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Original Article

Radiology Section

Role of Magnetic Resonance Urethrography in Evaluation of Male Urethral Stricture Against Conventional Retrograde Urethrography

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ABSTRACT

Introduction: Magnetic Resonance Urethrography (MRU) is a new and less widely used technique in the evaluation of male urethral strictures.

Aim: This study intends to establish the role of MRU in the evaluation of male urethral strictures and to compare the efficacy with that of conventional Retrograde Urethrography (RUG).

Materials and Methods: A total of 32 patients with symptoms of poor urinary stream and straining during micturition underwent conventional RUG followed by MRU. The parameters studied by RUG and MRU such as stricture site, number, length, diameter and associated false tracts or diverticulum were compared with intraoperative findings, which is taken as gold standard. The sensitivity, specificity, positive and negative predictive values of all the parameters was calculated. Karl pearson correlation coefficient and Wilcoxon's signed rank test were used where appropriate. A p-value of <0.05 was considered statistically significant.

Results: Both modalities had 100% sensitivity and specificity in the detection of stricture site. MRU showed better correlation with surgical findings than RUG in strictures less than 3 cm and the RUG showed better correlation with surgical findings than MRU in strictures longer than 3 cm, even though there was no significant statistical difference between the two. Stricture lengths in four cases of long penile urethral strictures with submeatal extension were underestimated by MRU. RUG overestimated the length of four cases of penile urethral stricture. Both RUG and MRU slightly overestimated the severity of strictures in the 2 to 4 mm diameter range. RUG detected all the false tracts, whereas MRU failed to detect one of the false tracts. Accuracy in the detection of spongiofibrosis in MRU was directly proportional to the severity, with no false negatives in moderate to severe degrees of spongiofibrosis.

Conclusion: RUG and MRU are equally efficacious in detecting urethral strictures. MRU showed better stricture length assessment in bulbar urethra and accurately delineated posterior urethral distraction defect. MRU effectively detects and characterises spongiofibrosis, which is not possible in RUG.

Keywords: Posterior distraction defect, Retrograde Urethrography Technique, Spongiofibrosis

INTRODUCTION

Stricture disease of male urethra has long been evaluated by conventional RUG, which is considered as the standard imaging technique of urethra. It has limitations like poor definition of stricture length (that varies according to patient position and the degree of stretch of penis) and no information about periurethral tissue [1-6]. Sonourethrography was already explored as an alternative tool to overcome these limitations. Characterisation of strictures in terms of length, diameter and periurethral pathologies, like spongiofibrosis and false tracts, is done with greater sensitivity using sonourethrography as compared with RUG [6]. Magnetic Resonance (MR) has the ability to delineate clear anatomic details regarding the urethra and periurethral tissue with three dimensional orientation of the lesion [7]. MRU may result in change of surgical plan for individual patients based on the stricture length and severity of spongiofibrosis [8]. Very few studies have been published about the role of MRU in the evaluation of male urethral strictures [8-11]. This study intends to establish the role of MRU in the evaluation of male urethral stricture disease and compare the efficacy of the same with conventional RUG.

MATERIALS AND METHODS

This was a prospective study done in the Department of Radiology, Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER) between January 2010 to January 2011, wherein patients with symptoms of stricture disease such as thin or weak stream of urine, straining during micturition, retention or scattered stream underwent conventional RUG followed by MRU. The study was approved by the ethical committee and all patients gave informed consent to participate in the study. Patients who were claustrophobic, having known contraindication to MRI namely cochlear implants, pacemakers, etc. were excluded from the study. Overall 32 patients were evaluated first by RUG followed by MRU. All the patients had normal renal function tests prior to MRU procedure.

Conventional Retrograde Urethrography Technique

Patient was placed in right oblique position with right knee partially flexed, left leg stretched above the right leg, and left hip just lifted from the table. Water-soluble low osmolar iodine based contrast medium (Iohexol) was injected with a catheter or syringe tip placed in the external meatus. The external meatus was pressed tightly around the tip of the catheter to prevent escape of the contrast medium. Gentle traction was applied to straighten the shaft of penis during contrast injection. About 15-20 mL of the contrast medium was injected and a spot film was taken during injection.

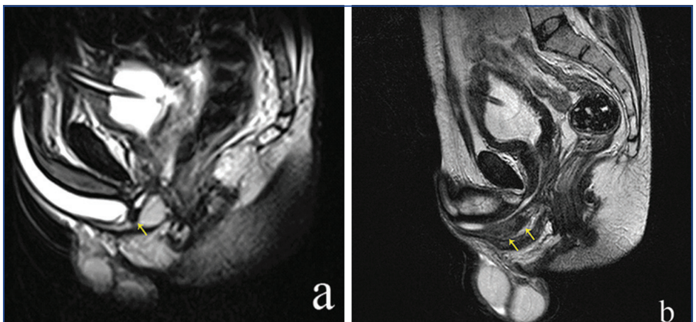
MR Urethrography Technique

MR imaging was performed in supine position in a 1.5 Tesla device (Magnetom Avanto-Siemens, Erlangen, Germany, 2006). The penis was positioned over anterior abdominal wall in supine position, in mid sagittal plane, held by soft gauze tied around the corona and taped to the abdominal wall, over which a loop surface coil was placed. The image acquisitions were complemented by pelvic phased array coil. Images start with the acquisition of scout images in all the three planes viz., axial, sagittal and coronal. T2W TSE sequences obtained in sagittal and axial planes followed by 3D CISS in sagittal plane. Then penis is released and the tip of a 20 mL syringe filled with normal saline (or a fine cannula in cases of meatal stenosis) was inserted into meatus and injected until proper distension of the urethral lumen is achieved as evidenced by mild discomfort experienced by the patient. Penis was secured to the previous mid sagittal position. T2W TSE and 3D CISS sequences were repeated as before. Additionally, T1 FLASH 3D fat saturated sequences were obtained in sagittal plane. Then, intravenous injection of MR contrast (Gadobenate dimeglumine-Multihance) was done at a dose of 0.1 mmol/kg followed by repetition of T1 FLASH 3D fat saturated sequence. Sagittal post contrast and 3D CISS images were reformatted in coronal and axial planes wherever necessary for additional information.

T2W TSE axial images were acquired with TR/TE: 12420/94, Slice thickness 3 mm, Distance factor 0, FOV 380×230. T2W TSE sagittal images were acquired with TR/TE: 5010/108, Slice thickness 3 mm, Distance factor 0, FOV 380×230. T2 3D CISS sagittal images were acquired with TR/TE: 750/117, Slice thickness 1.25 mm, Distance factor 0.63, FOV 380×230. T1 FLASH 3D fat saturation sagittal images were acquired with TR/TE: 42/5.5, Slice thickness 1.25 mm, Distance factor 0.63, FOV 380×230.

Image Analysis

Conventional RUG and MRU studies were interpreted independently and separately by two radiologists, each unaware of the findings of the other. RUG and its corresponding MRU images were done in this study. Information regarding the clinical history was furnished and the interpreters were aware of high probability of urethral stricture disease as diagnosed clinically. The following parameters that were evaluated from both conventional RUG and MRU images are number, site, length, and diameter of strictures and presence of any associated findings such as false tracts, calculus, diverticulae. The presence and severity of spongiofibrosis were noted only in MRU images. Stricture length and diameter were determined by direct measurement on the X-ray film or the MR image. Stricture lengths for non obliterating strictures were measured in both modalities by measuring the length of luminal narrowing, including the tapered segments on either side of the stricture. For Posterior Urethral Distraction Defect (PUDD), stricture length was determined to be the distance between the proximal limit of the distended distal urethra and the prostatic apex on sagittal T2W and contrast enhanced T1W images with luminal distension. Stricture severity was graded based on the degree of luminal narrowing (Mild-less than one third of the lumen is narrowed; Moderate-one third to half is narrowed; Severe -more than half is narrowed) [6]. Spongiofibrosis was interpreted when T2W and post contrast T1W images showed hypointense areas in the periurethral spongiosum with the normal and intact surrounding spongiosum showing strong contrast enhancement on post-contrast T1W and appearing hyperintense on T2W images [Table/Fig-1]. Severity of spongiofibrosis was classified based on the depth/thickness of involvement of the corpus spongiosum. (Mild-less than one third; Moderate-one third to half; Severe-more than half) [6].



[Table/Fig-1a,b]: Spongiofibrosis seen as dark (hypo intense) areas in sagittal T2 TSE MRU images in two patients (yellow arrows).

The parameters studied by RGU and MRU were compared with intraoperative findings noted either during urethroscopy or urethroplasty. The extent of spongiofibrosis was assessed intraoperatively by: a) colour of urethral mucosa-pink (mild), gray (moderate), white (severe); and b) resistance to incision-mild, moderate, severe.

STATISTICAL ANALYSIS

The sensitivity, specificity, positive and negative predictive values of all the parameters was calculated. Independent correlation of the length of strictures between the two imaging modalities with the operative findings was assessed using Karl Pearson correlation coefficient. Measurement errors between imaging and surgical values of stricture length were calculated in each imaging method and compared by Wilcoxon's signed rank test. A p-value of <0.05 was considered as statistically significant. Graphpad Instat (version 3.10) was used for statistical analysis.

RESULTS

The total number of strictures evaluated was 38 in 32 patients, with six of the patients having two strictures each. The patient's age range was 14 to 75 years. All the 32 patients underwent both RUG and MRU. Both RUG and MRU demonstrated the precise location of all the strictures in all the patients. A comprehensive analysis of the strictures based on the conventional RUG, MRU and the operative findings are summarised in the [Table/Fig-2]. Three out of thirty eight strictures are obliterative strictures with distraction defect. Hence the remaining thirty five strictures are assessed statistically by their diameters and respective severity in comparison with operative findings. The estimation of stricture length by RUG revealed a low sensitivity ranging from 50-75% for strictures of 1-3 cm length. MRU had a higher sensitivity (85-100%) for the same. Most of these strictures were situated in the bulbar/proximal penile urethra.

Stricture		RUG findings	MRU findings	Operative findings
Site and number	Penile urethra	10	10	10
	Bulbar urethra	14	14	14
	Diffuse	10	10	10
	BMJ	3	3	3
	PPU+DBU	1	1	1
Length (mm)	≤10	10	11	10
	11-20	3	3	3
	21-30	4	6	7
	31-40	2	3	1
	41-60	4	3	4
	61-80	2	2	3
	Diffuse	10	10	10
Diameter (mm)	0-2	15	15	10
	2.1-4.0	14	17	22
	4.1-6.0	4	2	1
	6.1-8.0	2	1	2
Severity	Mild	6	4	3
	Moderate	12	11	15
	Severe	17	20	17
Spongiofibrosis	None	NA	19	15
	Mild	NA	8	6
	Moderate	NA	9	12
	Severe	NA	2	5
False tracts		10	9	10

[Table/Fig-2]: Shows the RUG findings, MRU findings and the Operative findings of the patients with urethral strictures.
BMJ: Bulbomembranous junction; PPU: Proximal penile urethra; DBU: Distal bulbar urethra

Correlation Between	Length of the stricture	Pearson Coefficient	p-value
RUG vs. Surgical Findings	≤3 cm	0.90	0.000*
MRU vs. Surgical Findings	≤3 cm	0.94	0.000*
RUG vs. Surgical Findings	>3 cm	0.90	0.000*
MRU vs. Surgical Findings	>3 cm	0.80	0.000*

[Table/Fig-3]: Correlation of MRU and RUG with surgical findings.
Correlation between the two modalities with operative findings-Karl Pearson correlation coefficient.
* denotes significant

Both the modalities showed statistically significant correlation for stricture lengths in both the subgroups (less than 3 cm and more than 3 cm) [Table/Fig-3]. However, MRU showed better correlation with surgical findings for strictures less than 3 cm and RUG showed better correlation for strictures more than 3 cm. Overall measurement of errors between imaging and surgical values of stricture length in each imaging method by Wilcoxon's signed rank test showed p-value of 0.065 (>0.05), thereby showing no significant difference in overall estimation of stricture length between RUG and MRU.

Both RUG and MRU overestimated the severity of strictures in the 2 to 4 mm range leading to increased false negatives. The sensitivity of RUG and MRU in estimating stricture diameter between 2-4 mm was 63.6% and 72.2% respectively. RUG correctly diagnosed all the 10 false tracts whereas, MRU failed to detect one of them.

MRU detected the presence of spongiofibrosis correctly in 15 out of 19 patients. Four cases interpreted as having no spongiofibrosis were documented to have mild spongiofibrosis peroperatively. Accuracy in the detection of spongiofibrosis was directly proportional to the severity of the same. Sensitivity in the detection of grade of spongiofibrosis ranges from 40-100% with 'down grading' of severity in six cases (31.5%). However, it is highly specific (100%) for detection of moderate to severe spongiofibrosis with no false negatives in these subgroups.

DISCUSSION

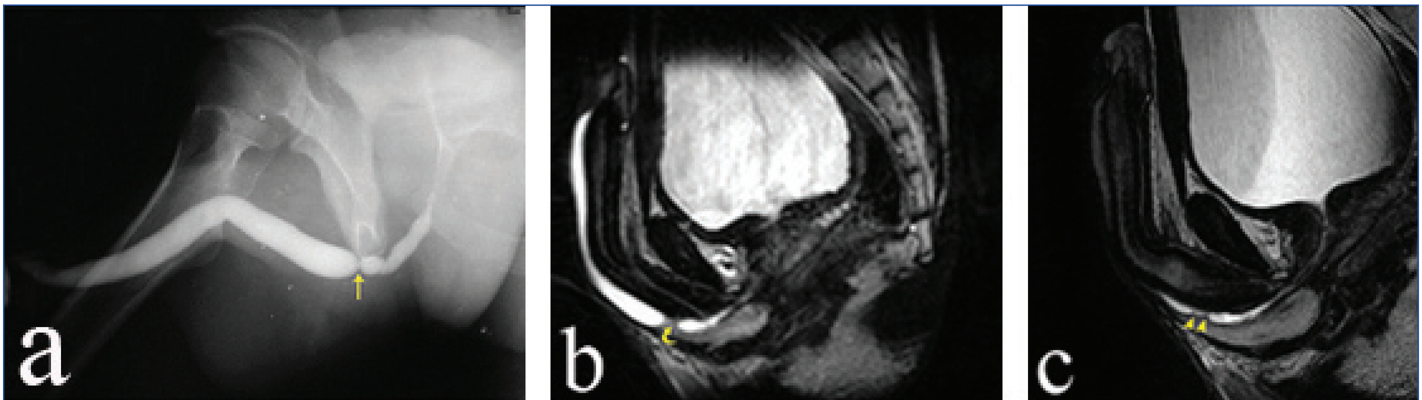
Retrograde urethrography has been the standard imaging study for urethral stricture disease. RUG is readily available, cost effective and easy to interpret. However, RUG has its own limitations such as underestimation of stricture length, no information about the periurethral tissue [1-6] and incomplete evaluation of posterior urethral strictures. MRU was explored as an alternative tool with few studies demonstrating the urethral stricture by luminal distension using either saline or gel [9,12]. MRU, owing to its excellent soft tissue contrast and multiplanar capability, can provide better anatomic details about periurethral tissues.

In the present study, all the patients detected to have stricture disease by RUG were also detected by MRU and confirmed peroperatively. Both RUG and MRU were 100% specific and sensitive in the detection of the site and number of urethral strictures. However, in cases of obliterative strictures in three patients, especially the post traumatic urethral strictures with distraction defect, proximal extent could not be demonstrated by RUG.

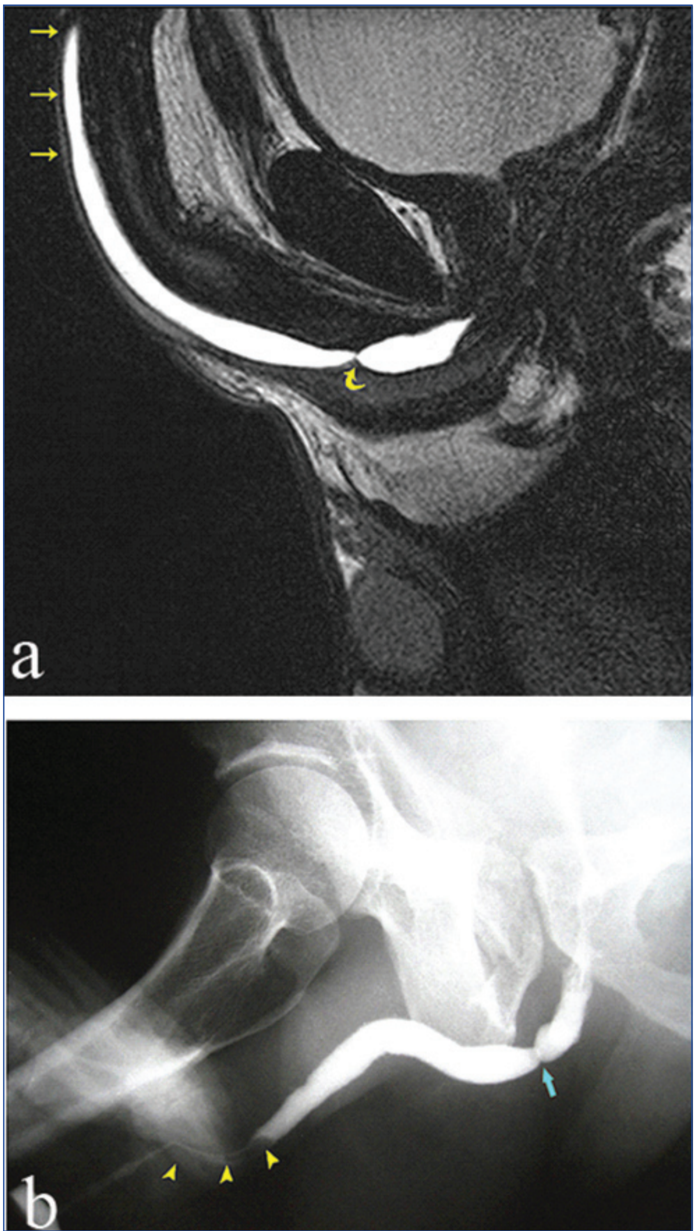
Many previous studies showed consistent poor correlation of stricture length between RUG and operative findings [1-6], more marked in strictures affecting the bulbar urethra. However, Babnik PD et al., has reported that RUG does not underestimate stricture length if the tapered segments were included in the measurement [13]. Osman Y et al., in their study of obliterative posterior urethral strictures showed that the mean length as measured by RUG and MRU showed no statistically significant difference between the modalities [9]. A similar study by Sung DJ et al., concluded that MRU measurement of stricture length demonstrated significantly lower errors than did RUG combined with Voiding Cystourethrography (VCUG) [8]. In this study, MRU showed better correlation of stricture length with surgical findings than RUG (0.94 vs. 0.90) in strictures less than 3 cm and the RUG showed better correlation with surgical findings than MRU (0.90 vs. 0.80) in strictures longer than 3 cm. But there is no significant statistical difference between the two modalities.

Accurate measurement of stricture length is one of the determinants for selecting the appropriate operative procedure. In a previous study, MRU findings were reported to have made the urologists to change the operative procedure in seven of the patients that would have otherwise been planned based on RUG findings [8]. Also Oh MM et al., stated that MR findings can cause a change in the surgical procedure due to defect length and spongiofibrosis. The surgical procedure had previously been determined by findings on conventional RUG [10]. This was based on the fact that, ultrashort strictures (<1 cm) were managed with urethrotomy; short strictures (1 to 2.5 cm) were managed with anastomotic urethroplasty and long strictures (>2.5 cm) were managed with urethroplasty augmented by using graft such as buccal mucosal graft or penile skin flap [8].

Another similar study by El-ghar MA et al., stated that MR gives accurate estimation of stricture length in good agreement with that measured by endoscopy [11]. The possible cause for under estimation of stricture length by RUG (especially in the bulbar urethra) would be the oblique position of the patient leading to tilting of the pelvis and long axis of posterior urethra with resultant foreshortening of the stricture segment in the apparent two dimensional X-ray image [6]. This was evident in the present study for the strictures located at bulbar urethra [Table/Fig-4,5]. Few of the longer strictures measured in the penile urethra showed discordance with operative findings in both RUG and MRU, due to different reasons. Stricture lengths in four cases of long penile urethral strictures (all measuring more than 5 cm) were considerably under estimated by MRU, all located in the submeatal region and extending proximally along the penile urethra. This was because submeatal segment of the pendulous urethra not adequately distended with saline, due to occlusion caused by the gauze knot around the corona during the procedure of MRU.



[Table/Fig-4]: (a-c) Bulbar urethral stricture in a same patients taken in three different views RUG showing a 1 cm stricture segment in bulbar urethral (arrow). Corresponding sagittal T2 TSE image (cureved arrow); CISS 3D images showing a longer stricture (2 cm) (arrow heads) that correlated with surgical findings.



[Table/Fig-5]: Separate penile and bulbar urethral strictures in a patient.
a) MRU sagittal CISS 3D image showing the strictures (straight arrow and curved arrow); b) RUG showing both the strictures but with the apparent foreshortening of bulbar stricture (blue arrow) due to obliquity and overlapping proximal and distal urethra.

However, previous studies based on MRU did not include penile urethral strictures in their study groups [8,12]. Stricture lengths in four cases of penile urethral strictures (three measuring more than 5 cm and one measuring 2.5 cm) were considerably over estimated by RUG. This could be due to excessive traction of the penis during the procedure, leading to apparent lengthening of the measured stricture length compounded by some inherent radiographic magnification.

False tracts were shown in RUG as linear contrast filled tracts coursing parallel to the urethral lumen and communicating at a single point with the same [Table/Fig-6]. MRU also showed false tracts as linear fluid signal intensities in a similar fashion. RUG detected all the false tracts in this study, which were confirmed intra operatively, whereas MRU detected only nine of the ten false tracts. The one not detected might be due to temporary occlusion of the false tract neck secondary to focal adjacent inflammation at the time of MRU. The MRU also correlated well with the circumferential (o'clock) position of the origin of false tracts from the urethra with operative findings, as visualised in axial or coronal reformats.

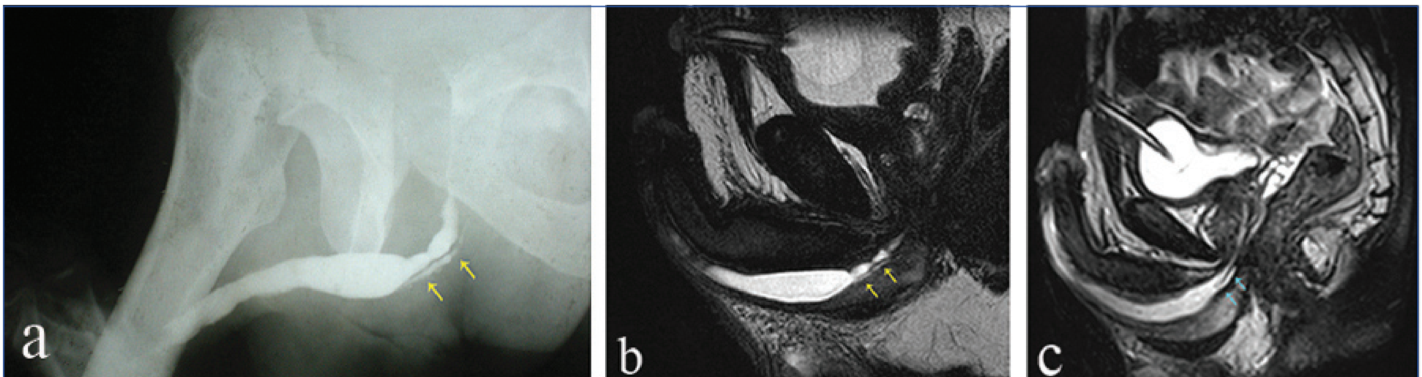
Spongiofibrosis, the critical determinant in the selection of the appropriate surgical method, is well delineated in MRU. Treatment selections have been reported according to the degree of spongiofibrosis [4]. MRU shows fibrous tissue on T2W and post contrast T1W images as areas of hypointensity with the normal surrounding spongiosum showing T2 hyperintense signal and strong contrast enhancement. So, the depth and extent of spongiofibrosis could be accurately delineated. Although detection of spongiofibrosis in MRU has been elucidated in previous studies [9,13,14], depth/thickness of the same with surgical correlation has not been reported yet. Overall accuracy in characterising spongiofibrosis by sonourethrography is directly proportional to its severity [2].

Peroperative assessment of spongiofibrosis was done by subjective criteria of the colour of the urethral mucosa and resistance to incision. Spongiofibrosis was detected in 15 of the 19 patients. Four cases documented as mild spongiofibrosis peroperatively were interpreted as having no spongiofibrosis in MRU. This can be attributed to either minimal immediate periurethral changes that are difficult to detect or absence of histopathology correlation and relying on the subjective criteria provided by the surgeon. However, MRU showed 100% specificity and positive predictive value for moderate to severe degrees of spongiofibrosis in the present study.

In post traumatic posterior urethral strictures, there is a distraction defect, which is accompanied by displacement of the prostatic apex. In such cases, the length of the 'stricture/distraction defect' can be measured as the distance between the proximal margin of the distended distal urethra and the prostatic apex, which can give a roadmap for the surgeons to operate.

LIMITATION

The limitations of present study were that when the cases were subdivided into subgroups for different lengths and diameters, number of patients was small and submeatal segment of the urethra was not adequately distended with saline to characterise strictures in this segment, due to occlusion caused by the gauze knot around the corona during the procedure of MRU. A study with larger number of patients will be better for comparing the aforementioned parameters between these two modalities.



[Table/Fig-6]: False tract.
a) RUG and; b) Sagittal CISS 3D MRU image showing flase tract in a patient in a (yellow arrows); c) MRU showing false tract in another patient (blue arrows).

CONCLUSION

Magnetic resonance urethrography showed better stricture length assessment in bulbar urethra and accurately delineated posterior urethral distraction defect. MRU detects and characterises spongiofibrosis which cannot be assessed with RUG. Thus, evaluating strictures with MRU may help in deciding the appropriate surgical procedure based on length and spongiofibrosis.

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