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Magnetic resonance imaging procedure for pelvic fracture urethral injuries and recto urethral fistulas: A simplified protocol

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ABSTRACT

Objective: The urethral gap in pelvic fracture urethral injury (PFUI) is traditionally assessed using voiding cystourethrogram (VCUG) and retrograde urethrogram (RGU). Magnetic resonance imaging (MRI) is performed in complex cases. We assessed the refined "Joshi" MRI protocol to evaluate complex urethral defects after PFUI.

Material and methods: A prospective study was conducted at our center from January 2018 to January 2020, involving patients aged >18 years with PFUI, suitable for MRI, and those who gave consent to perform standard RGU, VCUG, and MRI using standard and "Joshi" protocol. Forty men were included in the study. Distance between urethral/prostatic stumps was measured. Image quality was scored by four radiologists and four urologists. The surgical approach and type of PFUI repair were noted. We also established the need for inferior pubectomy by assessing the position of the posterior urethra (membranous) in relation to a horizontal line drawn from the lower edge of the pubic bone anteriorly to the rectum posteriorly in a sagittal image.

Results: The mean age was 30 years (SD, 5.25; range, 21–43), and the time from injury to imaging was 4 months (3–10 months); 40% of the men underwent crural separation, 57.5%, inferior pubectomy, and 2.5%, crural rerouting. There was a difference of 0.3 to 1.1 cm in the urethral gap measurements between MR images using the standard versus "Joshi" technique. MRI identified complex injuries such as rectourethral fistula, the need for inferior pubectomy, and the orientation of the posterior urethra. Urologists' and radiologists' satisfaction scores for the MR images were satisfactory to excellent. If the posterior urethra was over the defined mark, there was a 100% likelihood of inferior pubectomy (23/40 patients).

Conclusion: MR image acquisition using the "Joshi" protocol provided high-quality anatomical information in PFUI cases to assist with surgical planning.

Keywords: MRI; pelvic fracture urethral injury; stricture urethra; trauma; urethroplasty.

Introduction

Pelvic fracture urethral injuries (PFUIs) occur in 5–25% cases of pelvic fractures.[1,2] Motor vehicle collisions are the most common cause of pelvic fractures. The incidence of urethral injuries as a result of motor vehicles varies between 36% in India and 15% in Italy and USA.[3] Pelvic fracture results in urethral injury at the membranobulbar junction.[4-6] As a result of disruption of the ligamentous attachments of the urethra and injury to the periprostatic venous plexus, a hematoma is formed that displaces the prostate cephalad and posteriorly.[7] In PFUI, there is no loss of urethral tissue.[8]

Preoperative assessment of the urethral gap is important when deciding the type of surgical approach. In most cases, a gap of less than 2.5 cm can be treated by a simple perineal approach, while larger gaps may require an elaborate perineal approach or trans-pubic procedure. [9-14] Therefore, preoperative gap assessment aids in determining the type of approach. Conventionally, a retrograde urethrogram (RGU) along with a voiding cystourethrogram (VCUG) is performed, while in complex cases, an MRI of the pelvis is performed to assess the urethral gap and delineate additional pathologies such as rectourethral fistula, orientation of the proximal urethral end, presence of bone fragments, etc.

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MR images in these cases can be difficult to assess by urologists due to the non-standardization of image acquisition, and not many urologists are well versed with MRI. Hence, most urologists prefer using RGU and VCUG, missing out on crucial additional soft tissue information that can be obtained from a pelvic MRI, especially in complex cases.

The aim of this study was to describe a simplified protocol for MRI in patients with PFUI and compare differences in the quality and precision between the modalities. We hypothesized that the protocol is feasible, the results are reproducible with similar image acquisition, and the images provide a good anatomical outline for surgical planning.

Material and methods

The current study assessed a refined "Joshi" protocol for MR image acquisition designed specifically for evaluation of complex urethral defects after PFUI. The distance between the urethral ends was measured. Image quality was scored by four radiologists and four urologists. The surgical approach and type of PFUI repair were noted. We also established the need for inferior pubectomy by assessing the position of the posterior urethra to a horizontal line drawn from the lower edge of the pubic bone anteriorly to the rectum posteriorly in a sagittal image.

Study design

After obtaining approval from the ethics committee and IRB (KESI/05), we initiated this prospective study evaluating MRI imaging for PFUI. All male patients aged >18 years who presented with posterior urethral injury, suitable for MRI, and agreed to participate in the study were included. Written and informed consent was taken. Patients with incomplete urethral disruption, those not suitable for MRI, and those who did not consent to participate in the study were excluded. Data on demographic information, health history, injury characteristics, imaging studies, and type of surgical repair were collected.

VCUG and RUG protocol

All patients underwent RGU and VCUG. The bladder was filled using gravity filling via a suprapubic catheter (SPC), with 50% diluted contrast and normal saline, and the patient was asked to void;[15] at the same time, the voiding RGU was performed by injecting the same solution via the urethra while applying penile traction. A combined RGU and VCUG image was obtained. Thereafter, pelvic MRI procedures were performed using both the standard and "Joshi" protocol.

Main Points:

- MRI in patients with pelvic fracture urethral injuries and recto-urethral fistulas should be performed using the Joshi protocol: full bladder and lignocaine jelly in anterior urethra; T2 sagittal images.
- The Joshi protocol can help predict the need for pubectomy.
- This protocol helps determine the direction of displacement of the prostate and posterior urethra in cases of PFUI.
- This protocol can provide high-quality MR images.

MRI protocol

Standard MR pelvis was performed on an empty bladder. MR images using the standard procedure and the "Joshi" protocol were obtained. The night before the assessment date, the patient was premedicated with a selective alpha blocker so as to open the bladder neck. The bladder was filled with saline using an SPC. A mixture of sterile saline and lignocaine jelly was injected via the meatus, and the penis was clamped using a gauze piece. A T2 sagittal image was acquired on a full bladder with the patient attempting to pass urine. The images were used to evaluate the urethral gap, orientation of the posterior urethra, and the relation of the posterior urethra to the rectum. A urethral gap assessment was done for each patient. The surgical approach and type of PFUI repair were noted. Image quality was scored by four radiologists and four urologists as excellent (4), satisfactory (3), disappointed (2) and extremely disappointed (1).

Statistical analysis

Continuous variables were assessed using a paired t-test. Nominal variables were assessed using the Chi-squared test. The correlation between the modalities was calculated using the paired t-test. SPSS software was used for statistical analysis.

Results

Patient population

Between January 2018 and January 2020, 297 patients presented with PFUI; 40 male patients were eligible and agreed to participate in the study. The mean age was 30 years (SD, 5.25; range, 21–43 years) and the time from injury to imaging was 4 months (3–10 months); 40% of the men underwent step 2 (corporal separation), while 57.5% underwent step 3 (inferior pubectomy), and 2.5% underwent step 4 (crural rerouting) procedures.

Results of VCUG/RUG

VCUG and RGU were performed on all patients. The average gap was 2.77 cm (SD, 0.53; range, 1–4 cm).

Results of traditional MRI

Traditional MRI was performed on an empty bladder. The urethral gap ranged from 1 to 5 cm. The average gap assessment was 3.27 cm (SD, 0.68).

Results of "Joshi" protocol

MRI with the "Joshi" protocol was performed with a full bladder, premedication with alpha blocker, and instillation of saline with gel in the urethra. The urethral gap ranged from 1 to 4 cm. The average gap was 2.65 cm (SD, 0.53). The urethral gap range on the "Joshi" MR image was lower than that on standard MR image.

Comparison between the modalities

The urethral gap differed between the standard MRI and "Joshi" protocol MRI (range, 0.3–1.1 cm) (Table 1). The correlation coefficient between the standard MRI, RGU, and VCUG was 0.897 while between the "Joshi" protocol MRI, RGU, and VCUG, it was 0.96 on the paired t-test. The results of the MRI performed using "Joshi" protocol were very close to the results of conventional RGU and VCUG. The participating urologists stated that MR images acquired using our protocol essentially mirrored the images obtained from conventional RGU and VCUG and were easy to interpret, while providing additional information on anatomical and soft tissue.

Quality assessment of images between evaluators

The satisfaction scores of both radiologists and urologists ranged from satisfactory to excellent. The average scores of the radiologists and urologists were 3.8 and 3.82, with the median score being 4 for both.

Need for inferior pubectomy

Our protocol was also used to determine the need for inferior pubectomy in the patients (gap close to 3 cm) by assessing the position of the urethral stump to a horizontal line drawn from the lower edge of the pubic bone anteriorly to the rectum posteriorly in a sagittal image. The majority of the patients in our study required inferior pubectomy (23/40 patients). The risk of inferior pubectomy was 100% if the urethral stump was over the defined line, being statistically significant for Step 2 vs. Step 3 ($p<0.0001$) and Step 2 vs. step 4 ($p<0.0001$) (Figure 1).

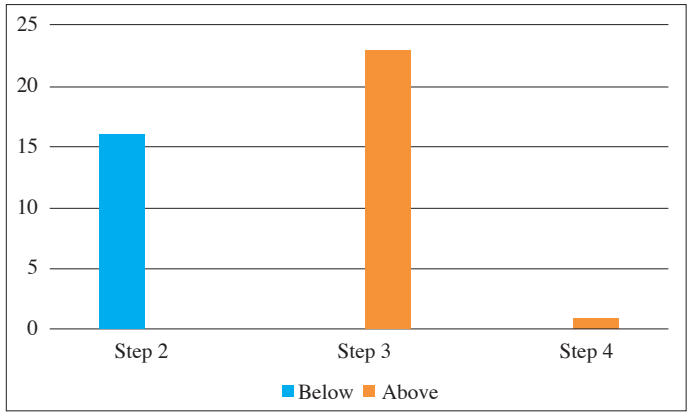

Figure 1. Need for pubectomy based on the horizontal line drawn between inferior pubic margin and rectum

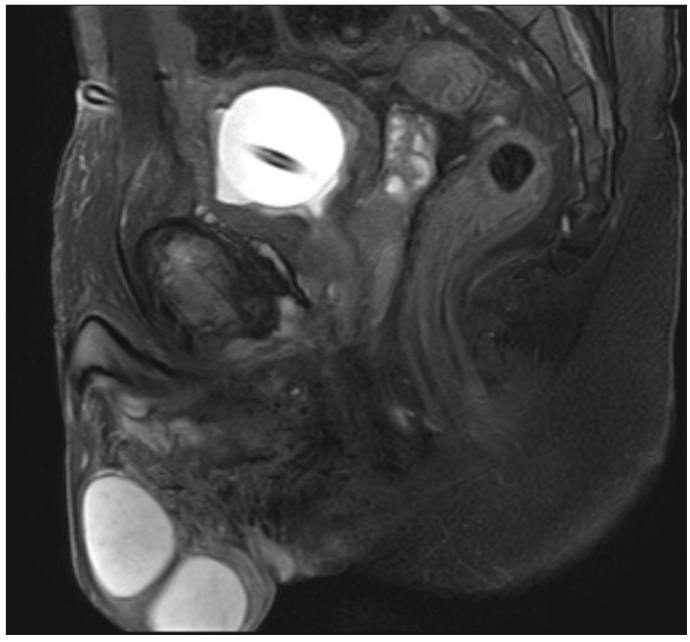

Figure 2. Routine magnetic resonance imaging (MRI) at the radiology department

Discussion

Assessment of the urethral gap in PFUI is of relevance in deciding the approach to anastomotic urethroplasty. Conventional assessments include RGU and VCUG. However, the accuracy of these assessments is limited when the urethral gap of the bladder neck is not open, there is prostatic displacement on the horizontal or vertical axis, and when the condition is complicated, e.g., fistula, diverticula, or false passages. MRI has been used in complex PFUI cases to overcome these limitations.[16]

On comparing the protocols, we found that the posterior and anterior urethral outlines were not well defined, and hence, the urethral gap assessment was difficult. While, in the "Joshi" protocol, the edges of the urethra were well defined due to the saline that acts as a natural contrast on MRI (Figures 2-5).

In a study by Dixon et al.[16] involving 18 patients, a T2-weighted MR image was acquired to evaluate PFUI patients. In our protocol, we used similar image acquisition modalities but with additional steps of a full bladder, pre-MRI alpha blocker administration, and urethral instillation of a premixed solution of sterile saline and jelly in the urethra. This assists in clearly defining the ends of the urethra and gap assessment.

Another study by Oh et al.[17] involving 25 patients with PFUI compared MRI with conventional RGU and VCUG and con-

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Table 1. Study results

Patient number	Age	MRI - standard	MRI - "Joshi protocol"	Difference	RGU + VCUG	Position of posterior urethra in relation to the line from lower edge of pubic bone to rectum	Surgical approach	Radiologist assessment	Urologist assessment
1	28	4	3.2	0.8	3.1	Above	Step 3	4	4
2	32	3.5	2.7	0.8	2.7	Above	Step 3	3	4
3	43	3	2.4	0.6	2.4	Below	Step 2	3	4
4	21	4	3.3	0.7	3.2	Above	Step 3	4	4
5	31	5	4	1	4	Above	Step 4	4	4
6	27	4	3	1	2.8	Above	Step 3	4	4
7	26	3.5	2.4	1.1	3	Above	Step 3	4	4
8	33	3	2.6	0.4	2.8	Above	Step 3	3	3
9	34	2.8	2.1	0.7	2	Below	Step 2	4	4
10	37	3	2.7	0.3	2.8	Above	Step 3	3	3
11	29	2.5	2.2	0.3	2.4	Below	Step 2	3	3
12	33	3	2	1	2.4	Below	Step 2	4	4
13	32	2.7	2.4	0.3	2.6	Above	Step 3	4	3
14	28	2.6	2.1	0.4	2.2	Below	Step 2	3	3
15	21	3.5	3	0.5	3.1	Above	Step 3	4	4
16	29	2.8	2.4	0.4	2.6	Below	Step 2	4	4
17	41	4	3	1	3.3	Above	Step 3	4	4
18	28	3	2.7	0.3	2.9	Above	Step 3	3	4
19	21	4	2.9	1.1	3	Above	Step 3	4	4
20	26	3	2.7	0.3	3	Above	Step 3	4	4
21	27	2	1.8	0.2	2	Below	Step 2	3	3
22	32	3.2	2.8	0.4	2.9	Above	Step 3	4	4
23	35	3.7	2.8	0.9	2.9	Above	Step 3	4	3
24	34	3	2.7	0.3	2.9	Below	Step 2	4	4
25	26	3.7	3	0.7	3.1	Above	Step 3	4	4
26	37	2.9	2.6	0.3	2.6	Below	Step 2	4	4
27	26	2.8	2.1	0.7	2	Below	Step 2	4	4
28	23	3.6	2.6	1	2.8	Below	Step 2	4	4
29	37	1.3	1	0.3	1	Below	Step 2	4	4
30	27	3.3	2.8	0.5	2.7	Below	Step 2	4	4
31	34	3.4	2.9	0.5	3	Above	Step 3	4	4
32	32	3.2	2.6	0.6	2.8	Above	Step 3	4	4
33	30	3.7	2.9	0.8	3	Below	Step 2	4	4
34	28	2.9	2.3	0.6	2.5	Below	Step 2	4	4
35	26	4	3.1	0.9	3	Above	Step 3	4	4
36	23	3.7	3.2	0.4	3.3	Above	Step 3	4	4
37	24	2	1.6	0.4	1.7	Below	Step 2	4	4
38	34	4.1	3.3	0.8	3.4	Above	Step 3	4	4
39	33	3.7	2.7	1	2.8	Above	Step 3	4	4
40	32	3.8	3.3	0.5	3.4	Above	Step 3	4	4

Figure 3. Magnetic resonance imaging (MRI) in same patient with full bladder using Joshi protocol

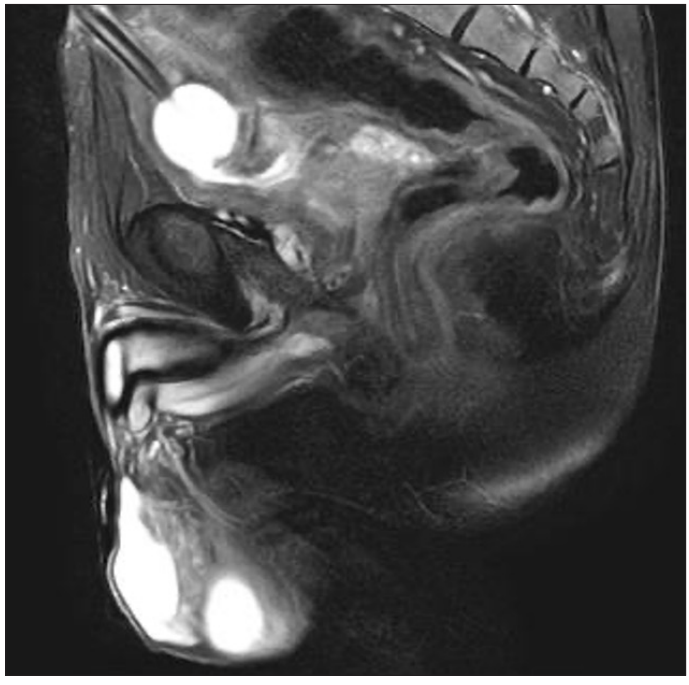

Figure 4. Magnetic resonance imaging (MRI) with empty bladder

cluded that MRI was more accurate than conventional imaging modalities. Our study compared RGU, VCUG, standard MRI, and "Joshi" MRI protocol. The main advantage of the Joshi protocol is that it uses saline as a natural contrast and delineates anatomical structures to improve image acquisition during an MRI study.

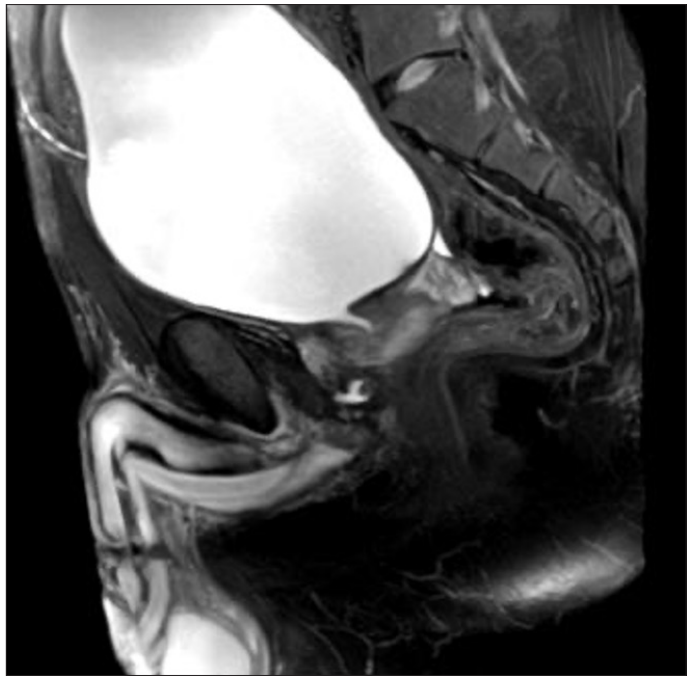

Figure 5. Magnetic resonance imaging (MRI) showing high-lying prostate with posterior dislocation

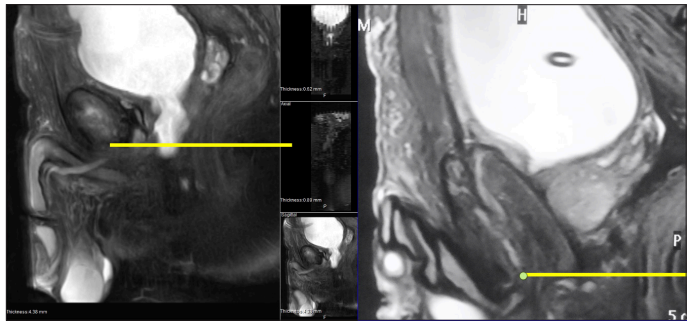

Figure 6. Horizontal line drawn from lower edge of pubic bone can predict the need for pubectomy

Can we predict the need for pubectomy?

A horizontal line was drawn from the lower edge of the pubic bone anteriorly to the rectum posteriorly in the sagittal image. If the tip of the posterior urethra (membranous urethra) was seen below this horizontal line, the risk of inferior pubectomy was low, but if the tip was above this horizontal line, and the risk was high (Figure 6). A high-lying posterior urethra would indicate the need for a transpubic approach. The majority of the patients in our study required inferior pubectomy (23/40 patients). The increased need for inferior pubectomy in India has been previously published.[14] Joshi et al.[18] described the technique of 3D printing in complex cases, which also serves a similar purpose as 3D visualization, which assists in preoperative planning.

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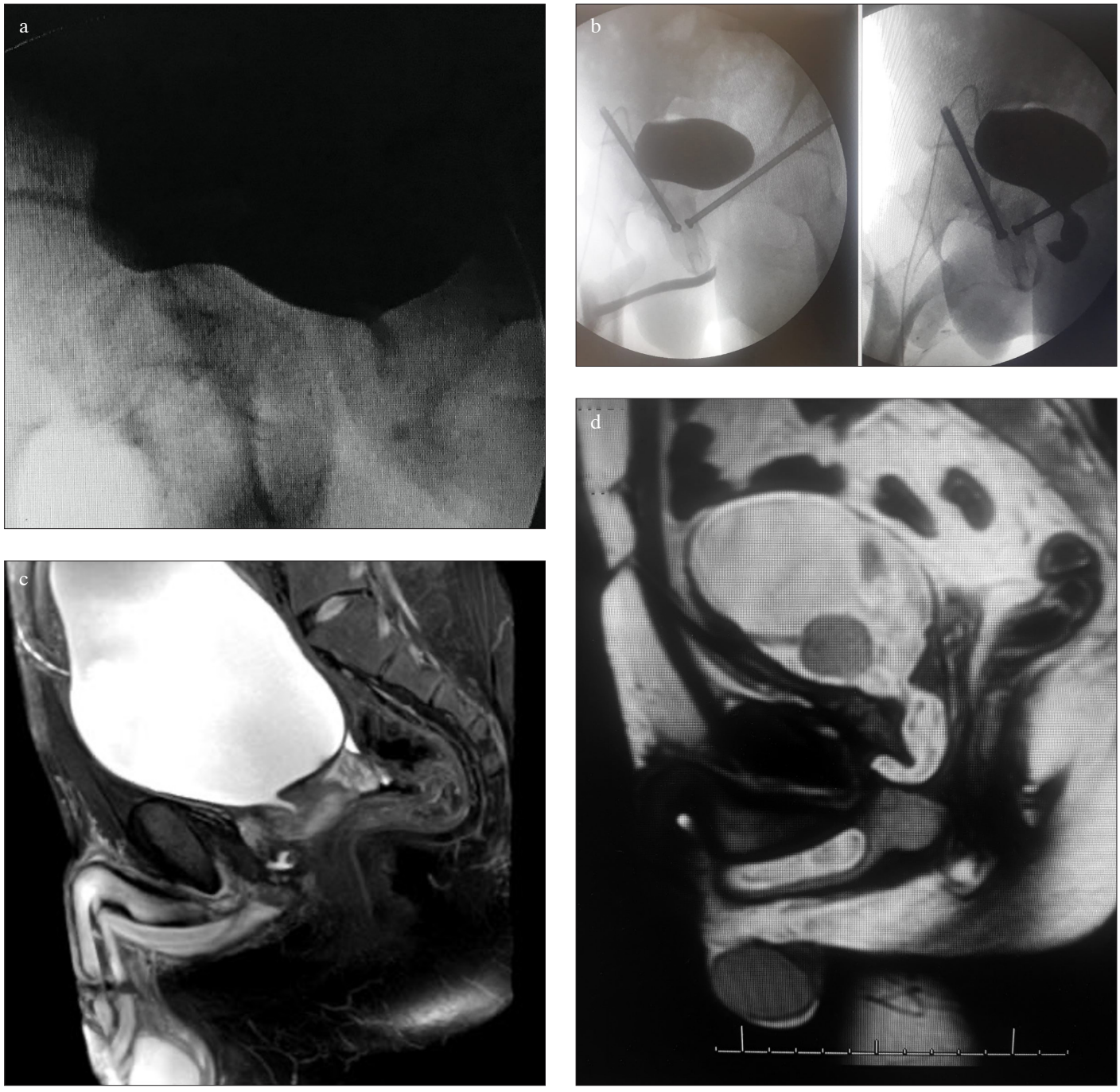

Figure 7. a-d. (a) Two-dimensional voiding cystourethrogram (VCUG) image. (b) Voiding cystourethrogram (VCUG) shows curved posterior urethra but does not predict the direction of displacement. (c) Magnetic resonance imaging (MRI) with our protocol showing posterior displacement of prostate. (d) Three-dimensional magnetic resonance imaging (MRI) showing that the posterior urethra is displaced anteriorly

Orientation of the posterior urethra

The most feared complication of posterior urethroplasty is the risk of rectal injury. The risk of rectal injury is higher if the posterior urethra is placed high and displaced towards the rectum. A typical VCUG provides a 2D image (Figures 7a, b). Our MR protocol accurately assessed the displacement of posterior urethra, towards the rectum or away from rectum, and assisted in surgical technique (Figures 7c, d). In cases of rectourethral

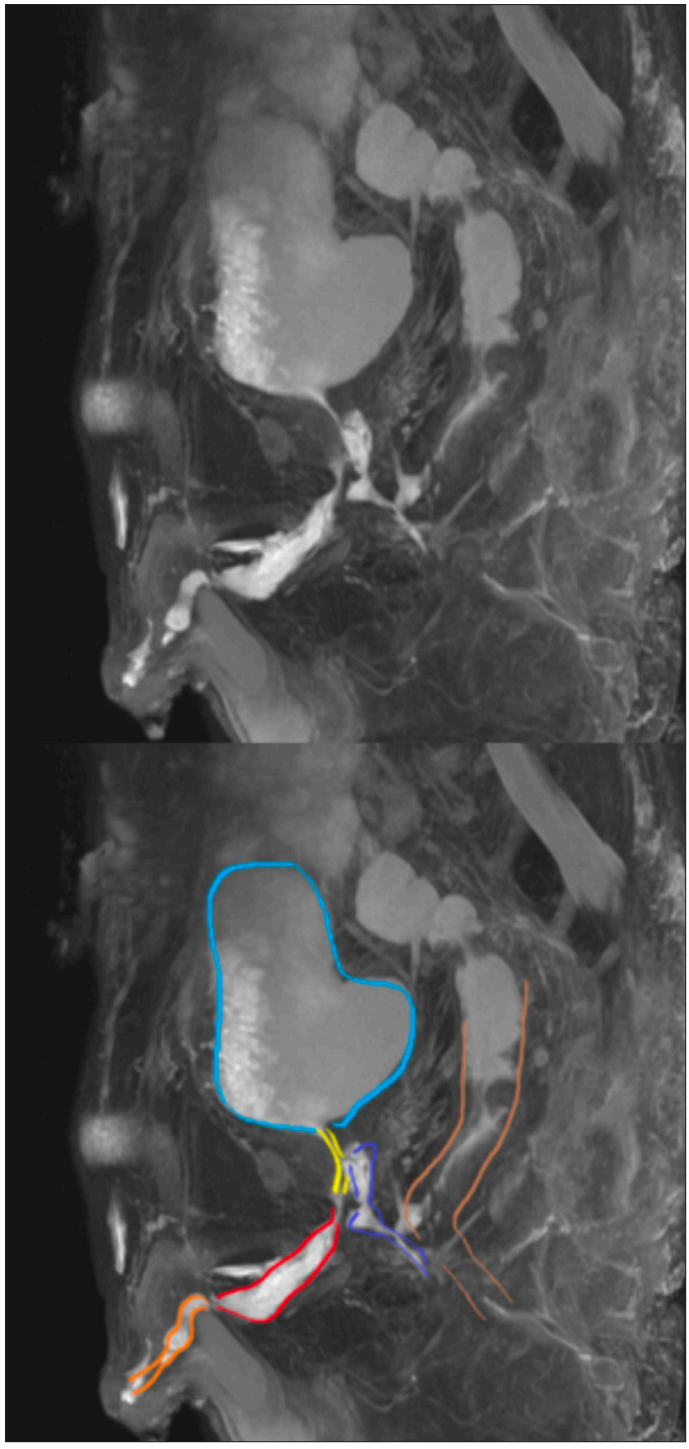

Figure 8. Magnetic resonance imaging (MRI) with our technique in patients with rectourethral fistula

fistula, by injecting lignocaine jelly in the anterior urethra, we could accurately demonstrate the fistulous tract (Figure 8). We propose a algorithm for imaging in pelvic fracture urethral injuries (Figure 9).

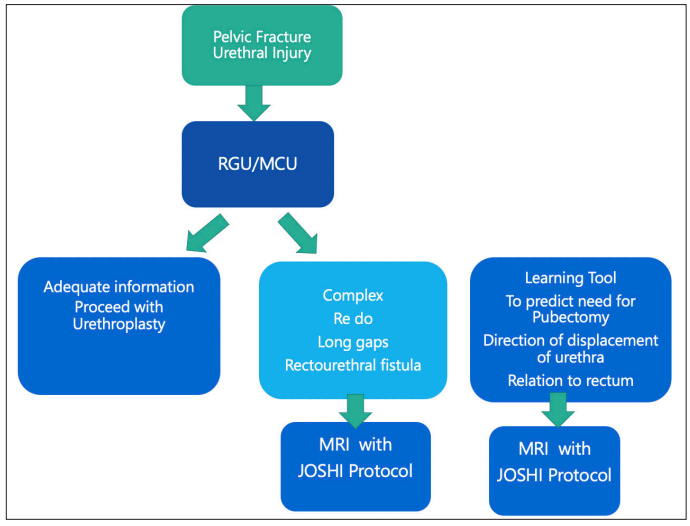

Figure 9. Algorithim for imaging in pelvic fracture urethral injuries

Conclusion

MR image acquisition using the simplified "Joshi" protocol gave good anatomical information in PFUI cases to assist with surgical planning. The images were well scored by both radiologists and urologists. Our MRI protocol may be used to replace conventional RGU and VCUG in cases of complex PFUI.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Kulkarni Endosurgery and Reconstructive Urology Centre IRB (KESI/05).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – P.M.J., D.J.D., S.B.K.; Design – P.M.J., D.J.D., S.B.K.; Supervision – P.M.J., D.J.D.; Resources – D.S., D.P.J.; Materials – P.M.J., D.J.D.; Data Collection and/or Processing – P.M.J., D.J.D.; Analysis and/or Interpretation – P.M.J., D.J.D., D.S., D.P.J.; Literature Search – D.J.D., P.M.J.; Writing Manuscript – D.J.D., P.M.J.; Critical Review – P.M.J., D.J.D., S.B.K.; Other – D.S., D.P.J.

Conflict of Interest: The authors have no conflicts of interest to declare.

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