

Original Article

DIAGNOSTIC YIELDS OF SONOURETHROGRAPHY AND RETROGRADE URETHROGRAPHY IN ADULT MALES WITH ANTERIOR URETHRAL STRICTURES DISEASE A PROSPECTIVE COMPARATIVE STUDY.

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ABSTRACT

Background: Retrograde urethrography (RUG) has been widely accepted by most clinicians as the gold standard imaging modality for diagnosing anterior urethral strictures(US). Sonourethrography (SUG) is an attractive alternative without the risk of radiation associated with RUG that is not being routinely utilized in our environment. We prospectively compared the effectiveness of SUG and RUG in diagnosing anterior urethral strictures.

Study Design: A Prospective Comparative Study.

Place and duration of study . Department of Urology Lagos University Teaching Hospital from jan 2023 to jan 2024

METHODS: We evaluated 60 patients clinically diagnosed with anterior US using the two imaging modalities at a referral hospital. The patients included in the study had both SUG and RUG done. The sensitivity, specificity, positive predictive value, and negative predictive values in diagnosing and evaluating various parameters of anterior urethral stricture were calculated for SUG against RUG as the gold standard. The percentage of patients detected to have spongiofibrosis on SUG was also computed.

RESULT: Sixty patients received examination with a mean age of 49.95 years between the ages of 23-84. SUG proved to produce higher diagnostic results than RUG by identifying stricture sites with 97.4% sensitivity and 94.3% specificity along with accurate stricture length assessment (sensitivity 97.4%, specificity 96.2%) and mucosal detection abilities (sensitivity 86.5%, specificity 63.3%) and evaluation of lumen narrowing (sensitivity 77.8%, specificity 86.7%). Through SUG examiners properly characterized the spongiofibrosis severity across the entire patient cohort.

CONCLUSION:SUG showed comparable diagnostic accuracy to RUG in diagnosing and characterizing anterior urethral stricture disease. Additionally, sonourethrography is also advantageous over RUG in assessing periurethral fibrosis.

Keywords: Urethral stricture, imaging, sonourethrography, urethrogram, spongiofibrosis

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INTRODUCTION

Urethral stricture (US) is quite common among men worldwide and is frequently associated with significant morbidities¹. Successful surgical treatments of urethral strictures correlate well with accurate preoperative assessment and planning². Many investigative tools including uroflowmetry-urethroscopy-voiding cystourethrography, retrograde urethrography, and magnetic resonance urethrography have been used for evaluating patients with US^{3,4}. Of all these retrograde urethrography (RUG) has been traditionally used as the gold standard for diagnosing anterior US by most clinicians over many years. However, its use of ionizing radiation and contrast medium to visualize the luminal anatomy of the anterior urethra is a well-recognized drawback^{2,3}. Magnetic resonance urethrography (MRU) which does not use radiation is another imaging modality that is being used increasingly to evaluate anterior urethral strictures and associated pathologies in developed countries^{5,6}. Unfortunately, the high cost of MRU does not make it readily accessible in developing countries, thus limiting its use in such environments. McAninch⁷ et al reported sonourethrography (SUG) as a novel imaging technique using high-frequency ultrasound for evaluating anterior urethra in males. Ultrasound scan eliminates the genuine fear and burden of exposing the gonads and bone marrow of patients to ionizing radiation in contrast to retrograde urethrography (RUG). A recent comprehensive literature search⁴ using Medline and Cochrane databases for prospective studies on ultrasound in the evaluation of male US yielded 17 relevant responses, and only one of these was from our environment. Most recent studies on SUG have largely emanated from developed countries with only a few studies coming from developing countries⁸⁻¹⁵. This is very likely because SUG is not being routinely used in the developing world for the evaluation and management of patients with US despite its availability and potential benefits. This study was done prospectively among adult males who were clinically diagnosed with anterior US in our hospital to compare the yields of RUG and SUG in confirming and characterizing the clinical diagnosis. Our focus was to characterize urethral strictures by their location, multiplicity, length, extent of luminal narrowing, and associated mucosal abnormalities using the two imaging modalities in all the subjects.

MATERIALS AND METHODS

This was A Prospective Comparative Study of adult male patients with clinically diagnosed anterior US who were seen at the Urology clinic of the Lagos University Teaching Hospital, and subsequently referred to the radiology department of our hospital for both SUG and RUG. The study was done in keeping with the Principles of the Helsinki Declaration. Ethical Approval For The Study Was

Obtained From Our Institution's Health Research Ethics-Committee-Before-Its-Commencement-Ethical Statement(No-DM/DCST/HREC/APP/1503.)

Informed consent was obtained from all participants in the study. The subjects for this study were 60 adult male patients with clinically diagnosed anterior urethral strictures who consented to participate. They were recruited consecutively over 9 months, with a target to exceed the calculated appropriate sample size of 50 for the study. All adult male patients with clinical features suggestive of US who presented during the study period were selected for inclusion with their consent. Patients who qualified for inclusion but who had any of the following exclusion criteria: active urethral discharge, metal or sub-metal stenosis, history of recent traumatic catheterization, complete urethral stricture, and symptoms of prostatic diseases that had responded to treatment were all excluded. Retrograde urethrographic examination of all the patients was supervised by a dedicated radiologist using 15 ml to 20 ml of pre-warmed, sterile, 50% diluted radiographic contrast (urography) following standard techniques. The radiographs were reviewed and interpreted by the dedicated radiologist. The strictures identified were characterized using the following parameters: site, length, number of strictures, the degree of luminal narrowing, and observable mucosal abnormalities. All sono graphic examinations were also performed by a single radiologist (without seeing their retrograde urethrograms) to eliminate errors due to bias. The SUG on each subject was conducted using a 7.5-10 MHz linear-array transducer on a real-time ultrasound scanner, (Toshiba Nemio XG diagnostic Ultrasound System). After a detailed explanation of the procedure to each patient, it was done aseptically using a small-size Foley catheter gently introduced into the navicular fossa of the patient following lubrication with xylocaine gel. The catheter's balloon was gently inflated with sterile water to keep it firmly in place. With the aid of a 50ml syringe, sterile 0.9% saline was infused into the urethra to distend it adequately, and the catheter was then clamped. Ultrasound gel was applied liberally along the urethra on the ventral surface of the penis which was gently pulled up. Multiple longitudinal and transverse images of the anterior urethra were obtained by ultrasound scans. A trans-scrotal scan of the urethra was also done to visualize the proximal penile urethra and the distal bulbous urethra. In addition, a trans-perineal scan was done to visualize the proximal bulbar urethra. Urethral strictures were identified as areas of narrowing of the column of contrast medium along the urethra on RUG. During SUG, strictures were identified as areas of the

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urethra with reduced distensibility on infusion of normal saline. Some strictures had associated mucosal irregularities identified through posterior acoustic shadowing. The strictures were categorized based on their locations into penile, bulbar, or a combination of both. Short-segment strictures were defined as those ≤ 2.5 cm, while long-segment strictures were >2.5 cm. The luminal narrowing was graded as mild stenosis ($< 33\%$ of the lumen), moderate (between 33 and 50%), or severe stenosis ($> 50\%$) Sonographically detected anterior US were staged using the McAnnick and Chiou criteria¹⁶ The data were analyzed using Windows Statistical Package for Social Science (SPSS), version 20.0 (IBM SPSS Statistics), and Microsoft Excel 2010 edition. The sensitivity, specificity, positive predictive value, and negative predictive values for the evaluated features of urethral stricture were calculated for SUG using RUG as the gold standard. The statistical level of significance of $P < 0.05$ was used. The percentage of patients with spongiofibrosis as also documented.

RESULTS

Sixty adult males with clinically diagnosed anterior US

were all conclusively evaluated using RUG and SUG. The patients' ages ranged from 23 to 84 years, with a mean age of 49.95 years(Table 1) RUG revealed that 45 patients(75.0%) had short segment strictures, 12 patients(20.0%) had long segment strictures and 3 patients(5%) had multiple strictures. SUG on the other hand showed that 41 (68.3%) patients had short segment strictures, 17 (28.3%) patients had long segment strictures and 2 had multiple strictures consisting of both long and short ones. RUG detected narrowing of the urethral lumen in all the patients, consisting of 9 (15%) of them with mild, 36 (60%) with moderate, and 15 (25%) patients with severe stenosis. In comparison, SUG detected 7 more patients with mild luminal narrowing, 6 fewer patients with moderate luminal narrowing, and 1 more with severe luminal narrowing (Table 2). Only SUG revealed spongiofibrosis (figure I), with mild periurethral fibrosis in 20 patients (33.3%), moderate fibrosis in 30 patients (50%), and severe fibrosis in 10 patients (16.7%). This feature could not be detected by RUG An incidental finding of a post-traumatic urethral diverticulum in one patient was detected by both SUG and RUG(figures II and III respectively). However, some calculi were noted in the diverticulum on SUG which were not obvious on the scout film of RUG.

Table 1: Age Distribution Of The Patients With Anterior Urethral Strictures

Age Range (Years),	Frequency (%)
$\leq 25,$	1 (1.7)
26 - 35	6 (10.0)
36 - 45	20 (33.3)
46 - 55	11 (18.3)
56 - 65	16 (26.7)
66 - 75	4 (6.7)
$> 75,$	2 (3.3)
Total	60 (100.0)

Table 2: Radiological characteristics of anterior urethral strictures demonstrated by retrograde urethrography (RUG) and sonourethrography (SUG).

Urethral Stricture characteristics	Detection by RUG FREQUENCY (%)	Detection by SUG FREQUENCY (%)
LOCATION		
• PENILE	17(28.3)	17(28.3)
• BULBAR	40(66.7)	40(66.7)
• BOTH	3(5)	3(5)
NUMBER		
• SINGLE	49(81.7)	49(81.7)
• MULTIPLE	11(18.3)	11(18.3)
LENGTH		
• SHORT SEGMENT	45(75)	41(68.3)
• LONG SEGMENT	12(20)	17(28.3)
• BOTH	3(5)	2(3.3)
LUMINAL NARROWING		
• MILD	9(15)	16(26.7)
• MODERATE	36(60)	30(50)
• SEVERE	15(25)	14(23.3)
MUCOSAL IRREGULARITY		
• PRESENT	45(75)	52(86.7)
• ABSENT	15(25)	8(13.3)
PERIURETHRAL FIBROSIS		
• MILD		20(33.3)
• MODERATE		30(50)
• SEVERE		10(16.)

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Table 3: Sensitivity (SEN) specificity (SPE) positive predictive value(PPV) and negative predictive value (NPV) of SUG in characterizing anterior urethral strictures in comparison to RUG.

Parameters	SEN (%)	SPE (%)	PPV (%)	NPV (%)	K-VALUE	P-value
Location of strictures	97.4	94.3	95.2	93.1	0.90	P>0.05
Number of strictures	97.4	94.3	96.3	93.5	0.91	P>0.05
Length of strictures	97.4	96.2	95.7	94.3	0.87	P<0.03
Extent of luminal narrowing	77.8	86.7	73.3	72.2	0.56	P<0.001
Mucosal irregularity	86.5	63.3	86.7	75.1	0.63	P<0.001

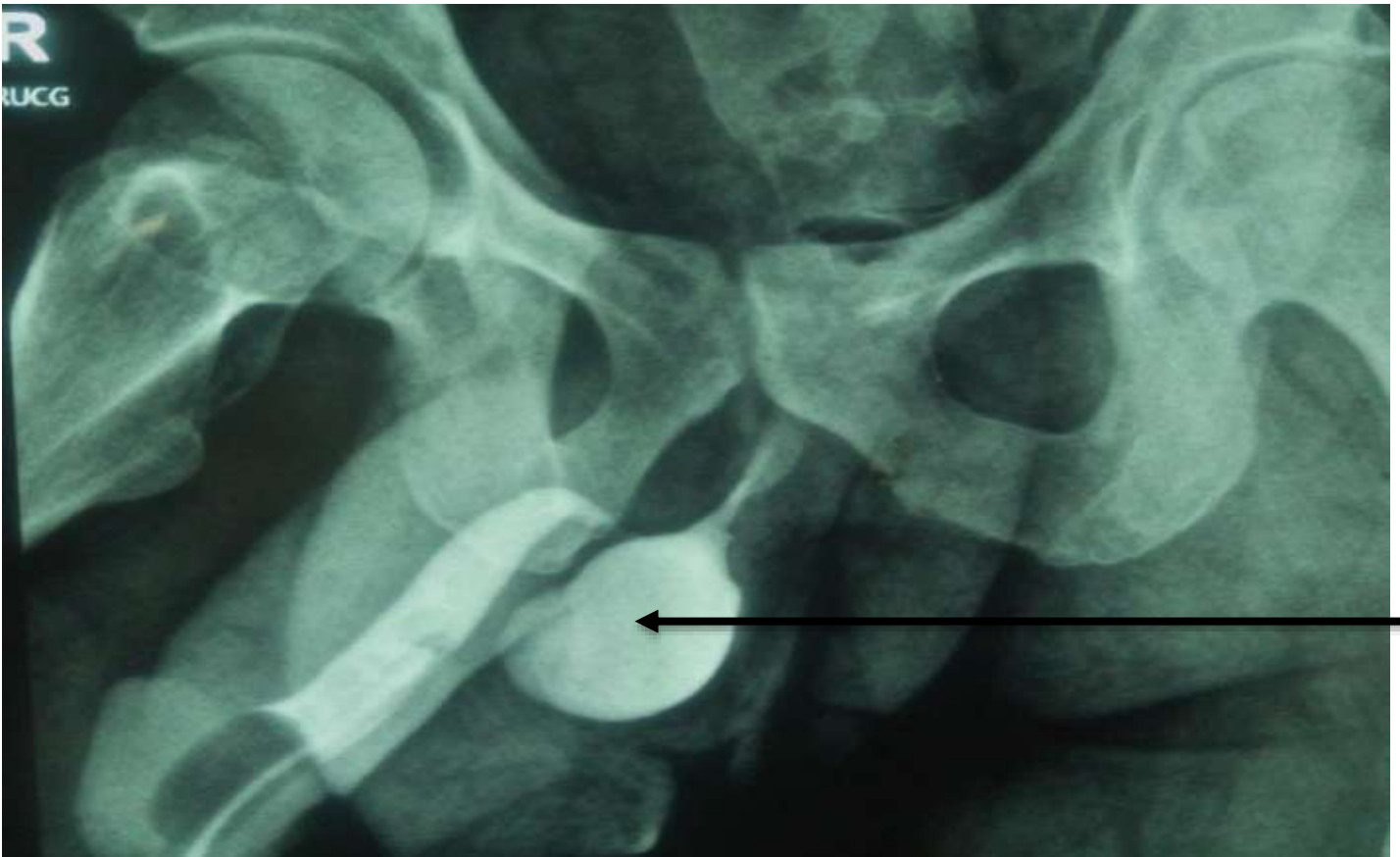
Figure I: Sagittal sonourethrogram of the penile urethra showing severe spongiofibrosis (white double arrows) in a patient



Figure II: Sagittal sonourethrogram of the bulbar urethra (white arrow) showing a diverticulum with multiple calculi (black arrow) in a patient.



Figure III: Retrograde urethrogram of the same patient in Figure I showing the diverticulum (black arrow) in the bulbar urethra.



DISCUSSION

Accurate preoperative evaluation and planning, along with the experience of the surgeon are required for excellent outcomes for the treatment of urethral strictures². Urethral ultrasound scan of the urethra or Sonourethrography (SUG) is increasingly being used to evaluate urethral stricture worldwide since it was proposed by McAninch et al in 1988. It had an impressive reported sensitivity, specificity, positive predictive value, and a negative predictive value of 66-100%, 97-98%, 50-80%, and 96-98% respectively in diagnosing anterior urethral strictures⁷. The mean age from this study is comparable to the mean age of 49.8 years in the study by Akano.¹⁵ From our study, urethral strictures were commonest in middle-aged men, while they were rare in young adults. Ani et al¹² and Nzeh et al¹⁹ also reported that most strictures in their series occurred in the fifth decade of life, and were mostly inflammatory in etiology. Urethral strictures, especially the post-inflammatory types tend to develop progressively over years after the initial urethral infection. Most of the anterior urethral strictures seen in our patients were located in the bulbar urethra. This finding is also similar to the reports of other studies from our sub-region.^{10,12,15} Palminteri¹⁷ et al reported that most of the strictures in their work from a developed country were also in the bulbar urethra. Fenton¹⁸ et al who also reported the bulbar urethral as the commonest location of anterior urethral strictures, noted that they tend to be post-traumatic and short urethral strictures. All the anterior urethral strictures in our subjects were identified and localized by RUG and SUG, with good concordance and no significant difference. Nzeh et al¹⁹ reported that SUG and RUG similarly diagnosed anterior urethral strictures in their patients. Gupta et al reported RUG in measuring the length of strictures from our study were 97.4, 96.2, 95.7, and 94.3 respectively (Kappa value = 0.87, P<0.03) The statistically significant difference between the yields of sonourethrography and retrograde urethrography in evaluating the length of anterior urethral strictures from this study is very similar to the finding by Pushkarna et al²² who reported superiority of SUG to RUG in measuring the lengths of strictures from their study. They noted a patient who had a normal RUG but was shown to have a 2 mm stricture on SUG. Gupta et al²³ also reported that SUG has better sensitivity than RUG in estimating the length of anterior urethral strictures with the mean length of SUG being closer to that at surgery. In our study, SUG detected 4 fewer patients with short-segment strictures, and 5 more patients with long-segment strictures compared to RUG which was taken as the gold standard. The modality with the superior yield would be accurately revealed by the intraoperative findings, which were not included in our study. However, other studies that have compared the lengths of the urethral strictures measured using SUG and

RUG to the actual lengths measured during urethroplasty reported better results for SUG. Pathan et al⁸ reported that lengths of US measured with SUG correlated more with the length measured during surgery than with RUG. Priyadarshi et al²¹ and Choudhary et al¹³ similarly reported that stricture lengths measured using SUG correlated better with the intra-operative findings than the measurements from RUG. Srinivas et al²⁴ studied 30 patients with RUG and SUG and compared the urethral stricture length of each patient measured using each modality with the intra-operative stricture length. They reported that RUG underestimated stricture lengths, and noted that the stricture lengths measured with SUG were closer to the actual stricture length measured during surgery in all the patients. Another study by Ravikumar et al²⁵ on 40 patients with urethral strictures showed that RUG underestimated stricture lengths, while the stricture lengths measured by SUG correlated more with their findings during surgery. The estimated length of US is an important criterion in decision-making for the appropriate approach for the best surgical treatment outcome. Therefore, SUG should be advantageously and routinely used as an essential ancillary tool to RUG in the armamentarium of surgeons embarking on urethral reconstructions. It can be readily repeated pre- and intraoperatively in doubtful cases, without exposing the patient to ionizing radiation⁴. In our study, SUG detected 7 more patients with mild luminal narrowing, 6 fewer patients with moderate luminal narrowing, and 1 less with severe luminal narrowing than RUG. In the study by Ravikumar et al.²⁵, the extent of luminal narrowing measured using SUG also correlated better with their cystoscopic and intra-operative findings than the measurements from RUG. In one of our patients, some calculi were seen in a urethral diverticulum with SUG but were not obvious with RUG. Choudhary et al¹³ that only two out of ten penile urethral strictures in their series were identified on SUG but missed on RUG, possibly because the strictures were sub-meatal in location. Akano in his study observed that a case of urethral stricture in the bulbar urethra was detected by SUG but was also missed on RUG¹⁵. Mikolaj et al⁶, however, noted that SUG is less accurate than RUG in the bulbar urethra because of significant technical errors in measurements of strictures of the proximal urethra. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of SUG compared to RUG in locating the sites of strictures in this study were high at 97.4, 94.3, 95.2, and 93.1 respectively (Kappa value = 0.90, P>0.05). The kappa value of 0.90 between both imaging modalities in our study indicates a high degree of similarity. Hatgaonkar¹⁴ (in India) and Ani et al¹² (Nigeria) also reported comparable sensitivity and specificity for the two imaging modalities. Both RUG and SUG detected equal numbers of single and multiple strictures in the anterior urethra of

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the subjects ($P > 0.05$). These findings are similar to those from some previous studies which also showed good agreement between both modalities for detecting the number of single or multiple strictures.^{10,20} Evidently, both imaging modalities adequately visualized the entire length of the anterior urethra, and the areas of narrowing are easily identified.¹⁴ Accurate preoperative measurement of the length of US is essential to surgeons in planning and making appropriate treatment decisions^{4,16}. Strictures shorter than 25 mm can be treated by anastomotic urethroplasty, whereas those greater than 25 mm typically require a graft or flap for reconstruction.²¹ The sensitivity, failure of endoscopic procedures in the treatment of urethral stricture. A clear idea of the degree of periurethral spongiofibrosis before surgery helps to plan the most appropriate surgical technique². RUG is grossly deficient in assessing spongiofibrosis because it relies on internal pacification of the urethral lumen. SUG was successfully used in this study to detect varying degrees of spongiofibrosis in our patients. Other studies^{23,25,26} have also highlighted this strong advantage of SUG over RUG. Gupta et al reported that the sensitivity of SUG in detecting spongiofibrosis was 42%, 56%, and 83% in 52 men with mild, moderate, and severe peri-urethral fibrosis respectively.²³ Both imaging techniques have their limitations and drawbacks. Pain, urinary tract infection, and urethral bleeding are reported complications with both modalities, but they are less common and less severe with SUG compared with RUG.²⁵ The main limitation of SUG is its operator dependence, as it may influence the accuracy of the results obtained depending on the skill of the sonographer. SUG also has limited value in characterizing posterior urethral strictures compared to RUG. The determination of the extent of urethral luminal narrowing can be affected by the degree of pressure applied with the ultrasound probe to the ventral surface of the penis during SUG, and by the degree of stretch applied to the penis during RUG¹². In our study, the former

specificity, PPV, and NPV of SUG compared to reported cases of urethral calculi that were detected by SUG but missed on RUG. Ravikumar et al²⁵ reported that SUG identified other abnormalities like spongiofibrosis, diverticula, and stones which were not recognized with RUG. Such calculi may either be too small to be identified as calcific densities on the scout radiographs or as visible filling defects in the contrast phase of RUG. Spongiofibrosis is an important prognostic factor, and it may negatively affect the outcome of urethroplasty with recurrence of the stricture if not excised completely. The presence of dense spongiofibrosis can predict limitation was mitigated by ensuring that gentle pressure was uniformly applied on the ventral surface of the penis when scanning, and by simultaneously checking on the ultrasound machine monitor to ensure that the ovoid shape of the urethral lumen was not altered. The latter was mitigated by ensuring the anterior urethra was straightened by exerting a gentle but constant pull on the penis during injection of the contrast medium. RUG may also be affected by the positioning of the patient on the examination table, as this can alter the radiographic magnification. This was mitigated in this study by adjusting the patient-to-film and the source-to-patient distances appropriately.

CONCLUSION

Sonourethrography showed comparable diagnostic accuracy to retrograde urethrography in diagnosing and characterizing anterior urethral stricture disease. SUG which is devoid of the hazards associated with radiation exposure and the use of contrast use, can be safely used repeatedly as a reliable substitute or as ancillary to RUG when done routinely by a dedicated and properly trained operator. Additionally, SUG is also advantageous over RUG in assessing periurethral fibrosis, and associated findings such as diverticulum and urethral calculi can be detected better by SUG.

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