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Comparison Of Sonourethrography And Retrograde Urethrogram For Evaluating Urethral Stricture: A Single-Centre Cross-Sectional Study

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ABSTRACT

Background: Preoperative mapping of anterior urethral stricture requires accurate assessment of site, length, and tissue quality. Sonourethrography (SUG) provides detailed soft-tissue characterization, whereas retrograde urethrogram (RGU) primarily depicts luminal narrowing.
Objective: To compare the diagnostic performance of SUG and RGU and describe SUG-based assessment of length, spongiofibrosis, and associated findings.
Methods: In this single-centre cross-sectional study, 65 adult males with suspected anterior urethral stricture underwent same-session SUG and RGU. Detection yield and diagnostic indices (sensitivity, PPV, NPV, accuracy) were calculated using SUG as the reference standard.
Results: SUG detected strictures in 55/65 (84.6%) versus 45/65 (69.2%) for RGU. Against SUG, RGU had sensitivity 69.2%, PPV 100%, NPV 0%, and accuracy 69.2%. Strictures were most often bulbo-membranous (41.5%) or penile (33.8%). On SUG, 47.7% measured ≤15 mm, and 71.9% showed spongiofibrosis (mild 35.4%, moderate 20.0%, severe 15.4%). Associated findings included urethral calculi (20.0%), bladder calculi (16.9%), and urethritis (15.4%).
Conclusion: SUG demonstrated higher stricture detection than RGU and uniquely assessed extent and tissue fibrosis while identifying associated pathology. These findings support SUG as a complementary or front-line modality for preoperative evaluation of anterior urethral strictures.

***Keywords**: sonourethrography, retrograde urethrogram, urethral stricture, spongiofibrosis, preoperative mapping.*

INTRODUCTION

Since its first urologic description by McAninch et al. in the late 1980s, sonourethrography (SUG) has evolved from a preliminary adjunct to a practical front-line tool for anterior urethral stricture evaluation, offering real-time lumen, wall, and peri-urethral tissue assessment without ionizing radiation [1]. Contemporary consensus statements from the SIU/ICUD emphasize that imaging should answer surgical questions—precise site, length, and tissue quality—to streamline decision-making and follow-up pathways [2]. Accurate preoperative mapping is not merely diagnostic; it influences resource use and the choice between endoscopic and reconstructive strategies across the patient journey [2,3].
Comparative work has repeatedly highlighted limitations of retrograde urethrography (RGU)—notably length underestimation and missed short or poorly distensible segments—while showing that SUG can improve delineation of stricture extent and peri-urethral fibrosis (spongiofibrosis) that governs reconstructive planning [4]. From a management standpoint, durable outcomes hinge on selecting the right operation for the right lesion: short, non-fibrotic strictures may be amenable to endoscopic approaches, whereas longer segments and those with substantial spongiofibrosis favor urethroplasty—a paradigm reflected in modern reviews and practice frameworks [3,5]. Importantly, SUG's utility extends to pediatric anterior strictures as well, where feasibility studies have demonstrated clinically actionable visualization of length and tissue changes, underscoring its breadth of application [6].

Against this background, we conducted a single-centre comparative study to quantify the detection yield of SUG versus RGU and to report SUG-based extent (length bands) and tissue characterization (spongiofibrosis) that are directly relevant to operative planning.

AIMS & OBJECTIVES

Aim

- To assess and compare the utility of sonourethrography (SUG) with retrograde urethrogram (RGU) in evaluating strictures of the penile urethra, bulbar urethra, and bulbo-membranous junction.

Objectives

1. To determine and compare the sensitivity of SUG and RGU for identifying anterior urethral strictures.
2. To evaluate the accuracy of stricture length measurement by SUG and RGU.
3. To assess the capability of SUG to detect and grade peri-urethral fibrosis (spongiofibrosis) and to identify associated peri-urethral pathology (e.g., urethral/bladder calculi, urethritis) relevant to preoperative planning.

MATERIALS AND METHODS

Study setting, design, and duration

This cross-sectional imaging study was conducted at the Parul Institute of Medical Sciences & Research (PIMSR), P.O. Limda, Waghodia, Vadodara, Gujarat (India) in the Departments of Urology and Radiology. Recruitment spanned 12 months from Institutional Ethics Committee approval.

Study population

The source population comprised patients referred from Urology to the Department of Radiology for evaluation of suspected urethral stricture. Consecutive adult males meeting eligibility criteria underwent same-session RGU and SUG.

Sample size and recruitment

Based on service volume (approximately 4–5 referrals/month by conventional pathway), an a priori target of 50–60 patients was planned; the final analytic cohort was 65 consecutive eligible cases accrued within the 12-month window.

Eligibility criteria

Inclusion criteria

- Male patients ≥18 years with clinical suspicion of urethral stricture (e.g., obstructive lower urinary tract symptoms, weak stream, retention, prior instrumentation/trauma) referred for imaging.
- Ability to undergo both retrograde urethrogram (RGU) and sonourethrography (SUG) in the same visit.

Exclusion criteria

- Female patients.
- Posterior urethral pathology requiring primary VCUG/MRI mapping (study focused on anterior urethra: penile, bulbar, bulbo-membranous junction).
- Active urethral bleeding precluding safe instrumentation/instillation at the time of imaging.

Sampling was pragmatic; the final analytic cohort comprised 65 adult males.

Imaging protocols

Retrograde urethrogram (RGU)

- Equipment: Digital X-ray/fluoroscopy unit (e.g., Wipro GE DX-300 or equivalent).
- Preparation: Sterile draping; a small-calibre catheter placed at the fossa navicularis; gentle occlusion of the glans.
- Contrast and views: Low-osmolar iodinated contrast instilled retrograde under fluoroscopy; oblique and lateral projections obtained with gradual distension of the anterior urethra. When needed, a supplementary voiding cystourethrogram (VCUG) was added for proximal delineation.
- Interpretation: A stricture was defined as a persistent luminal narrowing with proximal dilatation and/or failure of full distension. Length was measured along the urethral axis from the distal to proximal margins of the narrowed segment on the best-distended image. RGU was used primarily as a lumenographic comparator.

Sonourethrography (SUG)

- Equipment: High-frequency linear transducer 5–12 MHz (e.g., Mindray DC-70/60 or equivalent).
- Technique: After sterile prep, an 8 Fr Foley was positioned at the fossa navicularis and the balloon inflated with 2–3 mL sterile water to achieve a seal. The anterior urethra was then distended with sterile saline (≈10–60 mL), titrated to patient comfort for adequate but non-painful distension. With the patient supine, the penis was gently extended on the abdomen. A ventral longitudinal and transverse sweep was performed from the meatus to the

bulbo-membranous junction; short-axis “step-off” views were added to confirm margins. Patients were asked to briefly contract the pelvic floor to retain saline during scanning.

Definitions and measurements:

- Stricture: Indistensible segment with reduced salino-lumen calibre compared with adjacent urethra, often with mural thickening.
- Length (SUG): linear distance between the distal and proximal transition points (measured on longitudinal images; cross-checked in transverse planes). Length was categorised ≤15 mm, 15–25 mm, >25 mm.
- Spongiofibrosis: hyperechoic peri-urethral bands or plaques with/without acoustic shadowing or mural thickening around the narrowed lumen; recorded as present/absent and graded mild/moderate/severe based on radial thickness and echogenicity.
- Associated findings: urethral calculi, bladder calculi, and features of urethritis (mural hyper-echogenicity/vascularity) were noted when present.

All examinations were performed by radiologists trained in the protocol, with immediate same-session RGU and SUG to minimise interval change.

Outcomes

The primary comparison was modality yield for detecting anterior urethral stricture (SUG positive vs RGU positive). Using SUG as the study reference, RGU performance was summarised as sensitivity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy, with accompanying 2×2 counts (TP, FP, FN, TN). Secondary SUG outcomes included stricture length bands, presence and severity of spongiofibrosis, and associated findings (urethral/bladder stones, urethritis).

Data collection

A structured case-record form captured demographics, presentation, prior instrumentation/trauma, and imaging outputs (site, length, fibrosis, associated findings). Measurements were recorded from PACS/ultrasound consoles to 0.1 cm precision where applicable.

Statistical analysis

Data were analysed using standard statistical software (e.g., IBM SPSS v25). Categorical variables are reported as n (%) and continuous variables as mean ± SD where appropriate. Detection yield is presented as proportions for SUG and RGU. For RGU (with SUG as reference), sensitivity, PPV, NPV, and accuracy were calculated from the 2×2 table. Comparisons of proportions (e.g., SUG vs RGU positive rate) used chi-square or Z-tests for proportions as appropriate. Two-sided $p < 0.05$ was considered statistically significant. Because the study frame contributed few/zero true negatives, specificity/NPV estimates for RGU were interpreted cautiously.

Ethics

The study protocol received Institutional Ethics Committee approval prior to recruitment. All participants provided written informed consent. The study adhered to the Declaration of Helsinki and maintained strict confidentiality of patient information.

RESULT

1. Study cohort

Sixty-five adult males were evaluated. Age distribution peaked in the 51–60 years band, with additional clustering in the 41–50 and 31–40 bands. The most frequent presentations were lower urinary tract symptoms, trauma-related referral, and prior catheterization, with other common complaints including dribbling, urinary retention, and a history of stricture (Table 1).

Table 1. Baseline characteristics (N = 65)

Variable	Category	n	%
Age (years)	18–20	4	6.2
	21–30	5	7.7
	31–40	11	16.9
	41–50	14	21.5
	51–60	**20**	**30.8**
	61–70	8	12.3
	71–80	3	4.6
Clinical presentation	Lower urinary tract symptoms (LUTS)	16	24.6
	Trauma-related	11	16.9
	History of catheterization	10	15.4
	Dribbling/weak stream	9	13.8

	Urinary retention	8	12.3
	Prior stricture	8	12.3
	Post-surgical status/trauma	5	7.7

Note: Values are presented as counts and percentages of the total cohort (N=65).

2. Modality yield and diagnostic performance

Sonourethrography (SUG) identified strictures more frequently than retrograde urethrogram (RGU). Using SUG as the study reference, RGU showed lower detection yield and an error pattern dominated by false negatives. On study-reported metrics, RGU achieved sensitivity 69.2%, diagnostic accuracy 69.2%, PPV 100%, and NPV 0%—reflecting that RGU-"normal" studies did not reliably exclude disease in this cohort (Table 2 and figure1)

Table 2. Modality detection and performance

Panel A — Detection yield

Modality	Positive n/N (%)
SUG	55/65 (84.6%)
RGU	45/65 (69.2%)

Panel B — RGU vs SUG (2×2 table and derived metrics)

	SUG +	SUG –	Total
RGU +	TP = 45	FP = 0	45
RGU –	FN = 20	TN = 0	20
Total	65	0	65

Derived metrics for RGU (vs SUG):

- Sensitivity = TP/(TP+FN) = 45/65 = 69.2%
- Specificity = TN/(TN+FP) = 0/0 (not informative)
- PPV = TP/(TP+FP) = 100%
- NPV = TN/(TN+FN) = 0%
- Accuracy = (TP+TN)/Total = 45/65 = 69.2%

Note: In this study frame, SUG functioned as the reference and the cohort contributed few/zero true negatives; therefore, specificity and NPV are not clinically interpretable and appear trivially zero. The principal error mode for RGU was false negatives relative to SUG.

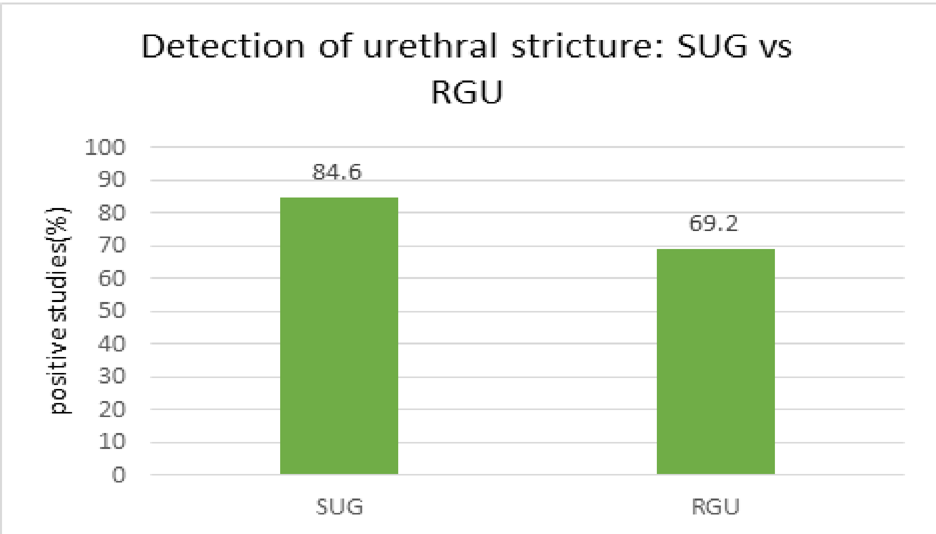

Figure 1 — Detection of urethral stricture: SUG vs RGU

3. Anatomical distribution and etiology

Strictures were most frequently located at the bulbo-membranous junction, with penile and bulbar urethra next most common. Etiologies were led by inflammatory and idiopathic causes, with notable contributions from iatrogenic and traumatic mechanisms (Table 3).

Table 3. Stricture site and etiology (N = 65)

Domain	Category	n	%
Site	Bulbo-membranous	27	41.5

	junction		
	Penile urethra	22	33.8
	Bulbar urethra	12	18.5
	Mixed (penile + bulbar)	4	6.2
Etiology	Inflammatory	16	24.6
	Idiopathic	13	20.0
	Iatrogenic	12	18.5
	Traumatic	11	16.9
	Post-TURP	6	9.2
	Infective	7	10.5

4. SUG characterization: length and spongiofibrosis

SUG demonstrated a bimodal length distribution, with nearly half of strictures ≤15 mm and about one-third >25 mm. Spongiofibrosis was frequent (≈72%), and severity grading was documented in all positives, with mild changes most common. These tissue and extent details—unavailable on RGU—directly inform endoscopic versus urethroplasty planning (Table 4, Figure 2).

Table 4. SUG characterization (extent and tissue)

Panel A — Stricture length (SUG)

Length band	**n**	**%**
≤ 15 mm	31	47.7
15–25 mm	14	21.5
> 25 mm	20	30.8

Panel B — Spongiofibrosis (SUG)

Category	**n**	**%**
Present	46	71.9
Absent	19	28.1

Panel C — Spongiofibrosis severity

Severity	**n**	**%**
Mild	23	35.4
Moderate	13	20.0
Severe	10	15.4

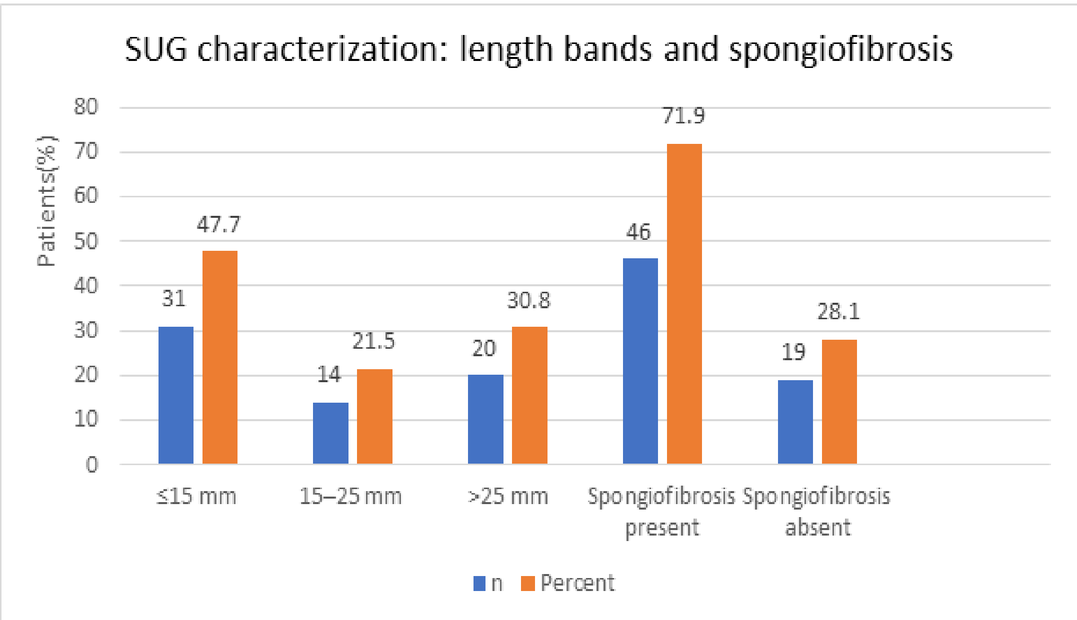

Figure 2. *SUG characterization of strictures by length band and spongiofibrosis. Bars display percentage of patients (N=65). Sample sizes per category: ≤15 mm n=31, 15–25 mm n=14, >25 mm n=20, spongiofibrosis present n=46, absent n=19. The distribution highlights a short-segment cluster (≤15 mm) and frequent spongiofibrosis, underscoring SUG's added value for extent and tissue assessment.*

5. Associated findings detectable on SUG

Beyond luminal narrowing, SUG identified additional pathology relevant to planning—most commonly urethral calculi and bladder calculi, with urethritis also observed. These findings are not assessed on RGU and can influence the choice and sequencing of intervention (Table 5).

Table 5. SUG-associated findings (N = 65)

Finding	n	%
Urethral calculi	13	20.0
Bladder calculi	11	16.9
Urethritis	10	15.4

Note: These adjunct findings highlight SUG's value in preoperative mapping, particularly when endoscopic clearance of stones or targeted treatment of peri-urethral inflammation is needed before/alongside reconstruction.

In summary, SUG outperformed RGU for stricture detection and uniquely characterized extent (length) and tissue status (spongiofibrosis) while revealing associated pathology (stones, urethritis), underscoring its complementary role in preoperative mapping.

DISCUSSION

Our findings reinforce that sonourethrography (SUG) detects anterior urethral strictures more frequently than retrograde urethrogram (RGU) and adds decision-critical information on extent and tissue quality. In a head-to-head comparison, Shahsavari et al. reported higher diagnostic performance of SUG than RGU for anterior disease, with SUG capturing lesions that RGU missed on lumenography—particularly short segments and areas with periurethral change [7]. That pattern mirrors our yield gap (SUG 84.6% vs RGU 69.2%) and the predominance of RGU false-negatives.

Tissue characterization is where SUG meaningfully advances preoperative planning. Oyelowo et al. showed that greater spongiofibrosis on SUG, together with longer stricture length, tracks with the need for formal urethroplasty and lower endoscopic success at follow-up [8]. In our cohort, spongiofibrosis was frequent (~72%) and length was often either short (≤15 mm, ~48%) or clearly long (>25 mm, ~31%), a distribution that aligns with the clinical inflection point between endoscopic and open reconstruction described by Kim et al. [8]. Methodologically, SUG performance depends on execution: Miszewski et al. identified independent determinants of SUG precision—including operator technique, adequate distension, and probe–urethra angle—that improved agreement with intraoperative findings [9]. We standardised a ventral approach with controlled saline distension, which likely contributed to the consistent depiction of margins and fibrosis in our series.

Classical comparative work also supports SUG's sensitivity for anterior disease. Choudhary et al. found that SUG outperformed RGU for detecting short-segment strictures and defined length more accurately, with SUG estimates more closely matching operative measurements (often within the 1–5 mm range) [10]. Conversely, modern multimodality reviews continue to caution that RGU may underestimate length and miss short or poorly distensible segments, while SUG and MR urethrography mitigate that limitation [11]. Our error pattern—RGU false-negatives against a positive SUG—fits those mechanisms (contrast column, positioning, and distension dependency on RGU).

Technique matters. Contemporary atlases describe practical SUG steps—a small Foley balloon at the fossa navicularis, controlled saline (10–60 mL), and a high-frequency linear probe—permitting dynamic, multiplanar assessment of luminal narrowing, wall echotexture, and periurethral echogenic bands/calcification that mark fibrosis [12]. Earlier clinical experience likewise showed SUG to be reproducible; Nash et al. reported acceptable interobserver agreement for anterior strictures when standardised views and measurement landmarks were used [13]. These technical anchors help explain why our SUG readings delivered consistent length-band assignment and fibrosis grading across operators.

Beyond accuracy, SUG's radiation-free profile is relevant to cumulative exposure and repeat studies. Radiologic reviews highlight that RGU/VCUG involve ionising radiation and iodinated contrast, whereas ultrasound avoids both and can be performed bedside, which is advantageous in serial assessments or in patients with contrast concerns [14]. From a pathway perspective, guideline syntheses emphasise an imaging strategy that answers surgical questions (site, length, and tissue) efficiently and cost-consciously; SUG is increasingly positioned as a first-line or complementary test for anterior disease in that framework [15].

Importantly, our data apply to anterior strictures. For posterior urethral pathology—particularly pelvic fracture urethral injuries—comprehensive reviews suggest that RGU combined with VCUG and, when available, MR urethrography provide superior delineation of distraction defects and surrounding pelvic anatomy [16]. This methodological distinction explains why a SUG-first approach is not universal; modality selection should track the anatomical problem.

SUG's ability to reveal associated pathology also has practical value. Real-time ultrasound can identify urethral and bladder stones—including radiolucent calculi that may be inconspicuous on fluoroscopy—supporting pre-emptive clearance prior to reconstruction [17]. Bedside bladder ultrasound is likewise widely used for quantification and mapping in perioperative settings, facilitating efficient planning without additional fluoroscopy [18]. In our series, urethral calculi (~20%) and bladder calculi (~17%) were not rare; having that information upfront can alter sequencing (e.g., stone management before urethroplasty).

Epidemiologically, our site and etiology distributions are consistent with large consensus statements: anterior strictures are commonly inflammatory/idiopathic, with meaningful iatrogenic and traumatic subsets depending on regional practice patterns and catheterisation exposure [19]. The predominance of bulbo-membranous/penile involvement and the mix of inflammatory, idiopathic, and iatrogenic causes we observed match those ranges. Finally, the clinical interpretation of SUG findings flows naturally into treatment selection. Again, Oyelowo et al. linked longer length and more extensive spongiofibrosis to reduced endoscopic durability and a greater likelihood of urethroplasty [20]. Our bimodal length distribution (short vs long) and frequent fibrosis therefore provide a coherent, imaging-led rationale for stratifying patients toward endoscopic dilation/urethrotomy versus definitive open repair.

Taken together, the literature suggests that for anterior strictures, SUG offers higher detection than RGU, more accurate length estimation, and unique visibility of spongiofibrosis, all of which sharpen preoperative decision-making [7–15]. Posterior injuries remain a separate domain favouring RGU/VCUG and MRI [16]. Regional variation in aetiology, operator expertise, and equipment will shift absolute performance, but the directionality is stable: when executed with standardised technique, SUG is a robust, radiation-free adjunct (and often front-line test) that complements RGU by resolving the very questions that govern whether to scope, reconstruct, or stage care [7–20].

Limitations

This was a single-centre cohort with a modest sample size (N=65) focused on anterior urethral strictures. Sonourethrography (SUG) was used as the study reference, which constrains interpretation of specificity/NPV for RGU because true negatives were sparse. Not all cases had uniform surgical correlation as a gold standard, and interobserver variability for SUG measurements was not evaluated. The cross-sectional design precludes assessment of long-term outcomes (e.g., endoscopic durability vs urethroplasty success).

CONCLUSION

SUG demonstrated higher stricture detection than RGU and uniquely characterized extent (length) and tissue status (spongiofibrosis) while revealing associated pathology (e.g., urethral/bladder calculi). These features are directly actionable for preoperative planning and support SUG as a complementary—or first-line—modality for anterior disease, with RGU/VCUG (and MRI when indicated) reserved for posterior pathology and complex mapping. Larger, multicentre studies with a surgical gold standard, interobserver analyses, and longitudinal outcomes are warranted to refine accuracy estimates and link SUG phenotypes to treatment selection and durability.

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