International Journal
of
Radiology and Diagnostic Imaging

E-ISSN: 2664-4444
P-ISSN: 2664-4436
www.radiologypaper.com
IJRDI 2021; 4(2): 15-29
Received: 13-02-2021
Accepted: 15-03-2021

Dr. Vinay Niranjan Seerla
Post Graduate Resident,
Department of Radiodiagnosis,
Narayana Medical College,
Nellore, Andhra Pradesh,
India

Dr. KS Vedaraju
Professor and HOD,
Department of Radiodiagnosis,
Narayana Medical College,
Nellore, Andhra Pradesh,
India

Dr. Ramakrishna Rao Baru
Professor,
Department of Radiodiagnosis,
Narayana Medical College,
Nellore, Andhra Pradesh,
India

Dr. P Suneetha
Professor,
Department of Radiodiagnosis,
Narayana Medical College,
Nellore, Andhra Pradesh,
India

Dr. Archana B
DMRD Postgraduate,
Narayana Medical College,
Nellore, Andhra Pradesh,
India

Dr. Maj T Saikrishna
MD Radiology,
Department of Radiodiagnosis,
Narayana Medical College,
Nellore, Andhra Pradesh,
India

Dr. Venkatesh Manchikanti
Assistant professor,
Department of Radiology,
Narayana Medical College,
Nellore, Andhra Pradesh,
India

Corresponding Author:
Dr. Venkatesh Manchikanti
Assistant professor,
Department of Radiology,
Narayana Medical College,
Nellore, Andhra Pradesh,
India

Study of sonourethrography in comparision to conventional retrograde urethrography in evaluation of male urethral pathologies

Dr. Vinay Niranjan Seerla, Dr. KS Vedaraju, Dr. Ramakrishna Rao Baru, Dr. P Suneetha, Dr. Archana B, Dr. Maj T Saikrishna and Dr Venkatesh Manchikanti

DOI: http://dx.doi.org/10.33545/26644436.2021.v4.i2a.195

Abstract
Sonourethrography is a dynamic 3-dimensional study that can be repeated with minimal radiation exposure, provides higher efficiency than RGU in the detection of anterior urethral stricture disease and would greatly aid in diagnosis and choice of therapies and we have found it to be a notable improvement over the conventional radiographic urethrography in examination of male anterior urethra. SUG can evaluate anterior urethra more accurately than the conventional RGU. RGU fails to measure the exact length of the stricture urethra irrespective of the site due to anatomical and technical limitations. Periurethral changes, urethral lumen, plaques and spongiofibrosis are better visualised on sonourethrography. Based on the current study, it is strongly recommended that always the evaluation of the male urethra shall include both the conventional RGU and retrograde SUG to achieve accurate results and thus helping in further management. SUG results did change the final management mode in 32.14% of the cases, and the techniques and graft preparation were decided after SUG in almost 100% of the cases that required urethroplasty, which is very significant (p<0.001).

Keywords: sonourethrography, RGU, urethrogyaphy, SGU, urethral strictures, spongiofibrosis, urethropalsty

Introduction
The obstructive urethral pathologies, especially stricture disease, is a gray area that needs thorough imaging. Retrograde urethrography (RGU/RUG) is the definitive imaging study for the diagnosis and management of urethral stricture disease. But radiation exposure, contrast medium usage, relatively poor definition of stricture length, and degree of scar formation are its limitations. Also, as radiographic urethrography is 2-dimensional, the stricture's appearance varies according to the stretch on the penis and the patient's position.

Retrograde sonourethrography (SGU/SUG) is a relatively new technique but is underutilized in most centers despite its ability to give adequate details of the male anterior urethra and additional information in male urethral pathologies.

A dynamic 3-dimensional study that can be repeated with minimal radiation exposure would greatly aid in diagnosis and therapy choice. In sonourethrography, the male anterior urethra is examined with high-frequency ultrasound while installing intra-urethral normal saline.

The need to investigate this particular problem arose during my initial days of post-graduation in conventional radiology. I observed that the imaging of male urethral pathology is not widespread in the radiology literature because urologists conveniently study this part of the urinary tract. Also patient and the person performing the procedure are both being exposed to the radiation when there is a safe and more effective alternative, especially for the anterior urethral stricture disease.

Sonourethrography, though it cannot replace the conventional retrograde urethrography due to its limitation of inadequate visualization of the male posterior urethra, can become an adjunct to any urethrography examination and is superior to traditional retrograde urethrography while examining the male anterior urethra. And it can even replace the RGU when the anterior urethra is the area of concern.

Materials and Methods

Hospital-based prospective study at the Department Of Radiodiagnosis, Narayana medical college, and the hospital, Nellore over a period of 2 years amongst 60 patients who were being evaluated for signs and symptoms of stricture disease. Once an abnormality was visible on radiographic urethrography, the patient immediately underwent a sonourethrography for comparison. The radiographic findings were not disclosed to the sonographer until completion of the ultrasound examination.

Inclusion Criteria

Male patients referred for conventional RGU with poor stream of urine, difficulty in micturition, urethral injuries, fistulas will be selected especially those with anterior urethral pathologies are more preferred as posterior urethra will not be adequately visualized with normal linear probe.

Exclusion criteria

Those with symptoms suggestive of acute urethritis, recent instrumentation, allergic to conventional RGU contrast media will be excluded.

Informed consent regarding the procedures to be performed will be taken from all patients.

Sonourethrography is performed using a standard small-parts 7.5 MHz linear array transducer placed directly on the ventrum of the penis, scrotum, and perineum after the gel is applied. The real-time images of the urethra are obtained sequentially from the pendulous urethra proximally toward the deep bulbar area while the saline is slowly and repeatedly instilled through a catheter-tip syringe into the meatus.

Slow, constant infusion of approximately 10 to 15 ml. saline was required to evaluate the anterior urethra thoroughly. Multiple transverse and longitudinal scans were performed. The location and length of strictures were identified, and an attempt was made to detect the degree of scarring and spongiofibrosis within the strictures. Transscrotal scans were subsequently performed to evaluate the posterior urethra. The entire ultrasound examination could be completed by an experienced ultrasonographer in approximately 10 minutes. Stricture length was determined by direct measurement from the retrograde urethrography films and electronic caliper measurements from the sonourethrograms. Strictures were characterized as focal if they were 1 cm. long or less and diffuse if the length exceeded 1 cm. To diagnose the degree of the stricture, the anteroposterior diameter of the strictured area was compared to the average luminal diameter. The strictures were classified as mild-encroachment upon less than a third of the lumen, moderate-encroachment upon a third to half, and severe-encroachment upon more than half. Cystoscopy confirmed the presence of all strictures.

Strictures were characterized as

1) Focal: If 1 cm. or less in length and
2) Diffuse: If the length exceeded 1 cm.

To diagnose the stricture degree, the anteroposterior diameter of the strictured area and the average luminal diameter are compared. The strictures were then classified as

1. mild-encroachment: upon less than a third of the lumen,
2. moderate-encroachment: upon a third to half, and
3. Severe-encroachment upon more than half.

The presence of all strictures and their lengths was confirmed and compared during cystoscopy/surgery.

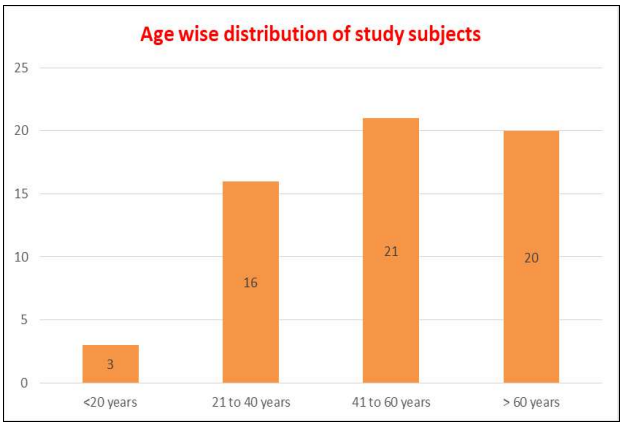
Results and Observations

60 patients are included in our study. All these 60 patients have clinical complaints related to difficulty during micturition. Imaging evidence of stricture disease is noted most of the study subjects. These patients are followed up during our study period and we noted the cystoscopic and surgical management of these patients. The results are as follows.

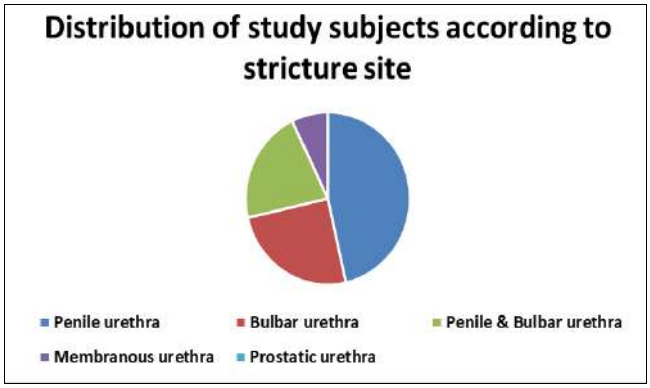
Table 1: The statistical values of RGU,SUG and intraoperative stricture lengths showing the accuracy of mean stricture lengths compared with intraoperative measurements *P.

Method/ Description	RGU	SGU	Intraoperative
Minimum	6	8	8
Maximum	67	89	89
Range	61	81	81
Size	61	59	63
Sum	1221	1817	1888
Mean	20.0163934	30.7966102	29.968254
Median	12	26	25
Mode	10	25, 10	10
Standard Deviation	15.1684891	18.3329171	18.8756271
Variance	230.08306	336.09585	356.289299
Mid Range	36.5	48.5	48.5
Quartiles	Quartiles:	Quartiles:	Quartiles:
	Q1 --> 9	Q1 --> 18	Q1 --> 11
	Q2 --> 12	Q2 --> 26	Q2 --> 25
	Q3 --> 30	Q3 --> 43	Q3 --> 43
Interquartile Range	21	25	32
Outliers	63, 67	89	None
Hypothesis	There is significant difference between the stricture lengths measured by RGU and intraoperative measurements	There is no significant difference between the stricture lengths measured by RGU and intraoperative measurements	-
NULL	No significant difference	Significant difference	-
P VALUE	< .00001	0.36317	

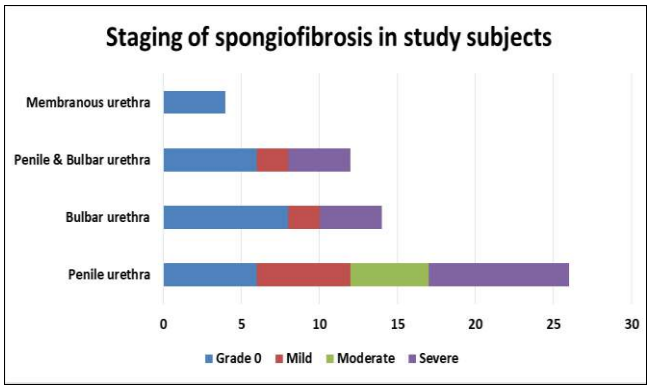
	The difference in mean values of RGU and standard population is highly Significant at p<0.01 Null hypothesis rejected	The difference in mean values of RGU and standard population is not significant even at p < 0.10. Null hypothesis rejected	



Graph 1: Bar chart showing age wise distribution of study subjects in our study.



Graph 2: Pie chart showing Distribution of study subjects according to stricture site involved in our study



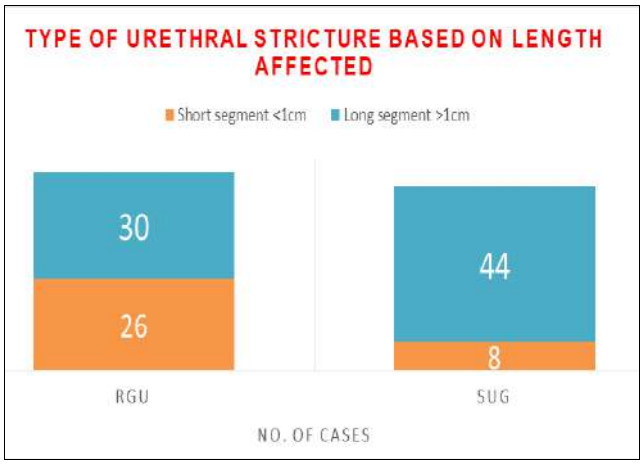
Graph 3: Bar chart showing number of cases and grade of stricture in study subjects.

Table 2: Total number of cases in short and long segment strictures and total number in each type of management

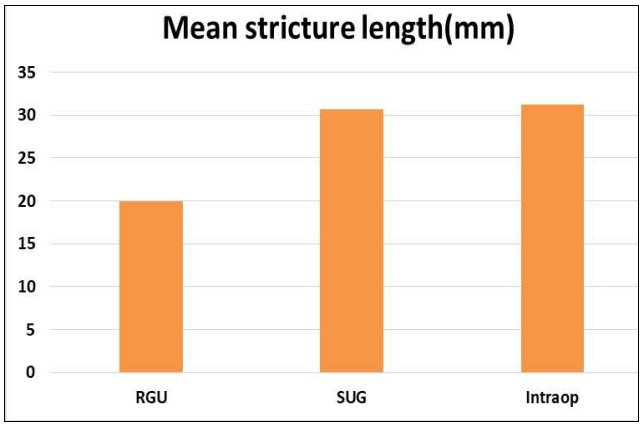
Parameter	Patients
Stricture length	
<1 cm	10
>1 cm	46
Management	
Direct vision internal urethrotomy	9
Urethroplasty (Prepuceal Graft)	21
Urethroplasty (BMG Graft)	22
End to end anastomosis	4

Table 3: Types of urethral strictures identified on each imaging modality in our study.

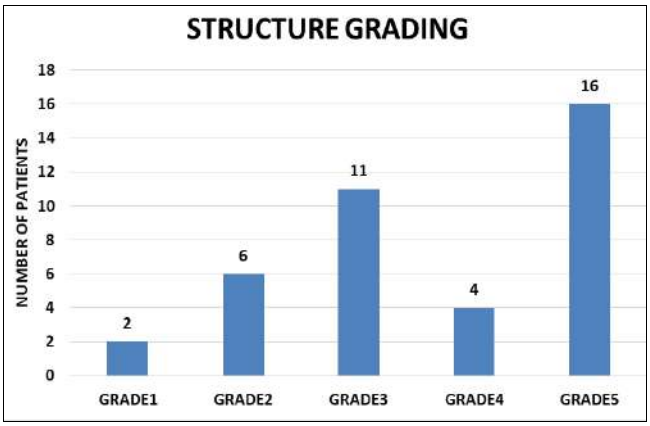
Type	No. of cases	
	RGU	SUG
Short segment <1cm	26	8
Long segment >1cm	30	44



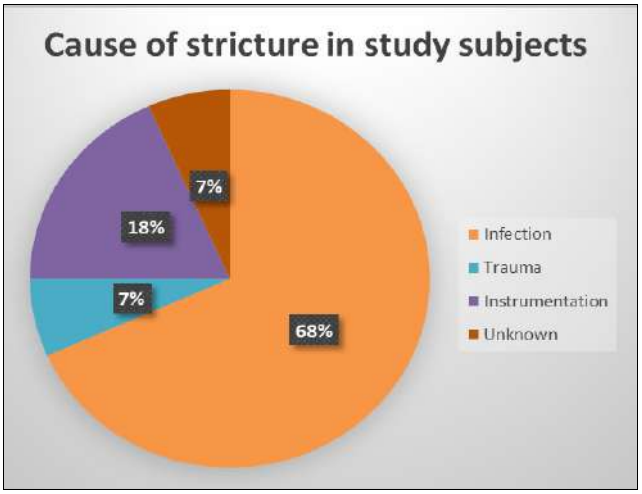
Graph 4: Bar chart showing the type of urethral stricture based on length affected identified on imaging in our study.



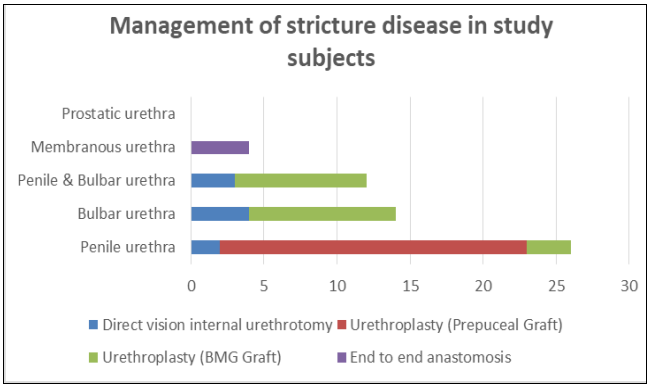
Graph 5: Bar chart showing the mean stricture length identified on each imaging in our study



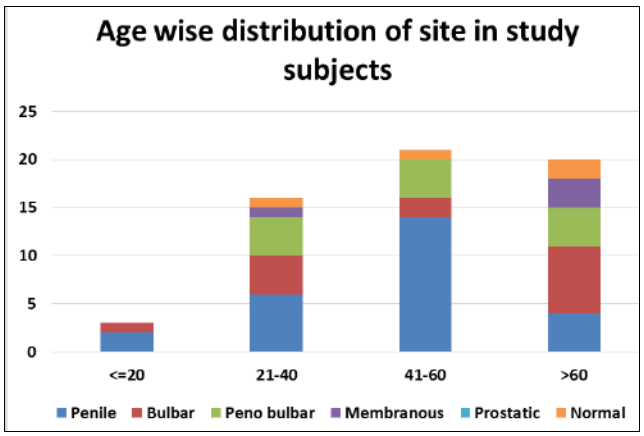
Graph 6: Bar chart showing grading of stricture on SUG



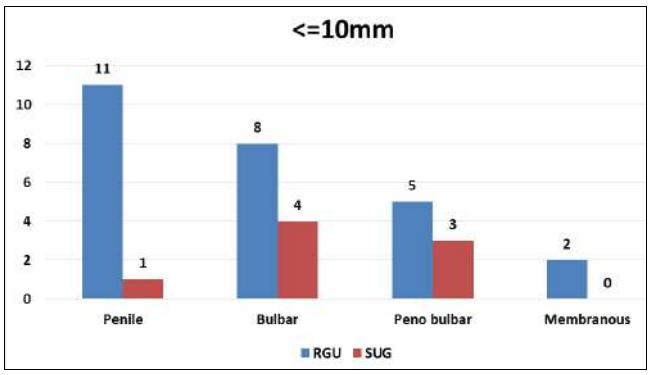
Graph 7: Pie chart showing the Cause of stricture in study subject



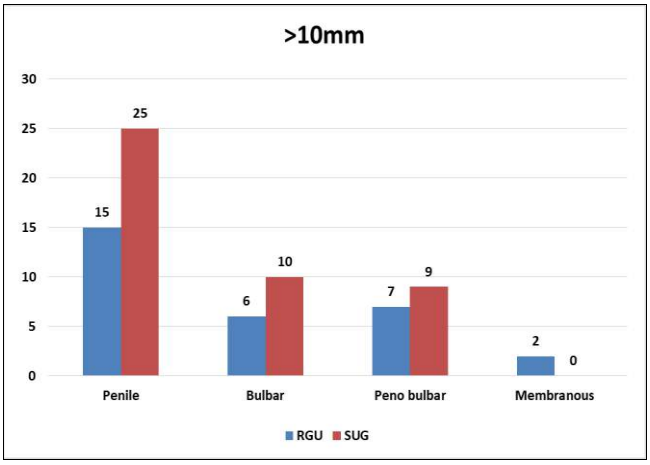
Graph 8: Bar chart showing the management of stricture disease in study subjects



Graph 9: Bar chart showing age wise distribution of site of stricture in our study



Graph 10: Bar chart showing No. of short segment strictures based on site and mode of imaging



Graph 11: Bar chart showing no. of short long strictures based on site and mode of imaging

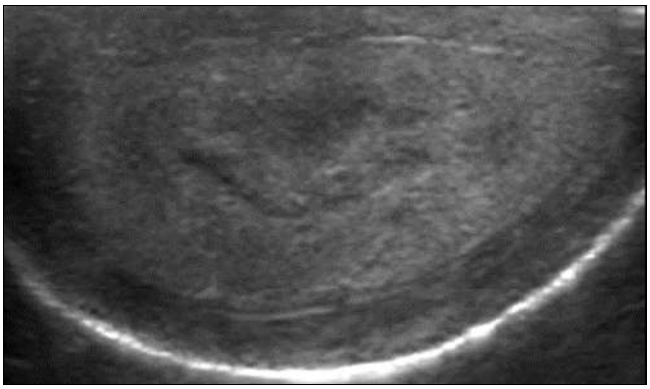


Fig 1: Normal hypoechoic appearance of spongiosa(arrow) in an undistended urethra

The echogenic appearance of collagen tissue within the stricture did not allow ultrasound per se to distinguish between normal and involved spongiosum. However, when the urethra was distended with saline the normal spongiosum was compressed easily, while the collagenladen stricture segment maintained a rigid configuration.

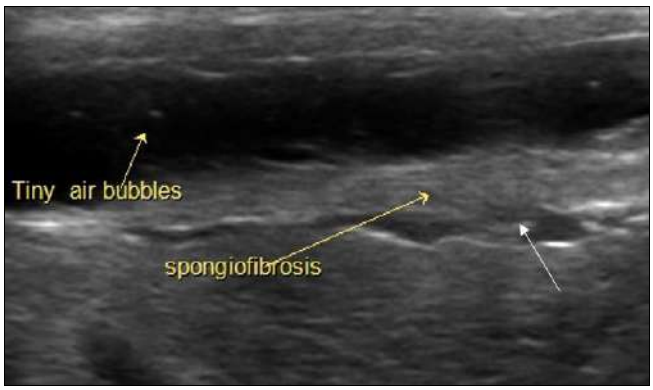


Fig 2: Mild degree of spongiofibrosis with periurethral seepage mimicking false tract (white arrow). Note the tiny air bubbles in the non-dependent position.

Sufficient information thereby was provided to classify the degree of spongiofibrosis. In the 6 patients who underwent full depth biopsy at urethroplasty, collagen had completely replaced the spongiosum and no normal spongiosum could be identified. In each case sonourethrography correctly classified the stricture as severe. Sonographic evaluation of the posterior urethra was technically limited despite a trans

scrotal approach owing to inability to scan the urethra in a perpendicular fashion.

Diagnostic studies were obtained in 56 (93.33 percent) cases. Surgical-cystoscopic follow-up in 38 patients with exclusive anterior urethral strictures agreed with the conventional RUG findings in less than 30% of cases and with the sonourethrography findings in almost 100% per cent of the cases.

Out of total 56 patients, 5 (8.9%) were having multiple strictures. Mean stricture length was 20.016mm, 30.79mm and 31.28 in RGU, SUG and intraoperative methods out of which intraoperative stricture measurement is the gold standard. Analysis of the results showed that when the stricture length measured by sonourethrography was compared with the measurements on conventional urethrography the difference between the two tests was significant ($P < 0.001$) and the correlation coefficient was poor.

- Maximum numbers of cases are noted in 41-60 years age group.
- Most of the patients presented with symptoms of poor stream of urine/ difficulty in micturition.
- Sonourethrography is limited to anterior urethra where conventional retrograde urethrography is relatively better in case of posterior urethral evaluation.
- Periurethral changes, urerthral lumen, plaques and spongiofibrosis are better visualised on sonourethrography compared to conventional retrograde urethrography.
- Anterior (penile) urethral stricture is the commonest stricture in our study. Urinary tract infection is the commonest cause most of the cases followed by instrumentation and trauma.
- In more than 80% cases of peno-bulbar urethral strictures, the stricture is noted predominantly involving the bulbar urethra.
- Simple short segment strictures are noted in smaller number(17.86%) of cases in our study.
- In cases of long segment strictures, infections accounted conflict in most number of cases.
- Maximum cases(82.14%) in our study are high grade long strictures and they received surgical management by BMG.
- Patients with short segment mild and moderate grade strictures received dilatation and DVIU.
- In 38 cases, the surgical findings are consistent with sonourethrographic findings, whereas RGU underestimated the stricture length in 18 cases. While SUG failed to adequately image the posterior urethral strictures in 4 cases, RGU picked up the stricture in all the cases with posterior urethral strictures.
- The procedure is well tolerated and can be used in the diagnostic or operating room to obtain repeated real-time assessments of questionable areas without radiation exposure.
- SUG results did change the final management mode in 32.14% of the cases and the techniques and graft preparation were decided after SUG in almost 100% of the cases that required urethroplasty which is very significant($p<0.01$)

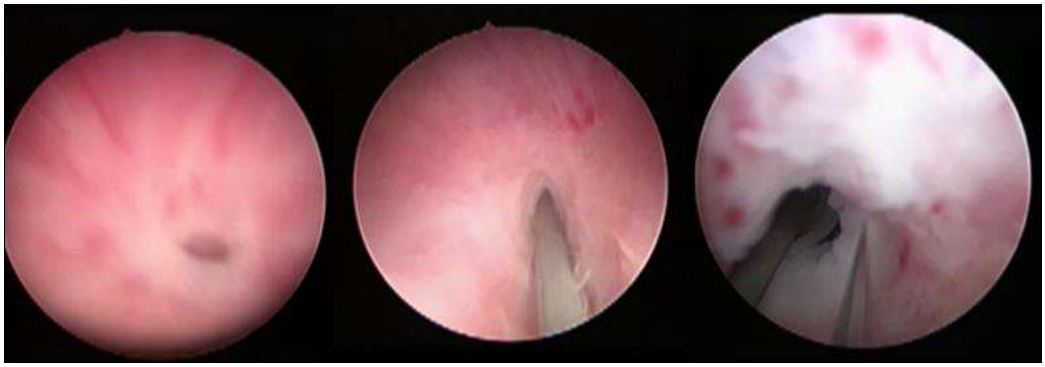
In all these patients sonourethrography defined the stricture length more precisely then conventional urethrography

A B C

Fig 3: RGU scout (a) and contrast (b) and Intraoperative(c) images showing the calculus within the bulbar urethra

A B

Fig 4: RGU images (a. scout, b. contrast) showing the calculus within the fossa navicularis



A B C

Fig 5: Cystoscopic images in 3 different patients with different grades of spongiofibrosis showing:
1. Mild (pink) form of spongiofibrosis
2. Moderate (grey) form of spongiofibrosis
3. Sever (white) form of spongiofibrosis

Fig 6: RGU in a case with Enlarged prostrate.

Three diagnostic points of cardinal importance can be noted in a case of prostatic enlargement

1. Lengthening of the prostatic urethra.
2. Displacement of the prostatic urethra by unequal growth of the lobes.
3. Intravesical projection.

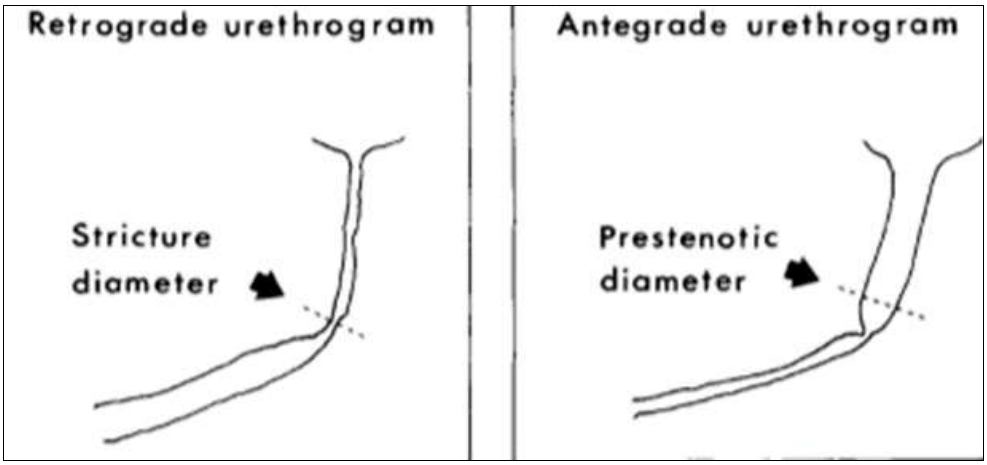


Fig 7: Schematic illustration of the methods used for measuring the stricture diameter and prestenotic urethral diameter [12]

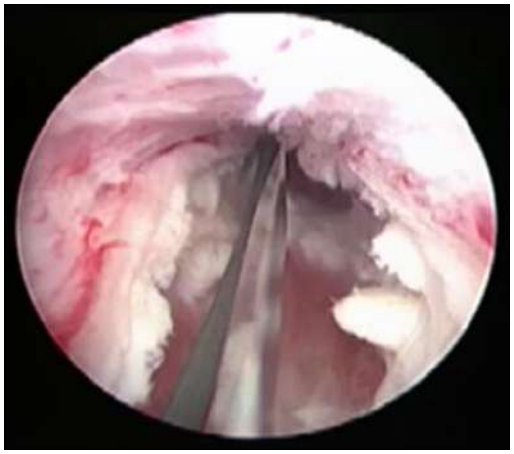


Fig 8: Urethroscopic image showing cut surface of the fibrosed spongiosa in a case with severe SF.

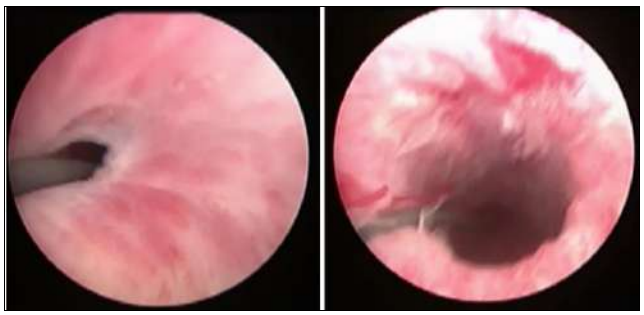


Fig 9: Urethroscopic images showing the urethral lumen before and after stricturotomy with the raw surfaces post proceedure.

Discussion

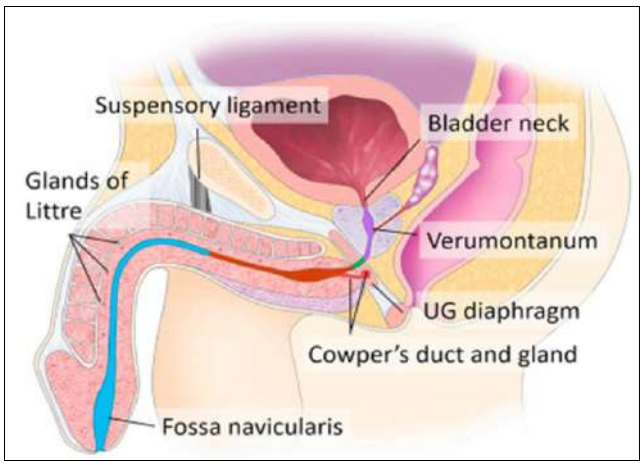


Fig 10: Illustration showing the anatomy of the male urethra and closely related structures [70].

The male urethra - divided into

1. Anterior portion- It is composed of the penile and bulbar urethra to the level of the urogenital diaphragm.
2. Posterior portion- It is composed of the membranous and prostatic urethra.

Variant anatomy

1. Hypospadias, Epispadias, Posterior urethral valves
2. Urethral duplication, Congenital rectourethral fistulae

Pathologies of urethra

Stricture, Calculus, Injury, Posterior valve, Tumors, Hypospadias, Diverticulum

The history of urethrography

Imaging of the urethra had not gained much attention until it was first popularized in 1910 by Cunningham. After that, radiographic retrograde urethrography (RUG) remained the gold standard imaging study for diagnosing urethral strictures. The radiographic technique has made great strides since 1925. Various imaging techniques and their implications on disease management were described by multiple authors down the lane, and gradually many other imaging modalities added up for examining the male urethra [1-70].

Cystoscopy is sometimes difficult due to the presence of strictures or haematuria, and it is then that urethrography is of definite value. In patients suffering from prolonged, tortuous stricture, with or without false passages, where instrumentation was hitherto impossible, a urethrogram will offer essential information such as the local topography, thus avoiding the unnecessary need for Internal or external urethrotomy.

Predominant urethral imaging techniques, including retrograde and antegrade urethrography, sonourethrography, and magnetic resonance imaging, are reviewed herein.

Biracan MK *et al*. in their concluded that, that the results of RGU are misleading when it is not combined with urethroscopy and that it must not be a routine method in the diagnosis of urethral strictures [25].

But now-a-days we initially can use ultrasonography to screen and diagnose the urethral pathologies.

RUG/AUG vs. VCUG/MCU

Generally, RUG/AUG shows anterior urethral abnormalities better than posterior ones.

VCUG/MCU: To visualize posterior urethral abnormalities.

RUG/AUG should be performed first, in case of trauma.

VCUG/MCU cannot be done before RUG, as it involves the blind insertion of the Foleys catheter into the bladder, which, when done in a trauma setting, may lead to additional iatrogenic urethral damage.

Ultrasonography for imaging urethra

To overcome the limitations of conventional radiographic techniques and better define the extent of urethral stricture disease, McAninch *et al*. first popularized the use of ultrasonography to image the male urethra in 1985. Since then, the technique of sonourethrography has been refined with the enhanced accuracy of today's high-resolution scanners.

McAninch JW *et al*. have used retrograde sonourethrography to gain additional information in stricture disease and have found it to be a notable improvement over the conventional radiographic examination.

Sonourethrography could not adequately image the posterior urethra, even when the trans scrotal approach is used. However, sonourethrography is preferable to radiographic retrograde urography since it is a dynamic 3-dimensional and repeatable study without risk of radiation exposure to evaluate patients with suspected anterior urethral strictures [13].

McAninch JW *et al*. The dorsal surface was chosen as the site of transducer application to increase the distance from the transducer to the urethra, thereby minimizing near field artifact. However, with the recent developments, this artifact is minimized, and the transducer is placed directly on the

ventral aspect. The entire anterior urethra could be evaluated readily since it was filled in a retrograde fashion by syringe injection of sterile saline.

Fibrosis of the corpus spongiosum, caused by urethral manipulation, and the resulting ventral penile curvatures are known as the urethral manipulation syndrome. This acquired, the largely iatrogenic deformity is noticed only by sexually active patients. Since fibrosis of the corpus spongiosum begins with urethral inflammation, patients in whom irregularities of the penile urethra are observed during urethrography should be questioned about any erectile deformity.

Beckert R *et al*. Sonourethrography adds as an adjunct to spongiosography and facilitates the decision-making for appropriate treatment. Spogiosum is not found in the membranous and prostatic urethra [16].

Das S *et al*. Ultrasonographic urethrography is a sensitive and reliable diagnostic tool for a comprehensive evaluation of anterior urethral stricture disease. Their comparative analysis found it to have the distinct advantages over standard radiologic urethrography.

Phil Bach *et al*. concluded in their study that independently reported RUGs are not as accurate as primary urologist reported RUGs when used in the preoperative staging of anterior urethral strictures [58].

Advantages of SUG

a. Ultrasonography avoids ionizing radiation, especially to the gonads, which are often within the field of radiologic urethrography [29].
b. Real-time ultrasonic studies allow prolonged periods of observation that can be printed as static images or videotaped for future reference.
c. Better delineate Intra urethral lesions, such as calculi, granuloma, neoplasm, and valves, that are often obscured in two-dimensional roentgenographic films of the contrast filled urethra;
d. Evaluation of postvoid residual urine in the bladder before urethrography indicates how the bladder empties against the outflow obstruction;
e. May reveal associated pathologic features in the neighboring structures, such as penile plaques, neoplasms, and vascular and prostatic pathologic processes [20-22, 31].
f. Cross-sectional 3 dimentional views of the urethral stricture, possible only with ultrasonography, can reveal the lumen size, compressibility, and thickness of the strictured urethra with more clarity [23, 24, 32, 37, 48].
g. Information on the presence and extent of spongiofibrosis, which helps determine the therapy most suitable for the particular patient, is evaluable only with ultrasonic urethrography [26, 31, 34, 39, 56, 57].
h. Ultrasonography can provide intraoperative monitoring to guide the proper selection of internal urethrotomy site and depth; [27, 28,42] and ultrasonic equipment is portable and can be transported to the bedside if necessary [17].

Role of higher cross sectional maging: [19, 44-46, 52, 53, 55, 59].

Xiao-ming Zhang *et al*. studied CT urethrography in diagnosing the male urethral strictures and concluded it as a better tool than the conventional RGU [44].

Kim B *et al*. in their study to determine the role of MR imaging in the diagnosis of urethral diverticula concluded that diverticular disease could be difficult to diagnose clinically, and its prevalence was underestimated until cystourethroscopic and radiologic techniques improved its detectability.

Although MR imaging has a high sensitivity with excellent positive and negative predictive value, it is not recommended as a primary imaging technique owing to its high cost (as much as three times that of VCUG).

The initial workup of the urethral diverticulum includes urethroscopy followed by VCUG. If these studies are inconclusive, but clinical suspicion persists, MR imaging should be considered [33, 40, 41]. The examination should be tailored to the problem and include thin-section axial Ti - and T2-weighted images and sagittal T2-weighted images.

Table 4: Comparison of 4 imaging methods for the diagnosis of male urethra strictures [54].

	RUG and VCUG	SUG	CT urethrography	MR urethrography
Position	Supine 45 oblique	Supine	Supine	Supine
Radiographic contrast	Iodine contrast medium	Gel or normal saline	Diluted Iodine contrast medium	Jelly or normal saline
Radiation exposure to operator	Yes	No	No	No
Radiation exposure to patients	Yes	No	Yes	No
3-dimensional images	No	Yes	Yes	Yes
Periurethral fibrosis	No	Yes	No	Yes
Contraindication	Iodine allergy	No	Iodine allergy	Metal implants
Cost effective	Yes	Yes	No	No

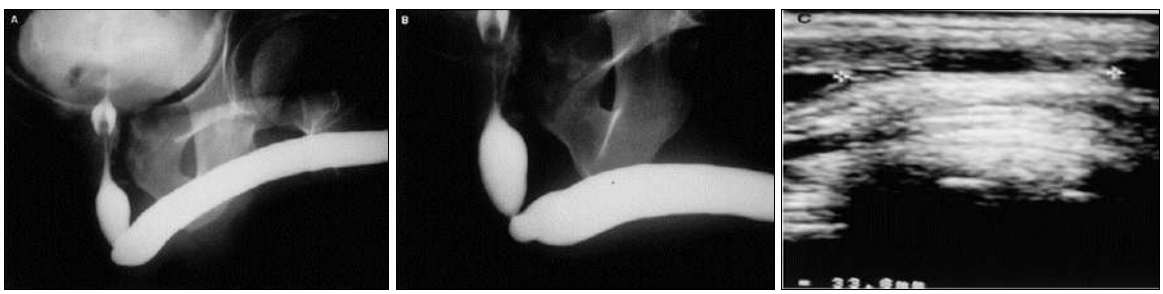


Fig 11: The accuracy of urethral ultrasound guides the selection of reconstructive methods for patients with short bulbar strictures. (A) Retrograde urethrogram shows short stricture that appears amenable to complete resection. (B) The oblique image suggests some complexity, previously unrecognized. (C) Sonourethrogram shows actual stricture length is 3.3 cm, demonstrating the need for buccal graft procedure, which was successful [32].

With urethrosonography, adult bulbar strictures up to 25 mm in length can be treated by resection and end-to-end anastomosis.

Spongiofibrosis

Stricture density (spongiofibrosis) is a critical determinant of appropriate therapy and ultimate prognosis [2]. Because spongiofibrosis is challenging to gauge using conventional imaging, traditional subjective grading systems are marginal clinical utility [36,37]. The urethral wall usually is thin, smooth, elastic, and easily compressible during retrograde saline instillation. Spongiofibrosis appears sonographically as thickened, irregular, nondistensible tissue encroaching into the otherwise anechoic urethral lumen. Echogenicity cannot be used to determine spongiofibrosis because it is variable and dependent on the examiner's technical adjustments. Although the depth of periurethral fibrosis cannot be accurately distinguished ultrasonically, sonourethrography allows spongiofibrosis to be objectively determined as severe by identifying posterior shadowing (Fig. 6) and by measuring a nondistensible lumen diameter to be\3 mm during maximum retrograde distention.

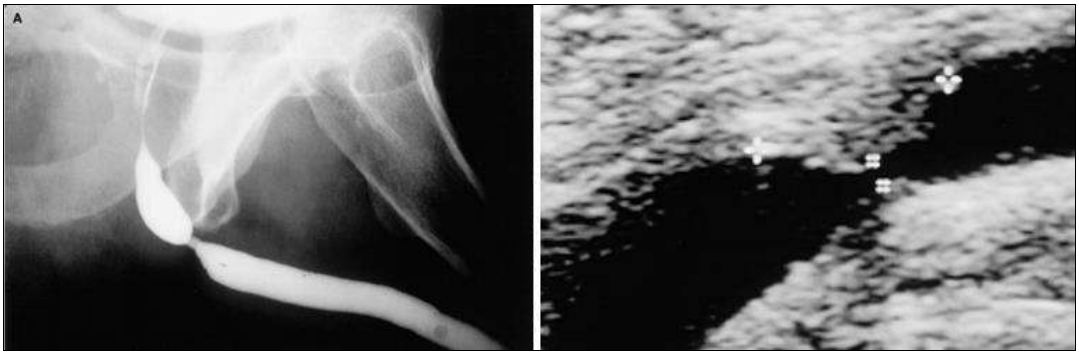


Fig 12: (A) RUG underestimates the severity of stricture. (B) Sonourethrogram demonstrates a correct stricture length of 17.0 mm and severe spongiofibrosis with a lumen diameter of 2.2 mm.

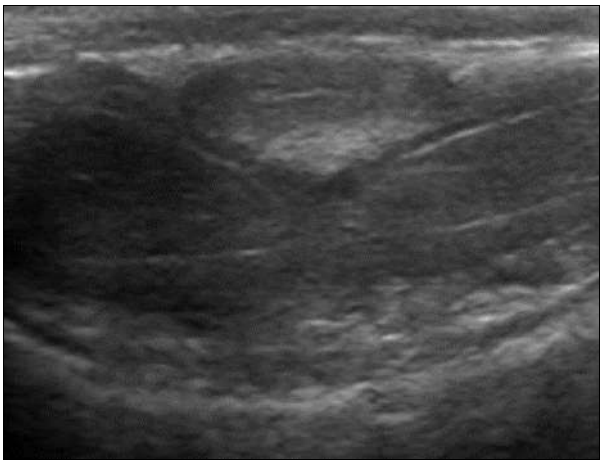


Fig 13: Axial sonographic image of penis showing increased echogenicity (arrow) in the corpus spongiosum

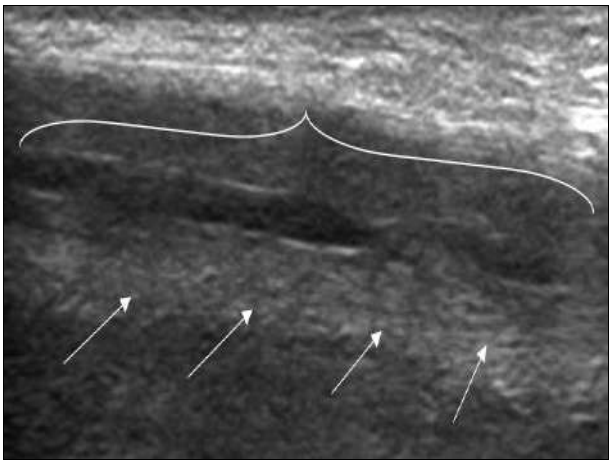


Fig 14: longitudinal SGU image showing long segment narrowing (bracket) of the penile urethra with surrounding spongiofibrosis(white arrows). Lichen sclerosus

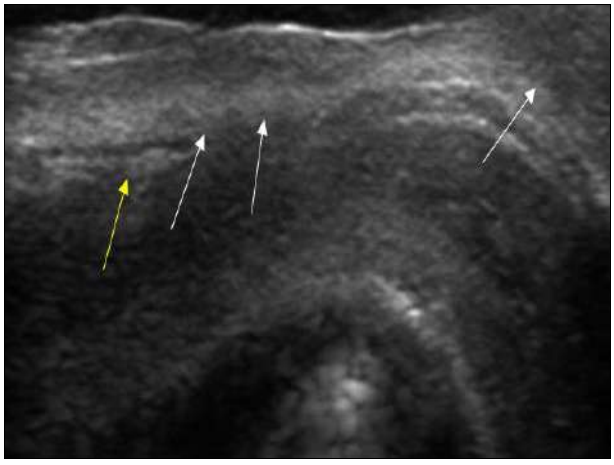
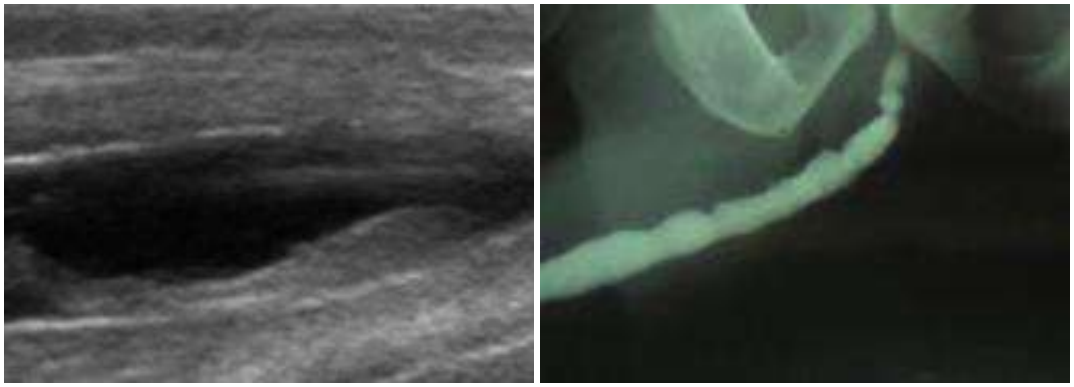


Fig 15: longitudinal SGU image showing long segment stricture of the peno-bulbar urethra with a severe degree of spongiofibrosis (white arrows). Seepage of saline was noted into the periurethral region (yellow arrow).



(a) (b)

Fig 16: SUG (a) with corresponding RGU (b) showing irregular urethral lining with a loose mucosal plaque in a case of chronic urethritis

Pathogenesis of stricture urethra

Irrespective of the cause, there will be inflammation, fibrosis of the periurethral tissue leading to stricture urethra.

Urethral calculi: Debenham first emphasized in 1930 the importance of abnormality in the urethra locally as a predisposing cause for the impaction of a migrating stone or development of a primary stone [9].

Grading of Stricture

Table 5: Grading of stricture based on SUG findings

S.N	Stricture grading	Sonographic findings
1	I	Short stricture with minimal spongiosal tissue involvement
2	II	Short stricture with moderate spongiosal tissue involvement
3	III	Short stricture with extensive spongiosal tissue involvement
4	IV	Long or multiple strictures with moderate spongiosal tissue
5	V	Long or multiple strictures with extensive spongiosal tissue

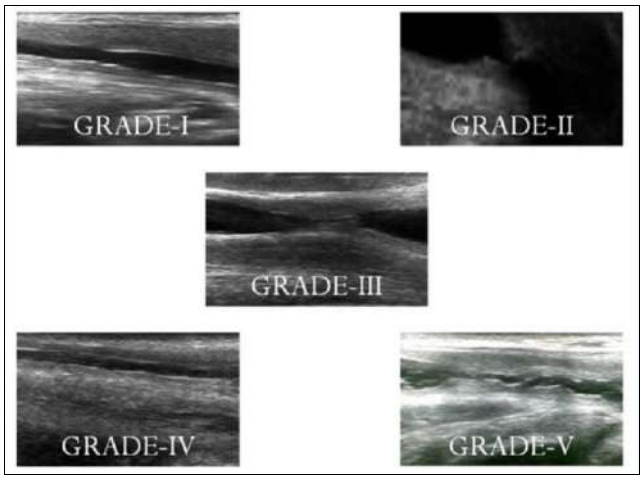


Fig 17: SUG imaging descriptions of the different grades of urethral strictures.

Effective antegrade imaging may be impossible in the case of severe post-traumatic stricture [24]. Additionally, it may be misleading when evaluating strictures in the bulbar urethra that extend into the membranous urethra. This "paradoxical dilation " can occur in 60% of patients and is the result of a dense stricture causing elevated pressures sufficient to dilate more proximal, softer scar tissue [1]. If only the dense aspect of the stricture is repaired, the soft aspect will contract after relief of the obstruction and result in recurrent obstruction.

Repeat urethroplasty

Patients undergoing repeat urethroplasty are known to be at increased risk for stricture recurrence [42]. Complete preoperative endoscopic evaluation of complex reoperative strictures may be impossible. In reoperative cases involving prior scrotal flap procedures, hair-bearing urethral segments may be detected sonographically. Urethral calculi and periurethral pathologies such as abscesses, diverticulae, fistulas, and false passages may be visualized sonographically [18, 24, 43, 44]. Preliminary sonographic staging has contributed substantially to favorable outcomes in this challenging group of patients compared to results reported in other earlier series [31, 42, 45].

In our study, forty patients with RUG findings suggestive of stricture disease were correctly identified by sonourethrography. In the majority of cases, only one stricture was present at the time of the study, but in five cases, synchronous strictures were imaged and available for comparison. Analysis of the results showed that when the stricture length measured by sonourethrography was compared with the measurements on conventional urethrography, the difference between the two tests was significant (P<0.001) and the corerelation was moderate. The presence of stricture and their locations, as determined by conventional and sonourethrography, was confirmed by cystourethroscopy.

On grouping the stricture by their anatomical site (penile and bulbar) and repeating the comparison, the correlation still remained moderate and the difference was significant when the stricture was located in the penile region. Even in the bulbar region the correlation remained poor and the significant difference remained (P<0.0001). The results show a statistically significant difference in the length of anterior urethral strictures on comparison to conventional contrast urethrography in the region of the bulbar urethra; thereby proving the hypothesis that the foreshortening due to the curved anatomical course of the bulbar urethra and also due to obliquity of the penile urethra during radiographic technique and the radiographic position necessary for its assessment leads to significant shortening of the visualized length, both of penile and bulbar urethra on conventional urethrography and the technique should not be relied upon for measuring stricture length in the anterior urethra.

Morey A F *et al*. in 1997 studied the accuracy of sonourethrography in strictures of the bulbar urethra in order to define the role of preoperative sonourethrography in establishing objective criteria for procedure selection for management of bulbar urethral strictures. Based on these and other studies, several authors recommend excision therapy with end-to-end anastomosis for strictures sonographically measuring up to 25 mm.

All the stricture urethra patients who underwent cystoscopy/surgery were available for direct measurement of stricture length. Our study suggests that there is a significant difference in length estimation between conventional and sonourethrography. The no of operative cases available for direct measurements is good enough and the correlation with the no of cases that have appeared in international literature was excellent.

Nash *et al*., in 1995 compared stricture length using conventional techniques and sonourethrography to preoperative findings. They determined that sonourethrographic estimates closely correlated with intraoperative lengths whereas retrograde urethrography length did not. Sonourethrography was thus shown to overcome the limitation of conventional radiographic procedure of retrograde urethrography, which showed an end-on view of bulbar stricture resulting in reduction in the apparent length of the stricture.

In Hillman BJ *et al* study, MCVU demonstrated extraluminal contrast in 17 cases and provided a qualitative assessment of the urodynamic significance of strictures. This method is a simple, accurate alternative to retrograde and compression voiding urethrography.

In McAninch JW *et al*. study, a total of 17 patients with suspected stricture disease underwent conventional RGU and SUG. The length of the stricture was assessed by each imaging modality was compared to measurements at open urethroplasty in 56 patients, sonourethrography was consistently more accurate. Distension of the urethra with saline during the ultrasound examination enabled classification of the degree of spongiofibrosis.

Table 6: Comparison of characteristics of urethral stricture disease between our study and other studies

			Stein *et al*. (n=2,589) (5)		
Characteristic	**Our study**	**Palminteri *et al*. (n=1,439) (4)**	**(US/Italy)**	**(India)**	**Fenton *et al*. (n=175) (6)**
Mean age (years)	45.8	45.1	42.7	38.2	-
Mean length (cm)	3.1	4.15	-	-	4.1
Most common site	Penile urethra	Bulbar urethra	Bulbar urethra	Bulbar urethra	Bulbar urethra
Etiology (%)					
Idiopathic	6	35.8	41.3	23.6	31.9
Trauma	6	10.8	15.8	36.1	9.6
Iatrogenic	18	38.6	35.0	16.6	31.9
LS	3	13.5	6.9	21.5	26.6

LS, lichen sclerosis.

Advantages and Limitations

SUG can evaluate only anterior urethra more accurately than the conventional RGU. It cannot evaluate the posterior urethra adequately.

Whereas the RGU can evaluate the male urethra in its entire length, but fails to measure the exact length of the stricture involving the bulbar urethra. Each procedure have their own advantage over the other, thus one cannot omit the other procedure in evaluating the male urethral pathologies, especially the anterior urethral stricture diseases. Both the procedures need to be done to completely and accurately evaluate the pathology.

SUG will consume relatively little more time than that of RGU, but the time spent is worth that It generates more detailed and 3 dimensional images of the urethra and periurethral soft tissues.

Advantages of saline over lignocaine gel.

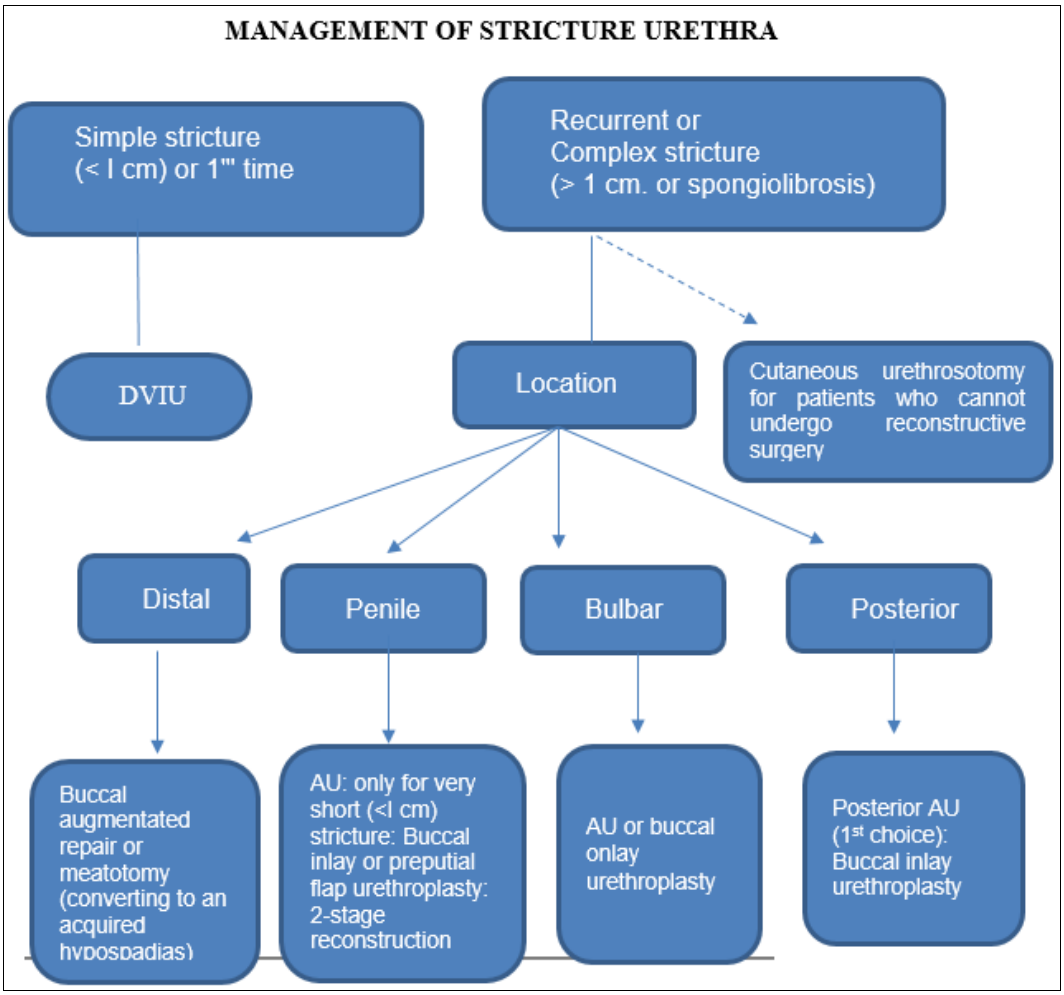
a. Air bubbles could be easily eliminated.
b. Easy to load and inject.
c. Flows easily in very narrow passages due to low viscosity.
d. Easily available and cheap.

Based on the current study, it is strongly recommended that always the evaluation of the male urethra shall include both retrograde urethrography and sonourethrography to achieve accurate results and thus helping in the further management. The procedure is well tolerated and can be used in the office or operating room to obtain repeated real-time assessments of questionable areas without radiation exposure.

Table 7: Summative comparison of imaging techniques and respective pros, cons, and the pathology best suited for each imaging modality

Imaging modality	Optimal pathology	Pros	Cons
RUG	Urethral stricture Urethral fistula Urethral diverticula	Familiar test for urologists Evaluates anterior and posterior urethra, Low cost	Ionizing radiation Position dependent No soft tissue detail May underestimate stricture length
VCUG	Urethral stricture Urethral fistula Urethral diverticula Urethral valves Vesicoureteral Reflux (non-urethral pathology)	Familiar test for urologists Evaluates anterior and posterior urethra Low cost, Provides additional information about concomitant bladder pathology or VUR	Ionizing radiation Position dependent No soft tissue detail May underestimate stricture length
US	Urethral stricture Spongiofibrosis	No ionizing radiation Soft tissue detail	Operator dependent Learning curve

		More accurately depicts stricture length, Low cost	Poor visualization of posterior Urethral, pathology
MRU	Urethral diverticula Urethral fistula Traumatic urethral injury Soft tissue masses Complex strictures	No ionizing radiation Soft tissue detail Information on surrounding structures	Takes longer time High cost Metal prohibits use Difficult to perform Difficult to interpret
CTU	Urethral diverticula Urethral fistula Traumatic urethral injury Soft tissue masses Complex strictures	Soft tissue detail Can use with metal implants/parts Information on surrounding structures	Ionizing radiation High cost Difficult to perform



** Within 1 cm from meatus: •• consider additional dilation up to 3-6 mo: DM, direct-visual internal urethrotomy: AU. Anastomotic ureduoplasty (resection and end to end reconstruction)

Graph 12: Flow chart showing the management of urethral strictures

Table 8: Management of stricture recurrence [50].

	Single, VIU	Single, dilatation	More than one, VIU/dilatation	End-to-end urethroplasty	Perineal urethroplasty
Group 1	3	1	0	1	1
Group 2	2	2	3	2	1
Group 3	2	2	1	2	1

Summary and Conclusions

- Sonourethrography is a dynamic 3-dimensional study that can be repeated with minimal radiation exposure, provides higher efficiency than RGU in the detection of anterior urethral stricture disease and would greatly aid in diagnosis and choice of therapies and we have found it to be a notable improvement over the conventional radiographic urethrography in examination of male anterior urethra. Sonourethrography can determine anterior urethral stricture length more accurately than any standard radiographic procedures.
- SUG can evaluate only anterior urethra more accurately than the conventional RGU. It cannot evaluate the posterior urethra adequately.
- RGU fails to measure the exact length of the stricture urethra irrespective of the site due to anatomical and technical limitations.
- Each procedure have their own advantage over the

other, thus one cannot omit the other procedure in evaluating the male urethral pathologies, especially the anterior urethral stricture diseases.
- Periurethral changes, urethral lumen, plaques and spongiofibrosis are better visualised on sonourethrography

Based on the current study, it is strongly recommended that always the evaluation of the male urethra shall include both the conventional RGU and retrograde SUG to achieve accurate results and thus helping in further management. SUG results did change the final management mode in 32.14% of the cases, and the techniques and graft preparation were decided after SUG in almost 100% of the cases that required urethroplasty, which is very significant (p<0.001).

References

1. Cave EH, Kohnstam GL. The X-Ray Examination of the Male Urethra. British Journal of Radiology: BIR Section 1925;30(297):121-7.
2. Kemble J. Urethrography. British medical journal 1939;2(4108):683.
3. Cave P, Konstam GL. Urethrography. British Medical Journal 1939;2(4110):786.
4. Brodny ML. A new instrument for urethrography in the male. The Journal of Urology 1941;46(2):350-4.
5. Ney C, Duff J. Cysto-urethrography: its role in diagnosis of neurogenic bladder. The Journal of urology 1950;63(4):640-52.
6. Lindblom K, Romanus R. Roentgen examination of the distal urinary tract and of the male genital organ. InDiagnostic Radiology Springer, Berlin, Heidelberg 1962, 366-476.
7. Palmer PE. Urethrography in the Male and Suprapubic Cystograp. The British journal of radiology 1964;37(443):867-70.
8. Shaver WA, Richter PH, Orandi A. Changes in the male urethra produced by instrumentation for transurethral resection of the prostate. Radiology 1975;116(3):623-6..
9. Godwin RJ. Urethral stone formation following urethroplasty. The British journal of radiology 1977;50(590):113-5.
10. Lebowitz RL. Pseudostricture of the urethra: urinal artefact on urethrography. American Journal of Roentgenology 1978;130(3):570-1.
11. Hillman BJ. Evaluation of postsurgical urethra and urethral strictures by meatal compression-voiding urethrography. Urology 1981;17(1):95-8.
12. Asklin B, Nilsson A, Pettersson S. Functional evaluation of anterior urethral strictures with combined antegrade and retrograde urethrography. Scandinavian journal of urology and nephrology 1984;18(1):1-7.
13. McAninch JW, Laing FC, Jeffrey RB. Sonourethrography in the evaluation of urethral strictures: a preliminary report. The Journal of urology 1988;139(2):294-7.
14. Yachia D. Acquired ventral penile curvature: spongiofibrosis caused by urethral manipulation. British journal of urology 1989;64(6):629-31.
15. Donald JJ, Rickards D, Milroy EJ. Stricture disease: radiology of urethral stents. Radiology 1991;180(2):447-50.
16. Beckert R, Gilbert P, Kreutzig T. Spongiosography: a valuable adjunct to the diagnosis of urethral strictures. The Journal of urology 1991;146(4):993-6.
17. Das S. Ultrasonographic evaluation of urethral stricture disease. Urology 1992;40(3):237-42.
18. Yoder IC, Papanicolaou N. Imaging the urethra in men and women. Urologic radiology 1992;14(1):24-8.
19. Kim B, Hricak H, Tanagho EA. Diagnosis of urethral diverticula in women: value of MR imaging. AJR. American journal of roentgenology 1993;161(4):809-15.
20. Gupta S, Majumdar B, Tiwari A, Gupta RK, Kumar A, Gujral RB. Sonourethrography in the evaluation of anterior urethral strictures: correlation with radiographic urethrography. Journal of clinical ultrasound 1993;21(4):231-9.
21. Heidenreich A, Derschum W, Bonfig R, Wilbert DM. Ultrasound in the evaluation of urethral stricture disease: a prospective study in 175 patients. British Journal of urology 1994;74(1):93-8.
22. Bearcroft PW, Berman LH. Sonography in the evaluation of the male anterior urethra. Clinical radiology 1994;49(9):621-6.
23. Heidenreich A, Zumbe J, Vorreuther R, Klotz T, Braun M, Engelmann UH. Stellenwert der Urethralsonographie in der Beurteilung pathologischer Harnröhrenveränderungen. Ultraschall in der Medizin 1995;16(06):254-8.
24. Nash PA, McAninch JW, Bruce JE, Hanks DK. Sono-urethrography in the evaluation of anterior urethral strictures. The Journal of urology 1995;154(1):72-6.
25. Bircan MK, Şahin H, Korkmaz K. Diagnosis of urethral strictures: is retrograde urethrography still necessary?. International urology and nephrology 1996;28(6):801-4.
26. Chiou RK, Anderson JC, Tran T, Patterson RH, Wobig R, Taylor RJ. Evaluation of urethral strictures and associated abnormalities using high-resolution and color Doppler ultrasound. Urology 1996;47(1):102-7.
27. Morey AF, McAninch JW. Ultrasound evaluation of the male urethra for assessment of urethral stricture. Journal of clinical ultrasound 1996;24(8):473-9.
28. Morey AF, McAninch JW. Role of preoperative sonourethrography in bulbar urethral reconstruction. The Journal of urology 1997;158(4):1376-9.
29. Kostakopoulos A, Makrychoritis K, Deliveliotis C, Nazlidou I, Picramenos D. Contribution of transcutaneous ultrasonography to the evaluation of urethral strictures. International urology and nephrology 1998;30(1):85-9.
30. Jacoby K, Rowbotham RK. Double balloon positive pressure urethrography is a more sensitive test than voiding cystourethrography for diagnosing urethral diverticulum in women. J. Urol 1999;162(6):2066-2069.
31. Pushkarna R, Bhargava SK, Jain M. Ultrasonographic evaluation of abnormalities of the male anterior urethra. Indian journal of Radiology and Imaging 2000;10(2):89.
32. Gallentine ML, Morey AF. Imaging of the male urethra for stricture disease. Urologic Clinics 2002;29(2):361-72.
33. Pavlica P, Barozzi L, Menchi I. Imaging of male urethra. European radiology 2003;13(7):1583-96.

34. Andersen HL, Duch BU, Nielsen JB, Joergensen B, Ledet T. An experimental model for stricture studies in the anterior urethra of the male rabbit. Urological research 2003:31(6):363-7.
35. Peskar DB, Perovič AV. Comparison of radiographic and sonographic urethrography for assessing urethral strictures. European radiology 2004;14(1):137-44.
36. Figueroa JC, Hoenig DM. Use of 7.5 F flexible pediatric cystoscope in the staging and management of urethral stricture disease. Journal of endourology 2004;18(1):119-21.
37. Khan N, Modishi HM, Tsatsi LD, Segone A. Comparison of sonourethrography and retrograde urethrography in the evaluation of anterior urethral strictures. SA Journal of Radiology 2004, 8(4).
38. Khan MB, Ghaffar A, Mahmood T. Role of Sonourethrography In Evaluation of Anterior Urethral Stricture and Its Comparison with Retrograde Urethrography. Pakistan Armed Forces Medical Journal 2006;56(3):300-5.
39. Gupta N, Dubey D, Mandhani A, Srivastava A, Kapoor R, Kumar A. Urethral stricture assessment: a prospective study evaluating urethral ultrasonography and conventional radiological studies. BJU international 2006;98(1):149-53.
40. Osman Y, Abou El-Ghar M, Mansour O, Refaie H, El-Diasty T. Magnetic resonance urethrography in comparison to retrograde urethrography in diagnosis of male urethral strictures: is it clinically relevant?. European urology 2006;50(3):587-94.
41. Sung DJ, Kim YH, Cho SB, Oh YW, Lee NJ, Kim JH *et al*. Obliterative urethral stricture: MR urethrography versus conventional retrograde urethrography with voiding cystourethrography. Radiology 2006;240(3):842-8.
42. Mitterberger M, Christian G, Pinggera GM, Bartsch G, Strasser H, Pallwein L, Frauscher F. Gray scale and color Doppler sonography with extended field of view technique for the diagnostic evaluation of anterior urethral strictures. The Journal of urology 2007;177(3):992-7.
43. Berná-Mestre JD, Berná-Serna JD, Aparicio-Meson M, Canteras-Jordana M. Urethrography in men: conventional technique versus clamp method. Radiology 2009;252(1):240-6.
44. Zhang XM, Hu WL, He HX, Lv J, Nie HB, Yang H *et al*. Diagnosis of male posterior urethral stricture: comparison of 64-MDCT urethrography vs. standard urethrography. Abdominal imaging 2011;36(6):771-5.
45. Park BK, Kim CK, Lee SW. Evaluation of anterior urethral stricture using thick slab SSFSE MR urethrography. Acta Radiologica 2010;51(10):1157-62.
46. Oh MM, Jin MH, Sung DJ, Yoon DK, Kim JJ, Moon DG. Magnetic resonance urethrography to assess obliterative posterior urethral stricture: comparison to conventional retrograde urethrography with voiding cystourethrography. The Journal of urology 2010;183(2):603-7.
47. Priyadarshi V, Singh M, Kumar V, Tiwari R, Gupta SK, Sehgal N. The role of sonourethrography in the evaluation of anterior urethral strictures: A correlation with retrograde urethrography. Uro Today Int J 2012;5:1-6.
48. Ani CC, Akpayak IC, Dakum NK, Ramyil VM, Shuaibu SI. Sonourethrography in the evaluation of anterior urethral stricture. Journal of the West African College of Surgeons 2012;2(1):1-3.
49. Li X, Sa YL, Xu YM, Fu Q, Zhang J. Flexible cystoscope for evaluating pelvic fracture urethral distraction defects. Urologiainternationalis 2012;89(4):402-7.
50. Srivastava A, Vashishtha S, Singh UP, Srivastava A, Ansari MS, Kapoor R *et al*. Preputial/penile skin flap, as a dorsal onlay or tubularized flap: a versatile substitute for complex anterior urethral stricture. BJU international 2012;110(11c):E1101-8.
51. Kathpalia R, Dalela D, Goel A, Mandal S, Sankhwar SN, Yadav R *et al*. Effect of phallic stretch on length of bulbous urethral stricture during retrograde urethrography. Urologiainternationalis 2014;93(1):63-6.
52. Portnoy O, Kitrey N, Eshed I, Apter S, Amitai MM, Golomb J. Correlation between MRI and double-balloon urethrography findings in the diagnosis of female periurethral lesions. European journal of radiology 2013;82(12):2183-8.
53. Sa YL, Xu YM, Feng C, Ye XX, Song LJ. Three-dimensional spiral computed tomographic cysto-urethrography for post-traumatic complex posterior urethral strictures associated with urethral-rectal fistula. Journal of X-Ray Science and Technology 2013;21(1):133-9.
54. Song L, Xie M, Zhang Y, Xu Y. Imaging techniques for the diagnosis of male traumatic urethral strictures. Journal of X-Ray Science and Technology 2013;21(1):111-23.
55. Angermeier KW, Rourke KF, Dubey D, Forsyth RJ, Gonzalez CM. SIU/ICUD Consultation on Urethral Strictures: Evaluation and follow-up. Urology 2014;83(3):S8-17.
56. Hatgaonkar A. A Comparative Study of Sonourethrography and Retrograde Urethrography in Evaluation of Anterior Male Urethral Strictures. Int J Sci Stud 2014;2(2):5-12.
57. Tembhekar NG, Sonawane BD, Mashirkar A, Titare PU, Anand A, Rathod PB. Sonourethrographic assessment of urethral obstruction. Journal of Evolution of Medical and Dental Sciences 2014;3(64):13971-9.
58. Bach P, Rourke K. Independently interpreted retrograde urethrography does not accurately diagnose and stage anterior urethral stricture: the importance of urologist-performed urethrography. Urology 2014;83(5):1190-4.
59. Orabi H, Aboushwareb T, Tan J, Yoo JJ, Atala A. Can Computed Tomography--assisted Virtual Endoscopy Be an Innovative Tool for Detecting Urethral Tissue Pathologies?. Urology 2014;83(4):930-8.
60. Alwaal A, Blaschko SD, McAninch JW, Breyer BN. Epidemiology of urethral strictures. Translational andrology and urology 2014;3(2):209.
61. Maciejewski C, Rourke K. Imaging of urethral stricture disease. Translational andrology and urology 2015;4(1):2.
62. Kuo TL, Venugopal S, Inman RD, Chapple CR. Surgical tips and tricks during urethroplasty for bulbar urethral strictures focusing on accurate localisation of the stricture: results from a tertiary centre. European Urology 2015;67(4):764-70.
63. BR R, Tejus C, KM M, Prashant D, GS D. A comparative study of ascending urethrogram and sono-

urethrogram in the evaluation of stricture urethra. International braz j urol 2015;41(2):388-92.
64. Talreja SM, Tomar V, Yadav SS, Jaipal U, Priyadarshi S, Agarwal N, Vyas N. Comparison of sonoelastography with sonourethrography and retrograde urethrography in the evaluation of male anterior urethral strictures. Turkish journal of urology 2016;42(2):84.
65. Lv XG, Peng XF, Feng C, Xu YM, Shen YL. The application of CT voiding urethrography in the evaluation of urethral stricture associated with fistula: a preliminary report. International urology and nephrology 2016;48(8):1267-73.
66. Bryk DJ, Khurana K, Yamaguchi Y, Kozirovsky M, Telegrafi S, Zhao LC. Outpatient ultrasound urethrogram for assessment of anterior urethral stricture: early experience. Urology 2016;93:203-7.
67. Theisen KM, Kadow BT, Rusilko PJ. Three-dimensional imaging of urethral stricture disease and urethral pathology for operative planning. Current urology reports 2016;17(8):54.
68. Moncrief T, Gor R, Goldfarb RA, Jarosek S, Elliott SP, Trauma and Urologic Reconstruction Network of Surgeons. Urethral rest with suprapubic cystostomy for obliterative or nearly obliterative urethral strictures: urethrographic changes and implications for management. The Journal of urology 2018;199(5):1289-95.
69. Horiguchi A, Edo H, Soga S, Azuma R, Shinchi M, Ojima K *et al*. Magnetic Resonance Imaging Findings of Traumatic Bulbar Urethral Stricture Help Estimate Repair Complexity. Urology 2020;135:146-53.
70. Tao W, Bai G, Fu G, Niu X, Wang H, Wang G. MR urethrography versus X-ray urethrography compared with operative findings for the evaluation of urethral strictures. International urology and nephrology 2019;51(7):1137-43.
71. Dawkins A, Ayoob A, Gupta S, Nair R. Anterior urethral strictures and retrograde urethrography: An update for radiologists. Clinical Imaging, 2020.