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RESEARCH ARTICLE

Standardisation of the Elasticity Value of the Testis by Shear Wave Elastography

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Abstract: Grey-scale ultrasound with colour Doppler is sensitive for detecting testicular abnormalities but lacks specificity, especially for focal hypoechoic lesions. Real-time elastography (RTE) differentiates tissue hardness, with cancers appearing harder than normal tissue. Shear-wave elastography (SWE) offers quantitative imaging of tissue stiffness, though its role in testicular diseases is uncertain. This study aims to determine the standard elasticity value of the test using SWE to enhance diagnostic accuracy in differentiating normal and abnormal testicular tissues. This prospective study will be conducted at the Department of Radiology, MMCHRI, over six months, with a sample size of 30 patients referred to hydrocele, varicocele, or infertility. Patients with gross scrota infections, filariasis, or testicular tumours will be excluded. All participants will undergo B-mode sonography and SWE using the Toshiba Aplio 500 ultrasound system. Two measurements will be taken per testis, and statistical analysis, including correlation (Pearson or Spearman), will evaluate the relationship between SWE values and testicular tissue characteristics. SWE is expected to provide a standardised assessment of testicular tissue stiffness, with abnormal tissues showing significantly higher stiffness than normal tissue. This may improve ultrasound specificity in diagnosing testicular pathologies. The study aims to validate SWE as a reliable imaging modality for testicular evaluation, addressing limitations of conventional ultrasound and enhancing clinical decision-making.

Keywords: Shear Wave Elastography (SWE), Testis, Testicular Elasticity, Hydrocele.

INTRODUCTION

Ultrasound imaging is still the most common modality in evaluating scrotal pathology, with extensive use in scrotal swelling, infertility, and acute pain [1]. Traditional B-mode and Doppler ultrasound offer morphological and vascular data, but are of no use in the measurement of tissue stiffness. Historically, urologists have been using palpation to evaluate testicular consistency, but this evaluation is subjective and is also limited by interobserver variation [2]. Elastography is a relatively new ultrasound method that enables objective assessment of soft tissue hardness. There are two predominant methods, which include strain elastography (SE) and shear wave elastography (SWE). SE measures tissue deformation by comparing the characteristics of the ultrasound beam pre- and post-compression, which gives semi-quantitative data. In spite of its clinical potential, SE has low reproducibility and requires operator dependence, limiting its clinical uptake [3]. Conversely, SWE uses a real-time a priori measurement of stiffness, which is quantitative and reproducible, and expressed in kilopascals (kPa), by creating and monitoring shear wave propagation in tissue [4]. This method has been successfully proven in liver fibrosis and thyroid nodules, and its use in the testis is also under investigation [5,6]. Whereas there are some studies that have examined testicular elastography, the majority of those studies have examined SE, and there are smaller-scale studies that utilised SWE [7]. It is therefore important to create standard values of testicular elasticity to be used in andrology and urology.

Anatomy of the Testis

The testis is the primary male gonad, which is housed in the scrotum and attached to the spermatic cord. The left testis is usually lower than the right. It is oval in form, of average length, breadth, and thickness, 5 cm long, 2.5 cm broad and 3 cm thick, weighing between 1014 g [8]. The testis is externally two-poled (upper and lower), two-bordered (anterior and posterior), and two-surfaced (medial and lateral). The epididymal head overlaps the upper pole with the posterior border, referring to the epididymal body and vas deferens. The epididymis is divided laterally by the sinu of the epididymis, which is a segment of the tunica vaginalis cavity [9].

Coverings:

- *Tunica vaginalis*: peritoneal extension covering the testis except posteriorly.
- *Tunica albuginea*: dense fibrous capsule thickened posteriorly to form the mediastinum testis.
- *Tunica vasculosa*: vascular inner layer beneath the albuginea.

Vascular and Neural Supply:

- Arterial: testicular artery from the abdominal aorta.
- Venous: pampiniform plexus testicular vein (drains into the inferior vena cava on the right and left renal vein on the left).

- Lymphatic: para-aortic lymph nodes.
- Nerve supply: sympathetic fibres from the T10 spinal segment via the renal and aortic plexuses [8].

Aim and Objectives

This study aims to standardise testicular elasticity values using shear wave elastography. The specific objectives are to:

1. Measure the elastic properties of the testicular parenchyma in normal testis, hydrocele, and varicocele.
2. Assess the elasticity of the testicular hilum in these conditions.
3. Establish standardised reference values for testicular stiffness using SWE, to improve reproducibility and clinical decision-making in urology and andrology.

MATERIALS AND METHODS

Equipment

All examinations were performed using a Mindray Insigths DC-80 ultrasound diagnostic imaging system equipped with a linear transducer (5–12 MHz).

Study Design and Population

This was a **prospective observational study** conducted over a period of three months (April 2025–June 2025) in the Department of Radiology, MMCH&RI. A total of **30 patients** were enrolled.

Inclusion Criteria

Control group: Normal volunteers with the following features:

- Vague pain with normal clinical examination.
- Normal testicular volume and echotexture.
- No evidence of epididymal obstruction or reflux on Valsalva manoeuvre.
- No history of infertility.
- At least one biological child.

Symptomatic group:

- Varicocele (grades 1–3, according to Dubin's classification; or non-palpable but confirmed reflux on Valsalva according to Sarteschi's classification).
- Hydrocele (fluid surrounding the testis with a variable echo-free region, with or without internal echoes if inflammatory).
- Scrotal swelling or scrotal infection.

Exclusion Criteria

- Filarial scrotum.
- Testicular tumour.
- Fournier's gangrene.
- Epididymo-orchitis.

Ethical Considerations: The study was approved by the **Institutional Ethics Committee.** Written informed consent was obtained from all participants before examination.

Patient Preparation: Each patient's identity was verified. Patients were instructed to change into a hospital gown, and the procedure was explained in detail. During examination, patients lie supine with the penis lifted toward the abdomen and covered with a towel.

Procedure

Baseline Ultrasound: Routine B-mode and Doppler ultrasound were performed to evaluate testicular echotexture, vascularity, and abnormalities. Both tests were scanned longitudinally and coronally to compare size, vascularity, and echogenicity. Testicular volume was calculated in all patients.

Shear Wave Elastography (SWE): SWE mode was activated once a uniform parenchymal image was obtained, ensuring minimal probe pressure to avoid stiffness overestimation (10,11). Dual-screen mode was used, with grayscale imaging on one side and a colour-coded stiffness map on the other.

For each testis:

- Region of Interest (ROI): Two circular ROIs (10 mm diameter) were placed in the parenchyma and hilum, respectively.
- The mean, median, and interquartile range (IQR) of stiffness (in kPa) and shear wave propagation speed (m/s) were automatically displayed.
- The average of two measurements was recorded as the final elasticity value for each site.
- Each testis was considered independently.

Data Classification

Patients were grouped into: Normal controls, Hydrocele and Varicocele. Elasticity values of hydrocele and varicocele patients were compared with controls.

Statistical Analysis

Data was entered into Microsoft Excel and analysed using R Studio (version 3.5.3). Testicular stiffness was expressed as mean ± standard deviation (SD), median, percentiles (0th, 25th, 50th, 75th, 100th), IQR, minimum, and maximum. Karl Pearson's correlation coefficient was used to assess the relationship between testicular volume and stiffness. Box plots were generated to illustrate testicular stiffness distribution. A p-value < 0.05 was considered statistically significant (12).

RESULTS

This prospective study included 30 male patients aged between 24 and 56 years, who underwent B-mode ultrasonography and Shear Wave Elastography (SWE) for both testes. The objective was to establish normal and pathological elasticity values of the testicular parenchyma and hilum.

Distribution of Cases by Diagnosis

Among the 30 patients, 15 (50%) had normal findings, while 15 (50%) showed abnormalities. Hydrocele was observed in 6 patients (20%), varicocele in 3 patients (10%), azoospermia in 4 patients (13.3%), atrophic testis in 1 patient (3.3%), and scrotal infection in 1 patient (3.3%) (Table 3.1).

Table 3.1: Number of Patients in Each Diagnostic Category

Finding	No. of Cases
Normal Study	15
Hydrocele	6
Varicocele	3
Azoospermia	4
Atrophic Testis	1
Scrotal Infection	1

Elasticity and Volume Analysis

The mean parenchymal elasticity in the normal testis was 3.3 ± 0.18 kPa, while the hilum showed 7.07 ± 0.18 kPa with an average testicular volume of 10.7 ± 2.46 mL. Patients with hydrocele exhibited increased parenchymal stiffness (5.15 ± 0.17 kPa) compared to normal values, while hilum values were 7.53 ± 0.08 kPa. In varicocele, the parenchymal value was 4.27 ± 0.20 kPa with lower hilar elasticity (4.5 ± 0.1 kPa) and reduced mean volume (6.17 ± 0.05 mL).

Azoospermia patients demonstrated reduced parenchymal stiffness (3.05 ± 0.22 kPa) but significantly elevated hilar elasticity (9.08 ± 0.16 kPa). The single case of atrophic testis revealed markedly high hilar elasticity (13.8 kPa) with reduced volume (5.9 mL). Similarly, scrotal infection demonstrated increased parenchymal (4.2 kPa) and hilar (6.1 kPa) stiffness, with reduced testicular volume (5.6 mL) (Table 3.2).

Table 3.2: Elasticity and Volume Summary

Finding	Parenchyma (kPa)	Hilum (kPa)	Volume (mL)
Normal Study	3.3 ± 0.18	7.07 ± 0.18	10.7 ± 2.46
Hydrocele	5.15 ± 0.17	7.53 ± 0.08	9.22 ± 0.26
Varicocele	4.27 ± 0.20	4.5 ± 0.1	6.17 ± 0.05
Azoospermia	3.05 ± 0.22	9.08 ± 0.16	9.05 ± 0.11
Atrophic Testis	4.1	13.8	5.9
Scrotal Infection	4.2	6.1	5.6

Representative Cases

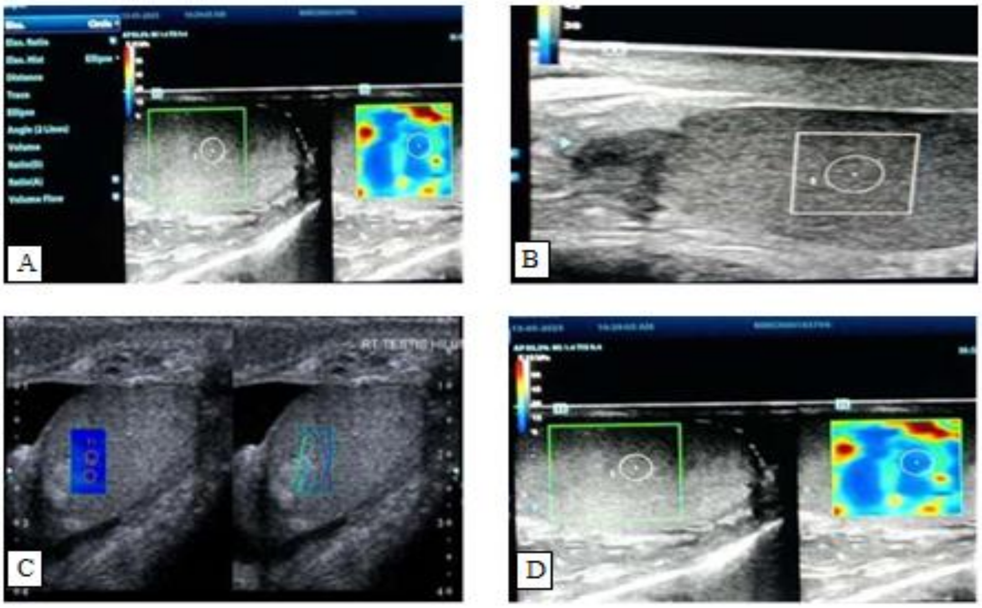

Figure 3. [a] Demonstrates a patient with normal testicular parenchyma and an SWE value of 1.09 kPa. [b] Shows a varicocele testis hilum with a SWE value of 1.17 kPa. [c] Illustrates a hydrocele testis hilum with an SWE value of 1.47 kPa. [d] Presents a patient with azoospermia, showing reduced parenchymal elasticity (0.90 kPa).

DISCUSSION

The research conducted shows that Shear Wave Elastography (SWE) can be used to gather useful quantitative data on testicular elasticity in both healthy and pathological individuals. Normal testis showed a parenchymal stiffness of about 3.3 kPa, which agreed with the baseline values previously reported [13]. However, pathological conditions showed different changes. The parenchymal stiffness was more pronounced in the presence of hydrocele and varicocele, with consequent decrease in the volume, in agreement with previous studies, which indicate that scrotal fluid pools and venous stasis affect the testicular microarchitecture [14]. Azoospermia was also characterised by the comparatively retained parenchymal stiffness and considerable increase in hilar elasticity, indicating the compensatory alterations in vascular and stromal elements. Atrophic testis exhibited significantly high levels of hilar stiffness and shrinkage, and these were associated with degenerative alterations. Equally, the scrotal infections were found to have more stiffness, indicating inflammatory infiltration [15]. These findings indicate that by using SWE, a non-invasive, reproducible adjunct to standard ultrasonography, it is possible to differentiate pathologies of the testicles. Nonetheless, this cannot be generalised because of the small sample size, and larger cohort studies should be used to prove the hypothesis.

CONCLUSION

Shear Wave Elastography (SWE) is a non-invasive method with a high level of reliability and standardisation that is useful in monitoring the health of the testis. In the paper, normal testis showed a uniform value of elasticity of 3.0 -3.7 kPa in the parenchyma and 6.7- -7.3 kPa in the hilum. Peculiar changes in elasticity were detected in the pathological cases like hydrocele, varicocele, azoospermia, atrophy and infection of the scrotum, and these changes are seen to be the structural and functional changes. These results demonstrate the possibility of SWE to supplement the traditional ultrasonography with the provision of quantitative data, enhancing diagnostic accuracy. Notably, SWE is especially useful when infertility, scrotal swelling and those with ambiguous results on a grayscale are being considered, with a standard imaging examination possibly being inconclusive. Since SWE is reproducible and clinically relevant, it should be included in the standard ultrasound test procedures in the testicular ultrasound to increase diagnostic certainty and patient management. It would be advisable to conduct future research using larger cohorts to provide exhaustive reference numbers and clinically prove its applicability.

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