OPEN ACCESS

PAKISTAN JOURNAL OF UROLOGY

ISSN: 3005-7582 (Online) : ISSN: 3005-7574 (Print)

ORIGINAL ARTICLE

Diagnostic Yields Of Sonourethrography And Retrograde Urethrography In Adult Males With Anterior Urethral Strictures Disease A Prospective Comparative Study.

Durojaiye Moshood Seun[1], Moses Adebisi Ogunjimi[2], Rufus Wale Ojewola[3], Rasheed Ajani Arogundade[4]

[1]Department of Radiology Lagos University Teaching Hospital. Nigeria
[2-]College of Medicine, University of Lagos, & Lagos University Teaching Hospital
[3,4-]Consultant Urological Surgeon, Lagos University Teaching Hospital Nigeria

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 and Radiology Lagos University Teaching Hospital Nigeria from 10-jan 2023 to 10-jan 2024

METHODS: 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

How to Cite this Article: **Durojaiye M, Ogunjimi MA, Ojewola RW, Arogundade R.** Diagnostic yields of sonourethrography and retrograde urethrography in adult males with anterior urethral stricture disease**. Pak J Urol.** 2024;2(2):**132–141.**

Corresponding Author: Moses Adebisi Ogunjimi

Department of Urology Lagos University Teaching Hospital. **Nigeria**
Orcid Id :https://orcid.org/0000-0002-8609-0400

Email: aogunjimi@unilag.edu.ng

Article Tracking History

Received:	**July**	**05-2024**
Revision:	**September**	**22-2024**
Accepted:	**November**	**17-2024**
Published:	**January**	**05- 2025**

DOI: https://doi.org/10.69885/pju.v2i02.69

INTRODUCTION

Urethral stricture (US) is a relatively common condition among men globally and is frequently associated with significant morbidity [1]. Successful surgical management of US is highly dependent on accurate preoperative assessment and planning [2].Various diagnostic tools—including,uroflowmetry,urethroscopy,voiding cystourethrography, retrograde urethrography (RUG), and magnetic resonance urethrography (MRU)—are employed to evaluate patients with urethral strictures [3].Among these, retrograde urethrography has long been considered the gold standard for diagnosing anterior urethral strictures. However, its reliance on ionizing radiation and contrast media presents notable drawbacks [2,3]. In contrast, magnetic resonance urethrography, which avoids radiation exposure, is increasingly used in developed countries for assessing anterior urethral strictures and associated pathologies [4]. Nevertheless, its high cost often limits accessibility in low-resource settings.As an alternative, sonourethrography (SUG)—first introduced by McAninch et al.—utilizes high-frequency ultrasound to assess the anterior urethra. Unlike RUG, sonourethrography does not expose patients to ionizing radiation, eliminating concerns about gonadal and bone marrow exposure. A recent systematic review of Medline and Cochrane databases identified 17 prospective studies on ultrasound in male urethral stricture evaluation, but only one originated from our region. Most published research on SUG comes from high-income countries, with limited studies from developing regions, where this modality is not yet routinely utilized despite its availability and potential benefits.This prospective study was conducted among adult males clinically diagnosed with anterior urethral stricture at our institution. The aim was to compare the diagnostic performance of RUG and SUG in confirming and characterizing urethral strictures. Specifically, we evaluated the strictures based on location, number, length, degree of luminal narrowing, and associated mucosal abnormalities using both imaging techniques in all participants.

MATERIALS AND METHODS

This Prospective Comparative Study Conducted in Department of Urology and Radiology Lagos University Teaching Hospital Nigeria from 10-jan 2023 to 10-jan 2024.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 (**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-perinatal 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 urethra with reduced dispensability 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 ≤2.5cm, while long-segment strictures were >2.5cm. The luminal narrowing

mild stenosis (< 33% of the lumen), moderate (between 33 and 50%), or severe stenosis (> 50%) Sonographically detected anterior US were staged using the McAnnich and Chiou criteria[16] 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 (%)
≤ 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.)

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.

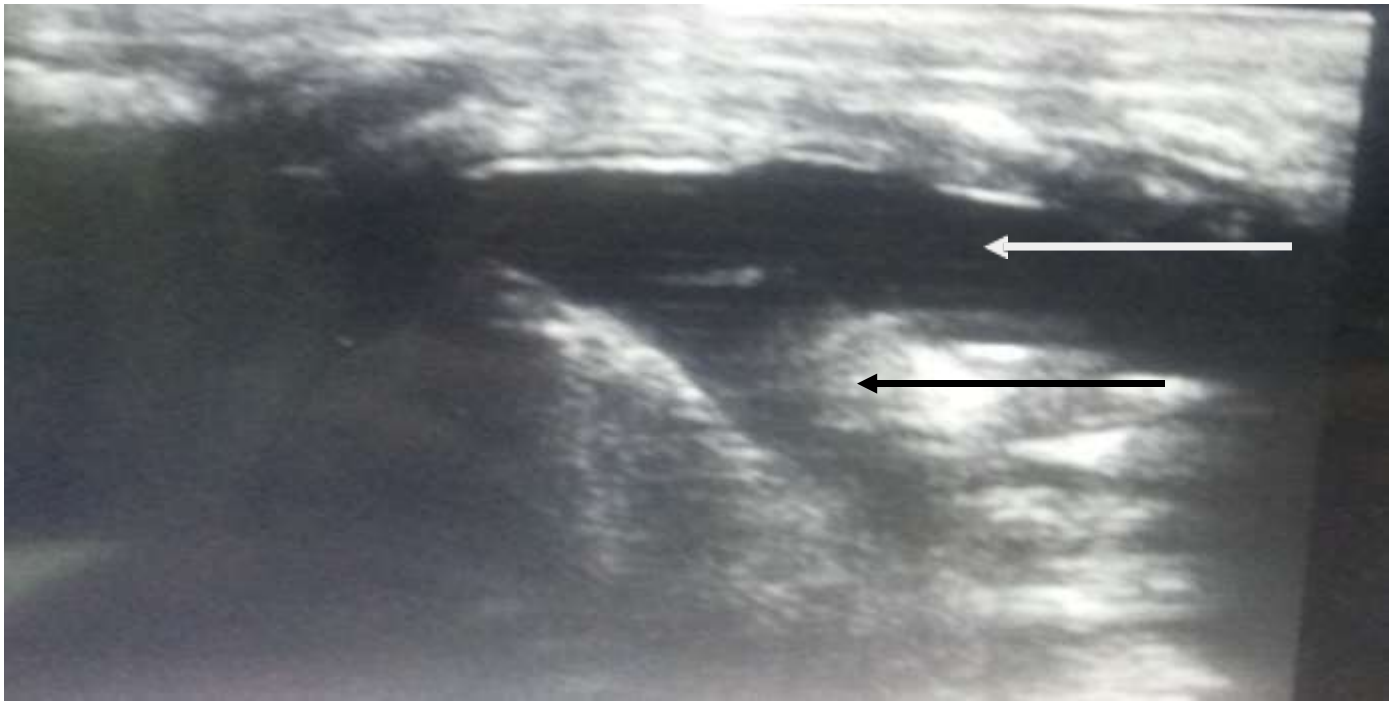
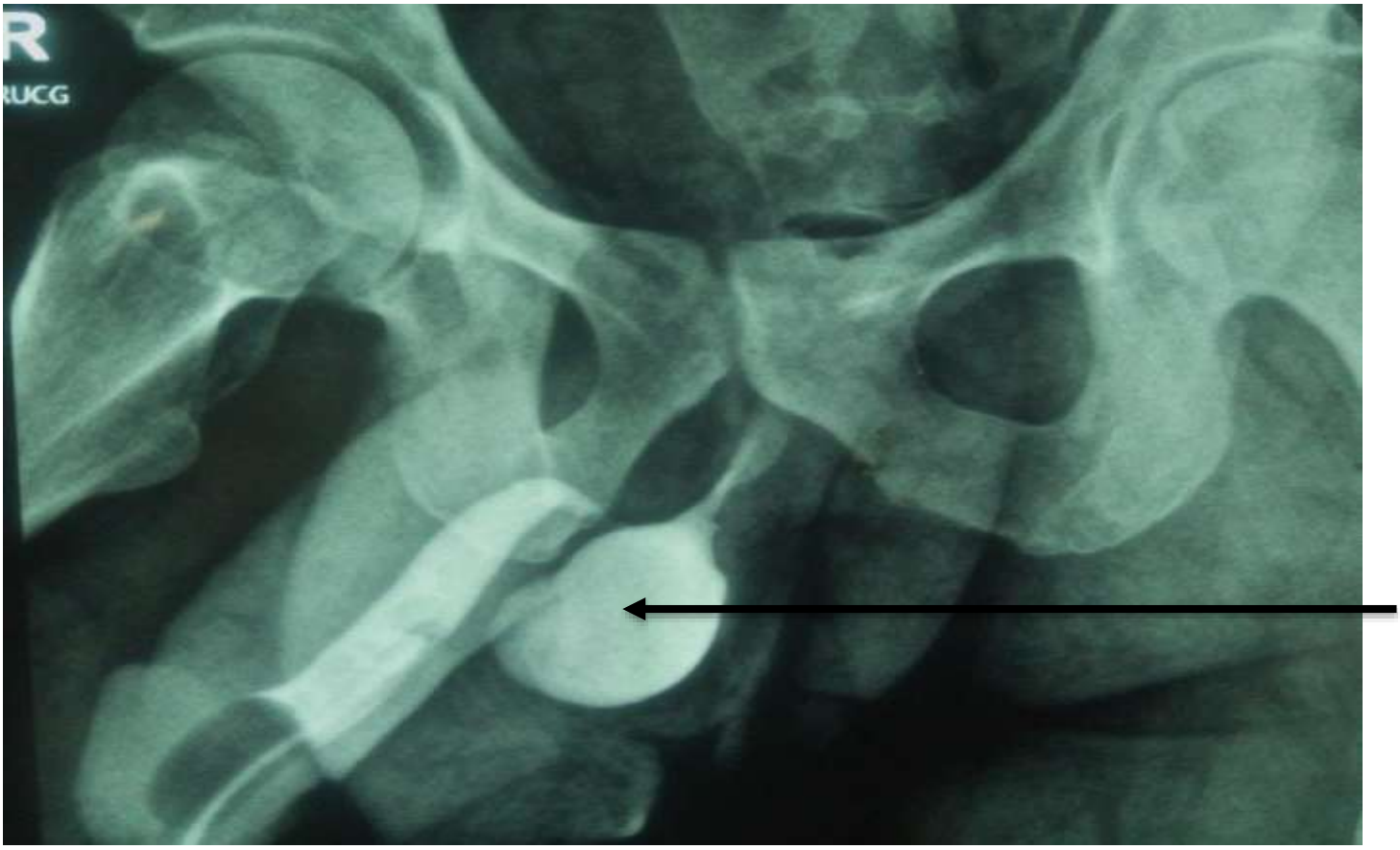


Figure III: Retrograde urethrogram of the same patient in Figure I showing the diverticulum (black arrow) in the bulbar urethra.



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 al[19] 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 reportedRUG 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 al*[22] 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 al [23] 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 al*[8] reported that lengths of US measured with SUG correlated more with the length measured during surgery than with RUG. Priyadarshi *et al*[21] and Choudhary *et al*[13] similarly reported that stricture lengths measured using SUG correlated better with the intra-operative findings than the measurements from RUG. Srinivas *et al*[24] 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 al*[25] 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 radiation[4]. 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 al[13] 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 RUCG and SUG detected equal numbers of single and multiple strictures in the anterior urethra of

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 technique[2]. 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] 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 RUG[12]. 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. Ravi Kumar et al[25]**.** 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[26]. 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.

Disclaimer: Nil

Conflict of Interest: Nil

Funding Disclosure: Nil

Abbreviation	Full Form
US	Urethral Stricture
RUG	Retrograde Urethrography
SUG	Sonourethrography
AUSD	Anterior Urethral Stricture Disease
LUTH	Lagos University Teaching Hospital
SPSS	Statistical Package for the Social Sciences
PPV	Positive Predictive Value
NPV	Negative Predictive Value
MHz	Megahertz
P-value	Probability Value
SD	Standard Deviation
MRI	Magnetic Resonance Imaging

Authors' Contributions:

Study Concept And Design: Durojaiye Moshood Seun

Data Collection: Moses Adebisi Ogunjimi, Rasheed Ajani Arogundade

Manuscript-writing/editing: Rasheed-Ajani Arogundade

Final approval: All Mention Authors Approved the Final Version.

REFERENCES

1. Ayoob A, Dawkins A, Gupta S, Nair R. Anterior urethral strictures and retrograde urethrography: An update for radiologists. Clinical imaging. 2020;67:37-48.

2. Bhatt S, Banerjee A, Tandon A, Dangwal S, Gupta A. A kaleidoscopic view of male urethral pathologies on 64-slice multidetector computed tomographic urethrography: A novel technique. SA journal of radiology. 2021;25(1):1964.

3. Daza González MA, Suárez-Redondo M, Ruíz-Fernández MJ, González-Soriano J, García-Real MI. Urethro-venous intravasation during retrograde urethrography in a dog. The Journal of small animal practice. 2022;63(5):412-5.

4. Elsingergy MM, Bellah RD, Back SJ, Weiss DA, Darge K. Retrograde urethrography in children: a decade of experience at a children's hospital. Pediatric radiology. 2023;53(5):862-74.

5. Frankiewicz M, Markiet K, Krukowski J, Szurowska E, Matuszewski M. MRI in patients with urethral stricture: a systematic review. Diagnostic and interventional radiology (Ankara, Turkey). 2021;27(1):134-46.

6. Freitas PS, Alves AS, Correia PS, Dias JL. Urethrocystography: a guide for urological surgery? Diagnostic and interventional radiology (Ankara, Turkey). 2023;29(1):9-17.

7. Gomez RG, Pfeifer J. Update on female urethral reconstruction. Current opinion in urology. 2021;31(5):486-92.

8. Kang K, Jang M, Choi KU, Kweon OK, Choi M, Yoon J. Antegrade and retrograde CT urethrography with virtual urethroscopy in a dog with urethral narrowing after bilateral triple pelvic osteotomy. Veterinary radiology & ultrasound : the official journal of the American College of Veterinary Radiology and the International Veterinary Radiology Association. 2021;62(5):E48-e53.

9. Kang K, Kim K, Oh D, Choi J, Choi M, Yoon J. Retrograde CT urethrography using a power injector quantitatively reveals effects of bladder distension on urethral size in healthy male Beagle dogs. Veterinary radiology & ultrasound : the official journal of the American College of Veterinary Radiology and the International Veterinary Radiology Association. 2020;61(3):302-11.

10. Kang K, Kim K, So J, Lee J, Jang Y, Choi J, et al. The urethra of healthy female dogs can be normally narrowed due to the urethral flexure in retrograde CT urethrography. Veterinary radiology & ultrasound : the official journal of the American College of Veterinary Radiology and the International Veterinary Radiology Association. 2021;62(1):61-7.

11. Kim SH, Yang HJ, Kim DS, Lee CH, Jeon YS, Kim KH. Clinical efficacy of retrograde urethrography-assisted urethral catheterization after failed conventional urethral catheterization. BMC urology. 2021;21(1):17.

12. Klemm J, Marks P, Dahlem R, Riechardt S, Fisch M, Vetterlein MW. [Contemporary management of pelvic fracture urethral injuries]. Urologie (Heidelberg, Germany). 2022;61(6):602-8.

13. Kühnke L, Fisch M, Vetterlein MW. [Contemporary management of urethral strictures in women . Aktuelle Urologie. 2021;52(3):260-7.

14. Kumar N, Jain S. Letter to the editor for the article "POIROT trial: post-operative imaging after urethroplasty with peri-catheter retrograde urethrography or trial of voiding with voiding cysto-urethrography". World journal of urology. 2022;40(6):1601-2.

15. Lee D, Yoon S, Kim C, Choi J. A comparative study of sono-urethrography using saline, agitated saline, and an ultrasound contrast agent in normal beagles. Veterinary radiology & ultrasound : the official journal of the American College of Veterinary Radiology and the International Veterinary Radiology Association. 2021;62(3):342-9.

16. Lee H, Jeong SY, Hwang K. A method of bedside urethrography before catheterization in pelvic trauma in Korea: a case report. Journal of trauma and injury. 2023;36(4):451-3.

17. Li W, Man L, Huang G. An innovative method for occluding the urethral meatus and accessing urethra strictures in retrograde urethrography in males. BMC

urology. 2023;23(1):158.

18. McNicholas DP, Omar AM, Khadr RN, Floyd MS, Jr. Letter to the editor re: Retrograde urethrography, sonouretrography and magnetic resonance urethrography in evaluation of male urethral strictures: should the novel methods become the new standard in radiological diagnosis of urethral stricture disease? Mikolaj et al., IJUN (October 2021). International urology and nephrology. 2022;54(2):287-8.

19. Mershon JP, Baradaran N. Recurrent Anterior Urethral Stricture: Challenges and Solutions. Research and reports in urology. 2021;13:237-49.

20. Mikolaj F, Karolina M, Oliwia K, Jakub K, Adam K, Mariusz B, et al. Retrograde urethrography, sonouretrography and magnetic resonance urethrography in evaluation of male urethral strictures. Should the novel methods become the new standard in radiological diagnosis of urethral stricture disease? International urology and nephrology. 2021;53(12):2423-35.

21. Mikolaj F, Karolina M, Oliwia K, Jakub K, Adam K, Mariusz B, et al. Response to: "Letter to the Editor, International Urology and Nephrology: Retrograde urethrography, sonouretrography and magnetic resonance urethrography in evaluation of male urethral strictures: should the novel methods become the new standard in radiological diagnosis of urethral stricture disease?". International urology and nephrology. 2022;54(4):813-4.

22. Preston S, Liu J, Eisenbeis L, Cohen A, Fishman EK, Coon D. 3D CT Urethrography With Cinematic Rendering (3DUG): A New Modality for Evaluation of Complex Urethral Anatomy and Assessment of the Postoperative Phalloplasty Urethra. Urology. 2023;174:212-7.

23. Sheehan JL, Naringrekar HV, Misiura AK, Deshmukh SP, Roth CG. The pre-operative and post-operative imaging appearances of urethral strictures and surgical techniques. Abdominal radiology (New York). 2021;46(5):2115-26.

24. Sulistio PA, Prijambodo. Urethrography for diagnostic of penile fracture with ruptured anterior urethra and right corpus cavernosum. Radiology case Reports. 2022;17(12):4694-9.

25. Verla W, Waterloos M, Waterschoot M, Van Camp C, Lambert E, Spinoit AF, et al. POIROT trial: post-operative imaging after urethroplasty with peri-catheter retrograde urethrography or trial of voiding with voiding cysto-urethrography. World journal of urology. 2022;40(5):1195-201.

26. Wang Z, Liang T, Song G, Lin J, Xiao Y, Wang F, et al. The effects of primary realignment or suprapubic cystostomy on prostatic displacement in patients with pelvic fracture urethral injury: a clinical study based on MR urethrography. Injury. 2022;53(2):534-8.