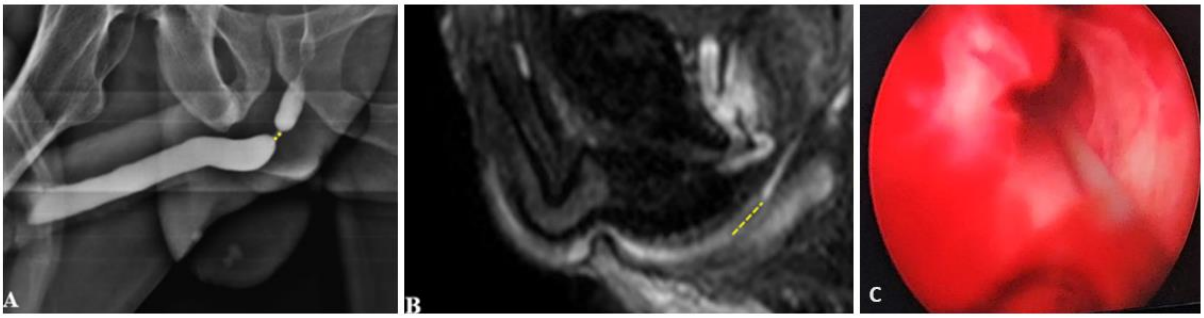

Figure 2: Imaging of short segmental bulbar urethral stricture. RGU (A), MRU (B) urethroscopy (C) showing short segment anterior (bulbar) urethral stricture (yellow dotted line). Note can be made of underestimation of anterior urethral stricture by RGU

Table 2: Stricture length among study participants by method

Stricture Length	**Retrograde urethrography**	**Magnetic resonance urethrography**	**Urethroscopy**
	Percentage (%)	Percentage (%)	Percentage (%)
Short	52.5 (n=32)	65.6 (n=40)	60.7 (n=37)
Long	47.5 (n=29)	34.4 (n=21)	39.3 (n=24)

Stricture length by MRU and RUG (MRU > RUG) had a strong positive correlation with stricture length by Urethroscopy which was statistically significant by Pearsons correlation coefficient.

Table 3: Correlation of Stricture length by Retrograde Urethrography and Magnetic resonance urethrography with urethroscopy among the study participants

Stricture length comparison	**Correlation coefficient**	**P value**	**Interpretation**
RUG and urethroscopy	0.779	**0.001***	Strong positive correlation
MRU and urethroscopy	0.985	**0.001***	Strong positive correlation

Retrograde Urethrography had a Sensitivity of 70.83% (48.9 to 87.3%), Specificity of 67.57% (50.2 to 81.9%), Positive Predictive Value of 58.62% (45.4 to 70.6%) and Negative Predictive Value of 78.12% (64.8 to 87.3%). MR Urethrography had a Sensitivity of 87.50% (67.6 to 97.3%), Specificity of 100% (90.5 to 100%), Positive Predictive Value of 100% (83.8 to 100%) and Negative Predictive Value of 92.50% (81.0 to 97.2%).

Table 4: Sensitivity, specificity, positive predictive value and negative predictive value of MRU vs RGU

	Sensitivity	**Specificity**	**Positive predictive value**	**Negative predictive value**
RUG	70.83%	67.57%	58.62%	78.12%
MRU	87.50%	100%	100%	92.50%

DISCUSSION

Retrograde urethrography is the preferred method for diagnosing urethral injuries. It is precise, simple, and can be done quickly in the trauma setting. (11) However, it is invasive, and does not show any pathology of the tissues around the urethra. (12) The benefits of MR urethrography are that it is non-invasive, does not use radiation, and can show periurethral pathologies. (6)

In our study, we classified the strictures by their location and found that the most frequent stricture location was anterior (bulbar) urethra followed by posterior (membranous) urethra. (table – 1). There was a strong correlation between stricture lengths measured by MRU and urethroscopy (r=0.985), indicating that MRU provides measurements closely aligned with the gold standard (urethroscopy). RUG also showed a positive correlation with urethroscopy (r=0.779), but it was less precise than MRU. (Table - 3) suggesting MR Urethrography findings closely corresponds with those identified through Urethroscopy, highlighting the reliability of MR Urethrography as a diagnostic tool for evaluating stricture length.

MRU demonstrated higher diagnostic accuracy with a sensitivity of 87.5% and specificity of 100% in detecting urethral strictures. RGU had lower sensitivity (70.83%) and specificity (67.5%) compared to MRU. In comparison to retrograde urethrography, MR urethrography displayed comparable mean values to urethroscopy. (Table- 4)

Table 5: Table comparing the studies on RUG and MRU

Study	Participants	Technique	Sensitivity	Specificity	Accuracy
Osmal et al (10) (2006)	20	RUG & MRU	-	-	~ 85%
Mahmud SM et al (13) (2008)	92	RUG	91%	72%	-
El ghar et al (14) (2009)	30	RUG & MRU	**RUG** Anterior – 91% Posterior – 81% **MRU** – 100%	**RUG** Anterior – 90% Posterior – 91.7% **MRU** – 91.7%	**RUG** Anterior – 90% Posterior – 90% **MRU** – 95%
Labana et al(15)	60	MRU	100%	93.4%	90.1%

Furthermore, retrograde urethrography tended to underestimate anterior urethral strictures and overestimate posterior strictures. These findings underscore the high diagnostic accuracy and reliability of MR Urethrography in detecting urethral strictures, making it a valuable tool in clinical practice for both diagnosis and treatment planning.

The small sample size and specific demographics in study may not represent broader patient population. RUG is invasive, involves radiation exposure and requires multiple patient positions, which can affect imaging quality. In contrast, MRU is more expensive and may face accessibility issues. MRU effectiveness is contingent in operator skill and it can struggle with visualization in extensive or posterior strictures. Additionally, patient comfort and compliance during MRU can impact imaging quality highlighting that while MRU is highly effective, its practical use may be constrained by these factors.

CONCLUSION

MR urethrography is a highly accurate and reliable diagnostic tool for urethral strictures, providing detailed anatomical and pathological information without radiation exposure. Despite higher costs and reliance on operator skill, MR urethrography is a superior alternative to RUG, particularly for comprehensive preoperative assessments.

Abbrevations:

RUG – Retrograde urethrography

MRU – Magnetic resonance urethrography

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