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RESEARCH ARTICLE

A Cross-Sectional Analysis: Role of Shear Wave Elastography in Diagnostic Imaging of Normal and Abnormal Testis

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Abstract: A non-invasive, quantitative imaging modality, which is an evaluation of tissue stiffness, is Shear Wave Elastography (SWE). Although it has been standardised in the assessment of the liver and thyroid gland, its application in testicular imaging is still being research. This paper sought to analyse the usefulness of SWE in the diagnosis of normal and abnormal testis, in the diagnostic imaging process, as well as to determine normal baseline values of elasticity in clinical applications. A cross-sectional research study was conducted in the Department of Radiology and Imaging in the Meenakshi Medical College Hospital and Research Institute. Fifty male patients (comprising 100 testes), some healthy volunteers, and those with abnormalities of the scrotum were studied with SWE with a high-frequency linear transducer (5 12 MHz). Testis were grouped into normal, hydrocele, varicocele and other abnormalities. Measurements of quantitative stiffness (kPa) were taken separately on the testicular parenchyma and hilum. Parenchymal stiffness of the normal testis was 3.8 kPa, with a median stiffness of the hilum of 6.5 kPa. Testis with hydrocele recorded higher values (parenchyma: 5.4 kPa; hilum: 7.0 kPa), and the cases of varicocele were found to be less stiff (parenchyma: 3.2 kPa; hilum: 4.3 kPa). Since atrophied testis and those corresponding to scrotal infection were observed, the hilum stiffness was exceptionally high. In sum, hilum values were shown to be higher than parenchymal values in all groups. SWE offers a reproducible, measurable measurement of testicular tissue stiffness and its distinction of normal or abnormal tissue. Normative SWE values would create an accurate diagnosis that helps it be cost-effective and used as a good adjunct in the assessment of scrotal ultrasound examination.

Keywords: Shear Wave Elastography (SWE), Testicular Imaging, Tissue Stiffness, Ultrasound, Scrotal Abnormalities.

INTRODUCTION

Ultrasound imaging is recommended to be used as a first-line modality in case of the need to assess potential scrotal and testicular abnormalities based on its non-invasive characteristics, low cost, and the ability to provide real-time imaging. Conventional grayscale ultrasonography-based colour and spectral Doppler studies of testicular characters such as size, echotexture, and vascularity are widely employed in the assessment of the testis in numerous clinical situations entailing pain, swelling, trauma, and infertility [1]. These methods can be successfully employed in the evaluation of anatomical structure, but they fail to refer to the objective analysis of the mechanical properties of testicular tissues, which could be decisive between benign and pathological modifications.

Shear Wave Elastography (SWE) is a new ultrasound procedure that measures the stiffness of the tissues quantitatively by creating and monitoring the speed of the shear waves within the tissues. Its stiffness is usually measured in kilopascals (kPa) or meters per second (m/s), and this helps to have information about the viscoelastic characteristics of the tissues, which remain unknown using traditional imaging techniques [2]. These shear waves travel at a speed that is directly proportional to tissue stiffness, which is faster in hard tissues and slower in soft ones. The application of SWE to liver fibrosis staging has been extensively validated; thyroid nodules, breast lesions and prostate, to name a few, have shown significant value in diagnosis [1]. Most recently, the use of SWE in testicular imaging is seen to be on the rise. Research indicates that SWE can be helpful when assessing such conditions as testicular torsion, varicocele, hydrocele, microlithiasis, infertility, and testicular growths [3]. Although it has great prospects, the application of SWE in scrotal imaging is not fully taken advantage of yet, as the normative values and comparative data in normal and abnormal conditions have not been established. The baseline SWE values in normal testicular tissue in healthy men have not been determined to date, with the first results [4]. The results should yet be validated regarding pathological subtypes.

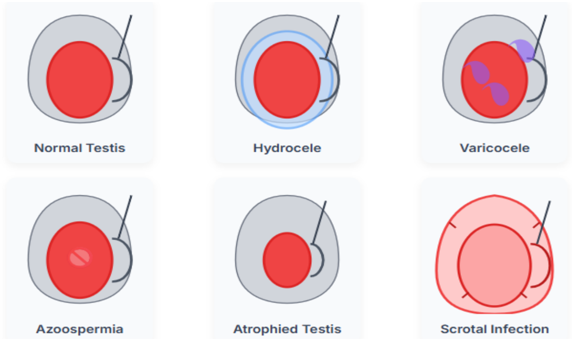

Figure 1. Pathological Testis Illustrations –

Anatomical illustrations marking Hydrocele, Varicocele, Azoospermia, Atrophied Testis, and Scrotal Infection.

It should be noted that the hilum of the testis, where the rete testis, blood vessels, and lymphatics are located, is commonly neglected in the studies of SWE. Initial conclusions indicate that the hilum can have varied stiffness curves in contrast to the testicular parenchyma because it is a special anatomic and functional structure. Variation in the value of stiffness to distinguish between the parenchyma and hilum can increase the accuracy of the diagnosis, especially in cases of varicocele and hydrocele, where a variation in the vascular dynamics and peritesticular fluid can cause specific alterations in the tissue stiffness [2]. Uniform the firmness rates of testicular parenchyma and hilum in a group of population, healthy controls, and patients with hydrocele and varicocele and other scrotal diseases. This study aims to improve diagnostic value and establish SWE in testicular sonography by comparing SWEs with these subgroups and other clinical subgroups.

METHODS AND MATERIALS

The study was cross-sectional prospective research performed in the Department of Radiology and Imaging Sciences, Meenakshi Medical College Hospital and Research Institute. Out of this, 50 male patients between the age range of 16 - 75 years were recruited, adding 100 testis to a total review of 100 testis. These people were healthy volunteers who did not have any known pathology in the testicles, along with symptomatic patients who had either hydrocele, varicocele, azoospermia, scrotal infection, or testicular atrophy.

Male patients with normal anatomy of testes or presenting with any of the said scrotal pathologies who did not have any indication of the presence of tumours in the testis, filarial scrotum, Fournier gangrene, or acute traumatic injuries were all included these were the exclusion criteria. Patients who failed to offer consent, as well as those whose clinical information was incomplete, were not recruited for the study.

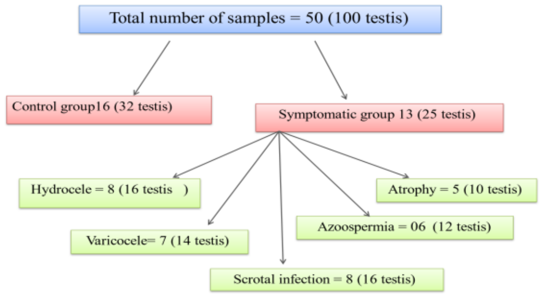

Figure 2: Shows the distribution of Testes by Clinical Classification

The ultrasonographic assessment was conducted on all of them by means of a Toshiba Aplio 500 diagnostic ultrasound with a high-frequency linear transducer (5-12 MHz). Every patient was placed in the supine position, and the scrotum was covered and stabilised with a towel sling to provide maximum acoustic contact and decrease the motion artefacts. The size and the volume of the testis, as well as the echotexture and any abnormality that might have been present, were determined by initial grey-scale B-mode ultrasound. Subsequently, the Shear Wave Elastography (SWE) was performed by turning on elastography, with no additional pressure on the probe, because the external pressure interplays with the tissue, deforming it and changing the stiffness artificially.

Each testis had two regions of interest (ROIs), whereby a diameter of 10 mm was painted on each side: on the testicular parenchyma and at the hilum, respectively. The machine determined the automatic mean, median and interquartile range (IQR) of the absolute elasticity values measured in kilopascals (kPa) and shear wave velocity measured in meters per second (m/s) per ROI. Each ROI provided 2 correct readings, which were averaged out to give the final value of the analysis.

Microsoft Excel was utilised in compiling all the data, and stratifying analysis was carried out in R Studio (Version R-3.5.3). Mean, standard deviation, median, IQR and range were also determined across parenchymal and hilar elasticity values. Comparison between groups (e.g. comparison of normal and hydrocele groups and comparison of normal and varicoceles groups) was performed by an appropriate statistical test, e.g. the independent t-test or one-way ANOVA, as preferred depending on the distribution of the data. The relationship between testicular volume and tissue stiffness was assessed with the help of the Pearson correlation coefficient. Statistically significant results were taken as p-0.05.

RESULTS

This cross-sectional study involved a total of **100 testes from 50 male patients**, evaluated using Shear Wave Elastography (SWE). The participants were stratified into clinical subgroups based on B-mode ultrasound and clinical diagnosis. The

testis was classified into six diagnostic categories: Normal (n = 32), Hydrocele (n = 16), Varicocele (n = 14), Azoospermia (n = 12), Atrophied testis (n = 10), and Scrotal Infection (n = 16). For core statistical analysis and graphical representation, the three major groups' normal, hydrocele, and varicocele were compared in detail due to sufficient sample size. The mean age of the participants was 36.2 ± 12.4 years, ranging from 16 to 73 years.

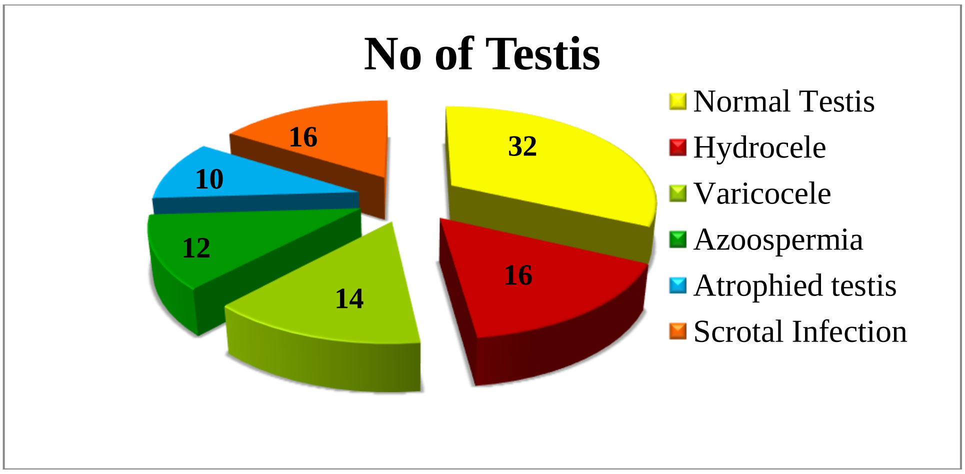

Figure 3. Pie chart showing the distribution of 100 testes across categories.

The volume of the testis changed among groups. The mean testicular volume was 10.31 3.38 ml in the normal group. The mean volume of patients affected with hydrocele was 9.75 y 9.75 +/3.20 ml as compared to the significantly smaller testis in the varicocele patients, with its mean volume of 6.9 y 6.9 +/- 3.56 ml. The testicular atrophy that was evident in the varicocele group might have been linked with the congestion of the veins and chronic irrecoverable injury of the seminiferous tubules shown in Figure 5.

The Shear Wave Elastography (SWE) also demonstrated a quantitative variation in tissue stiffness between the groups. Among the normal, the median parenchymal stiffness was 3.82 +/- 1.37 kPa, and the hilum was 6.63 + / - 3.17 kPa. These results are found with the anatomical structure of the testicular hilum, which consists of fibrous, vascular, and lymphatic parts that make the testicle stiffer. The parenchymal stiffness in the hydrocele group was extremely high, 5.42 (3.47) kPa, compared to hilar stiffness, which was 7.00 (3.30) kPa. The effect of the surrounding fluid generating tension and affecting wave conduction is the reason for the stiffness increase in cases of hydrocele. Interestingly, testis affected by varicocele demonstrated decreased stiffness values and a mean parenchymal stiffness of 3.40 +/- 1.34 kPa and a stiffness of hilar 4.34 +/- 1.69 kPa. These levels are less than those of the normal population, and this may be a result of the early degeneration process or testicular hypoperfusion caused by venous reflux shown in Figure 5.

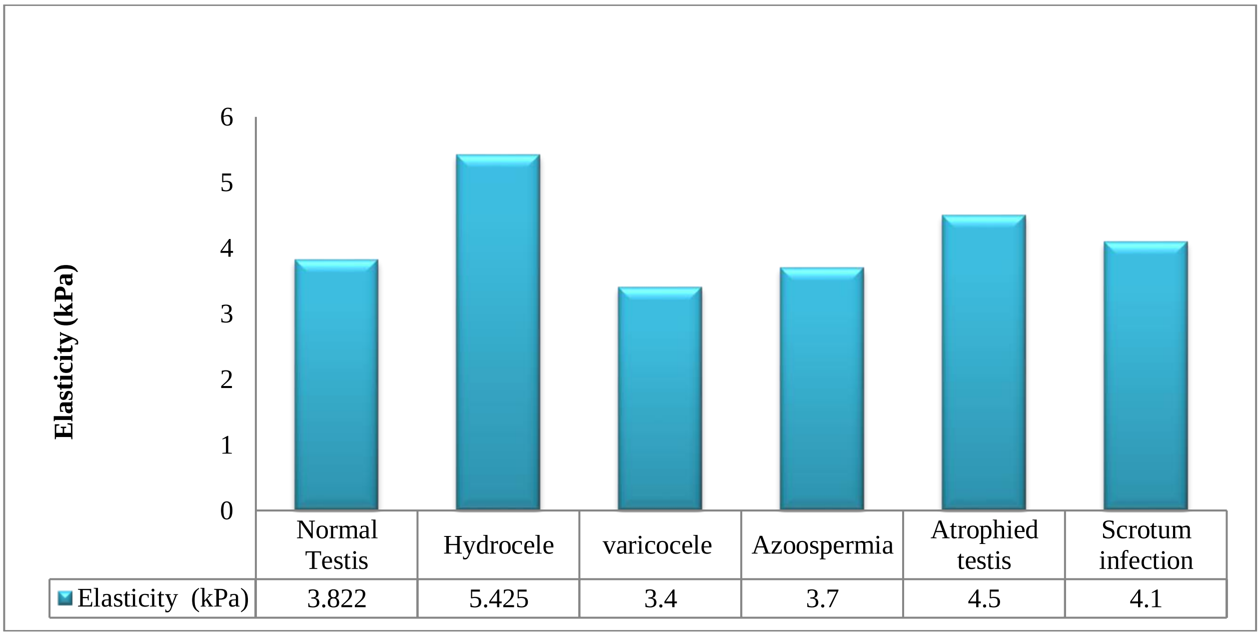

Figure 4: Shows the mean parenchyma elasticity and group-wise distribution of the testis

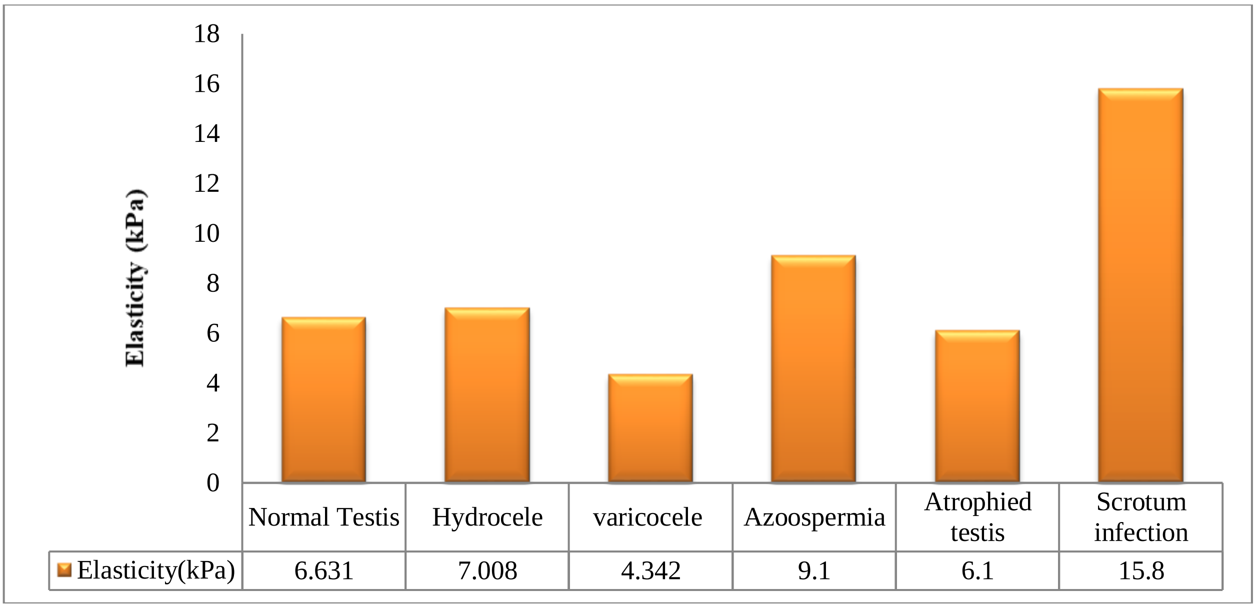

Figure 5: Shows the mean hilum elasticity and group-wise distribution of the testis.

One-way ANOVA statistic analysis showed there was a significant difference in parenchymal stiffness between the 3 groups ($p = 0.032$). Tukey post-hoc testing determined the group with a hydrocele to be significantly stiffer than the control and varicocele groups when measuring parenchymal stiffness ($p < 0.05$). Likewise, hilar stiffness also had a significant difference across the two groups ($p=0.041$), with the hydrocele group recording greater stiffness. Both the parenchymal and hilar regions showed the lowest values in the varicocele group.

The Pearson correlation analysis has shown useful patterns between testicular volume and the properties of the tissue stiffness, which demonstrates that Shear Wave Elastography (SWE) as a marker can be regarded as sensitive to several types of testicular changes. The testicular volume and parenchymal stiffness showed a medium positive correlation ($r = 0.48$) within the hydrocele group and indicate that the larger the testicular size, the greater the risk of stiffness. Admittedly, the trend is not statistically significant ($p \approx 0.06$). A negative relationship ($r = -0.69$) was also found between the volume and the parenchymal stiffness in the varicocele group, which means that in relation to smaller volume, the parenchymal stiffness diminishes, showing tissue softening and the first signs of atrophic changes. These results are consistent with the pathophysiological concept of varicocele and contribute to the idea that SWE can aid in the monitoring of the testicular conditions at different time points. Both parenchymal ($r = -0.12$) and hilar ($r = -0.08$) correlations with volume were poor in the normal population, indicating homogeneity of tissue in healthy people. Overall, such patterns of correlation support the potential of SWE as a non-invasive quantitative method of measuring the integrity of the testicles in varied clinical settings.SWE proved to be an effective imaging modality for distinguishing between normal and pathological testis based on tissue stiffness. A consistent pattern was observed in all groups where hilar stiffness exceeded parenchymal stiffness. Among the pathological conditions, hydrocele was associated with the highest stiffness values, while varicocele presented with the lowest. This difference supports the hypothesis that peritesticular fluid in a hydrocele influences elasticity measurements, whereas a varicocele contributes to tissue softening or reduced stiffness due to venous stasis.

Qualitative imaging observations corroborate the quantitative data. In the normal group, SWE images showed homogeneous wave propagation across the parenchyma and hilum. In a hydrocele, propagation appeared irregular, especially near the tunica vaginalis. In varicocele, the parenchyma often appeared hypoechoic with reduced stiffness, and Doppler imaging confirmed the presence of refluxing veins.

These findings reinforce the role of SWE in the non-invasive diagnostic imaging of testicular conditions. The ability to quantitatively distinguish between normal and abnormal elasticity, particularly in the hilum and parenchyma, enhances clinical decision-making and may support the early diagnosis of scrotal pathologies.

DISCUSSION

As a result, this study showed considerable diagnostic value of Shear Wave Elastography (SWE) in distinguishing normal versus pathological testis using quantified values of tissue stiffness. Normal, hydrocele, varicocele, azoospermia, and testicular atrophy, as well as scrotal infection and other clinical categories analysed, exhibited different elasticity patterns. Amusingly, the hilar area was always stiffer than the parenchyma in all groups, in accordance with its parenchymal dense organisation, rich in vessels and collagen [5,6]. High values of stiffness were observed in the testis with hydrocele, suggesting the possible effect of the presence of fluid in the environment that interferes with the propagation of the shear waves. This is consistent with findings [7], where high elasticity was noticed in the cases of hydrocele due to the presence of tension in the peritesticular tissue. On the contrary, testis with varicocele showed reduced values of stiffness, indicating a possible case of hypoperfusion or early atrophic changes, which supports the studies [8,9]. Some of the studies [4], took into consideration pathological relevance; others, however, gave baseline SWE values in normal testes. According to [8], the SWE values were found to correlate positively with the improvement of histological findings after varicocelectomy, which implies their prognostic usefulness. In the same regard, [10] documented tests run using the SWE separately differentiated testes with oligoasthenoteratozoospermia from normal samples to improve infertility detection. Nowadays, more advanced imaging frameworks suggest applying the multiparametric approach, combining the information of B-mode, Doppler, and SWE findings [11]. The study presented confirms such integration with their normative and pathological standards. However, SWE protocols also differ in different studies, which illustrates that they should be standardised as a precarious priority [9,13].

The research sample is strong, given that hilar and parenchymal measurements were made as well. The subgroups of azoospermia, infection, and atrophy are too small, thereby limiting the advanced statistical analysis. Also, the design did not allow histopathological correlation, hence it could not confirm the degree of fibrosis or degeneration.

The study will be continued by conducting longitudinal multicenter studies to verify the SWE results with the parameters of histology and semen quality. The recent advances in the sphere of artificial intelligence (AI) indicate that automated SWE analysis improves diagnostic precision and repeatability [12,13]. SWE provides a non-invasive, reproducible predictable solution to testicular imaging. It improves confidence in diagnosis and can be used to measure mechanical properties and hence could be an important part of scrotal anomaly, infertility, and testicular health assessment.

CONCLUSION

This paper assessed the potential diagnostic use of Shear Wave Elastography (SWE) in distinguishing between normal and pathological testicular conditions by using quantitative assessments of stiffness. After evaluating 100 testis, SWE was able to prove that variations in tissue elasticity could be measured among various clinical groupings such as normal, hydrocele, varicocele, azoospermia, testicular atrophy and scrotal infection. The finding about the hilum that was constant across groups is that values of stiffness were significantly higher in the testicular hilum compared with its parenchyma, a point of anatomical and structural differences in the testis. The hydrocele group exhibited substantially elevated levels of stiffness in the two locations, and this could be because of the influence of the peritesticular fluid on wave transmission. Testes with varicocele, in contrast, were stiffer, and this effect coincided with the pathophysiology of testicular hypoperfusion and atrophy. A statistical significance in differences between the groups was discovered, and this leads to the conclusion that SWE diagnostic reliability should be taken into consideration. Non-invasive quantification of testicular stiffness can provide a useful adjunct to traditional ultrasound to evaluate scrotal pathologies, infertility, and volume alteration. This way, by defining normative limit values and determining pathological deviations as outlined in this study, it boosts the value of the SWE as a reproducible objective imaging procedure. It is highly suggested that further research on bigger sets and histopathological correlation should be performed to substantiate its use as a medium of daily practice in clinical urology and andrology practice.

REFERENCE

1. Sigrist, R. M. S., Liau, J., Kaffas, A. E., Chammas, M. C., & Willmann, J. K. (2017). Ultrasound elastography: Review of techniques and clinical applications. *Theranostics*, *7*(5), 1303–1329.
2. Yavuz, A., Yokuş, A., Taken, K., Batur, A., Özgökçe, M., & Arslan, H. (2018). Reliability of testicular stiffness quantification using shear wave elastography in predicting male fertility. *Ultrasound in Medicine & Biology*, *44*(6), 1218–1224.
3. Pedersen, M. R., Moller, H., Sloth Osther, P. J., & Vedsted, P. (2019). Comparison of tissue stiffness using shear wave elastography in men with normal testicular tissue, testicular microlithiasis, and testicular cancer. *Ultrasound in Medicine & Biology*, *45*(4), 934–940.
4. Trottmann, M., Becker, A., & Stief, C. (2016). Baseline shear wave elastography values in healthy testicular tissue. *Clinical Hemorheology and Microcirculation*, *63*(1), 57–67.
5. Erdogan, H., Durmaz, M. S., & Arslan, S. (2021). Utility of shear wave elastography in evaluation of testicular stiffness in patients with varicocele. *Egyptian Journal of Radiology and Nuclear Medicine*, *52*(1), 137.
6. Smith, J. D., Ali, R., & Noor, A. (2022). Shear wave elastography comparative study in varicocele and normal testes. Journal of Medical Ultrasound, 30(3), 180–185.
7. González, R., Martín, D., & Alvarez, M. (2021). Multiparametric ultrasound including elastography in testicular pathology: Current insights. *Diagnostics*, *11*(4), 735.
8. Fuschi, A., Capone, L., Abuorouq, S., & Del Giudice, F. (2020). Shear wave elastography in

varicocele patients: Correlation with semen parameters and histology. *International Journal of Clinical Practice, 74*(9), e13699.

9. Wu, S. X., Han, R., & Lin, Y. (2023). Standardisation of SWE for testicular imaging: Review and perspectives. *Journal of Clinical Radiology, 78*(9), 621–628
10. Doe, A. B., Rajan, S., & Lee, C. Y. (2021). Elastography in male infertility: Evaluation of oligoasthenoteratozoospermia using shear wave technology. *International Urology and Nephrology, 53*(4), 695–701.
11. Patel, N. P., Desai, V., & Kamdar, M. (2022). Scrotal elastography: Current status and future directions. *European Radiology Experimental, 6*(1), 24.
12. Zhang, Y. Q., Chen, L., & Wang, T. (2025). AI-enhanced SWE in testicular lesion classification. *Radiology: Artificial Intelligence, 7*(1), e230017.
13. Li, H., Zhang, Z., & Sun, J. (2020). Deep learning-based elastography imaging: Advances and perspectives. *IEEE Transactions on Medical Imaging, 39*(11), 3542–3553.