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Original Research Article

Role of Testicular Ultrasound Elastography in Assessing Male Infertility due to Oligospermia: A Cross-Sectional Study

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Conflict of interest: Nil

Abstract:

Background: Oligospermia is a major contributor to male infertility, yet conventional diagnostic tools often fail to detect subtle testicular microstructural changes. Testicular ultrasound elastography (TUE) offers a non-invasive method to assess tissue stiffness, which may correlate with spermatogenic function.

Objective: To evaluate the diagnostic performance of TUE parameters in assessing male infertility due to oligospermia and to determine their correlation with sperm count.

Methods: In this observational, cross-sectional study, 86 participants were divided into healthy controls (n = 43) and oligospermic patients (n = 43). Grey-scale ultrasound, Doppler resistive index (RI), and TUE (strain value, strain ratio) were measured bilaterally. Semen analysis was performed in all participants. Group comparisons, correlation analysis, and ROC curve analysis were conducted.

Results: The mean age did not differ significantly between groups ($p > 0.05$). RI values were similar in both groups ($p > 0.05$). Oligospermic patients had significantly higher strain ratios (0.32 ± 0.12 vs. 0.23 ± 0.08, $p < 0.001$) and lower strain values (3.93 ± 1.85 vs. 6.03 ± 2.54, $p < 0.05$) compared to controls. Sperm count, normal morphology, and motility were markedly reduced in the oligospermia group (all $p < 0.01$). Strain value ($r = -0.456$, $p < 0.001$) and strain ratio ($r = -0.282$, $p = 0.008$) showed significant negative correlations with sperm count, while RI was not significantly correlated. ROC analysis demonstrated good diagnostic accuracy for strain value (AUC = 0.731) and strain ratio (AUC = 0.740) in predicting oligospermia ($p < 0.01$).

Conclusion: TUE parameters, particularly strain value and strain ratio, are sensitive, non-invasive indicators of testicular stiffness and correlate strongly with sperm quality in oligospermic men. Unlike RI and testicular volume, elastography offers superior diagnostic discrimination and may serve as a valuable adjunct in male infertility assessment. Larger multicenter studies are needed to standardize its clinical application.

Keywords: Oligospermia, Male Infertility, Testicular Ultrasound Elastography, Strain Ratio, Strain Value, Semen Analysis.

Introduction

Infertility affects an estimated 70 million people worldwide, with male factors contributing to ~50% of cases and impacting 9% of couples globally (WHO) [1]. Among couples with normal reproductive function, 90% conceive within 12 months and 95% within two years [2]. Male infertility accounts for 40–50% of cases [2,3] and is classified into endocrine disorders, sperm transport disorders, primary testicular defects (65–80%), and idiopathic infertility (10–20%) [4].

Oligospermia, defined as <15 million sperm/mL semen, is a common cause linked to varicocele, hypogonadism, genetic abnormalities, infections, and environmental exposures. Its pathophysiology typically involves impaired spermatogenesis, reducing fertility potential. Standard diagnostics (semen analysis, hormonal profiling, ultrasound) often fail to detect subtle microstructural changes [5,6].

Conventional imaging (ultrasound, MRI, venography, vasography) offers anatomical detail but limited functional assessment, with MRI costly and invasive methods carrying procedural risks. There is a growing need for non-invasive, real-time imaging that evaluates both structure and function [7].

Testicular Ultrasound Elastography (TUE) measures tissue stiffness—a marker of integrity and function—via strain elastography (SE) or shear wave elastography (SWE). SWE is quantitative, reproducible, and operator-independent [8]. Increased stiffness is associated with fibrosis, impaired spermatogenesis, and reduced fertility potential. Erdogan et al. [9] found stiffness correlated with abnormal semen parameters, Marcon et al. [8] established normative values, and Verma et al. [10] supported strain metrics but recommended larger studies.

TUE's benefits include being non-invasive, real-time, quantitative, and useful for monitoring treatment responses (e.g., post-varicocelectomy). This study aims to assess TUE's diagnostic utility in oligospermia by correlating stiffness values with sperm count, potentially establishing it as a non-invasive biomarker for reduced sperm production. To the best of our knowledge, no previous study has directly compared these parameters in this context.

Materials and Methods

The present observational, cross-sectional study was conducted in the Department of Radiodiagnosis, SMS Medical College and Hospital, Jaipur (Rajasthan), India, the study included male patients referred to the department who met the inclusion and exclusion criteria, with written informed consent obtained from all participants. The sample size was calculated as 43 cases in each group (cases and controls). Cases comprised male patients with infertility due to oligospermia (sperm count <15 million/mL), while controls were adult males without a history of infertility and with sperm counts ≥15 million/mL. Exclusion criteria for both groups included testicular pathology (tumors, atrophy, hydrocele, hernia), undescended testes, infarction, microlithiasis, unwillingness to give consent, refusal to undergo semen analysis, or non-cooperation.

Clinical and demographic data, semen analysis results, and testicular elastography parameters were recorded using a pre-designed, pre-tested semi-structured schedule. All participants underwent grey-scale ultrasound followed by testicular ultrasound elastography on Hitachi and Toshiba Aplio-500 scanners with 7–12 MHz linear transducers. Grey-scale imaging assessed testicular size, shape, position, and echogenicity in transverse and longitudinal planes. Elastography was performed according to the standard protocol to measure tissue stiffness. Ethical clearance was obtained through protocol presentation to the RRB, submission to the Institutional Ethics Committee, and permissions from the Head of the Department of Radiodiagnosis and the Imaging Center in-charge. Participants were provided with a Participant Information Sheet detailing study procedure, benefits, risks, and contact information, and confidentiality was ensured through anonymized data handling.

The outcome measures included mean ± SD of quantitative elastography and semen parameters, proportions for categorical variables, sensitivity and specificity of elastography findings, and correlation between testicular stiffness and sperm count. Statistical analysis was performed using SPSS version 28, with quantitative data expressed as mean ± SD and qualitative data as percentages/proportions. Group comparisons used unpaired t-tests and Chi-square tests; ROC analysis evaluated diagnostic performance; correlations were assessed using Pearson or Spearman coefficients; and odds ratios with logistic regression were applied to adjust for confounders. A p-value < 0.05 was considered statistically significant.

Results

The study included 86 participants, equally divided into healthy controls (n=43) and oligospermic cases (n=43). The mean age in the healthy group was 29.77 ± 6.47 years, while in the oligospermia group it was 27.98 ± 6.68 years, with no statistically significant difference (p > 0.05). Age group distribution was similar across both groups (Table 1).

Resistive index values were comparable between groups (0.48 ± 0.09 vs. 0.45 ± 0.07, p > 0.05). However, strain value and strain ratio were significantly higher in the oligospermia group compared to healthy controls (p < 0.05 and p < 0.001, respectively). Sperm count, normal morphology percentage, and total motile sperm percentage were significantly lower in the oligospermia group (all p < 0.01), whereas testicular volumes showed no significant difference (p = 0.54).

Table 1: Comparison of demographic, ultrasound elastography, and semen parameters between study groups.

Parameter	Healthy Group (n=43)	Oligospermia Group (n=43)	p-value
Resistive Index	0.48 ± 0.09	0.45 ± 0.07	>0.05
Strain Value	3.93 ± 1.85	6.03 ± 2.54	**<0.05**
Strain Ratio	0.23 ± 0.08	0.32 ± 0.12	**<0.001**
Sperm Count ($\times 10^6$/mL)	49.88 ± 6.82	14.93 ± 9.82	**<0.01**
Normal Morphology (%)	6.26 ± 1.79	0.70 ± 0.53	**<0.01**
Total Motile Sperm (%)	40.38 ± 3.19	10.23 ± 6.28	**<0.01**
Testicular Volume (mL)	14.99 ± 1.98	13.86 ± 3.51	0.54

Correlation Between Elastography Parameters and Sperm Count: Correlation analysis revealed no statistically significant relationship between resistive index and sperm count ($r = 0.172$, $p = 0.11$). In contrast, both strain value and strain ratio showed significant negative correlations with sperm count, indicating that higher stiffness parameters were associated with lower sperm counts. The strain value demonstrated a moderate negative correlation ($r = -0.456$, $p < 0.001$), while the strain ratio showed a weaker but significant negative correlation ($r = -0.282$, $p = 0.008$) (Fig. a, b and c).

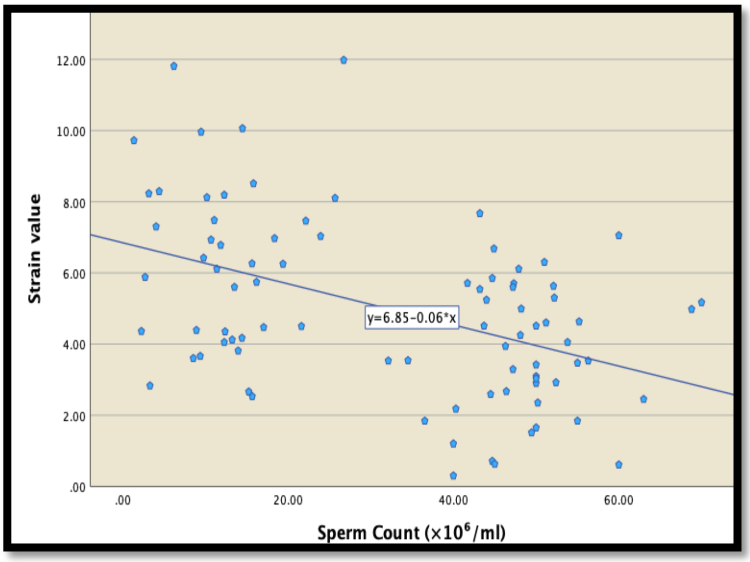

Figure 1: Correlation Between Strain Value and Sperm Count

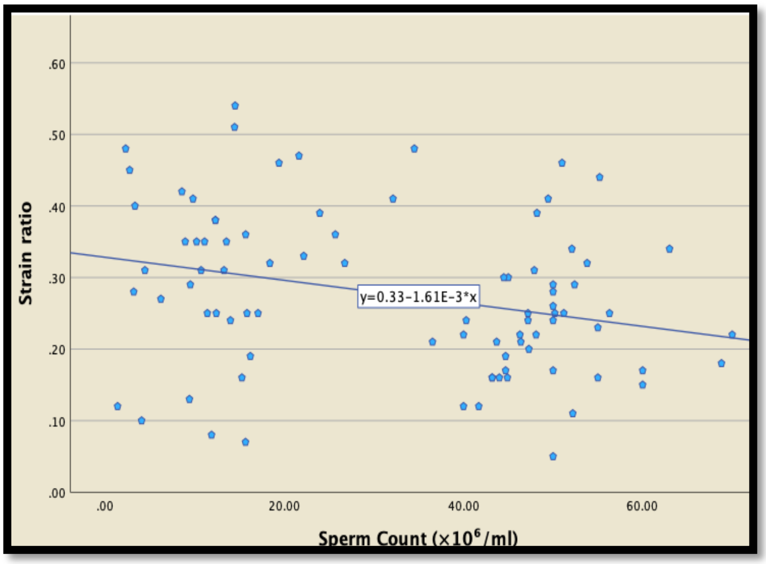

Figure 2: Correlation Between Strain Ratio and Sperm Count

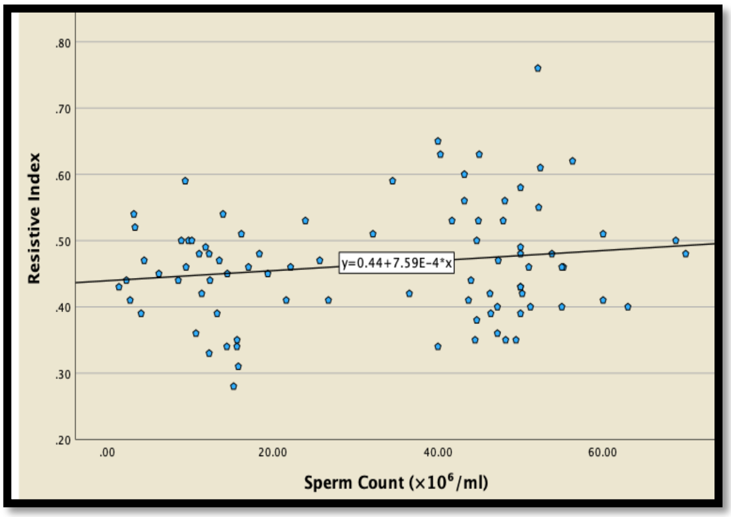

Figure 3: Correlation Between Resistive Index and Sperm Count

Table 2: ROC Curve Analysis for Strain Ratio/Value in Predicting Oligospermia

Parameter	AUC	95% of CI	P value
Strain Value	0.731	0.590 to 0.830	<0.01
Strain Ratio	0.74	0.597 to 0.844	<0.01

Receiver Operating Characteristic (ROC) curve analysis was performed to evaluate the diagnostic accuracy of elastography parameters in differentiating oligospermic patients from healthy controls. The Strain Value yielded an area under the curve (AUC) of 0.731 (95% CI: 0.590 to 0.830; $p < 0.01$), while the Strain Ratio demonstrated a slightly higher AUC of 0.74 (95% CI: 0.597 to 0.844; $p < 0.01$). Both parameters showed statistically significant discriminative ability, indicating their potential utility as non-invasive markers in the assessment of oligospermia.

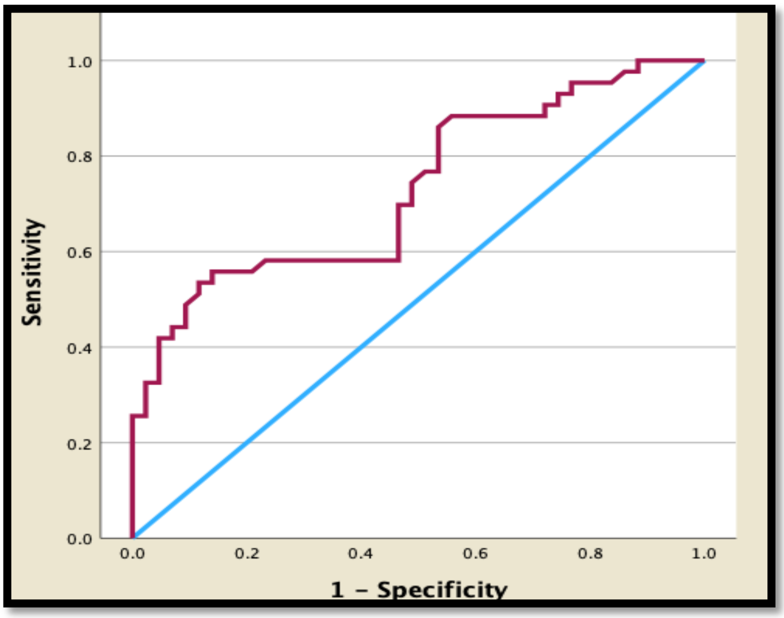

Figure 4: ROC Curve Analysis for Strain Value in Predicting Oligospermia

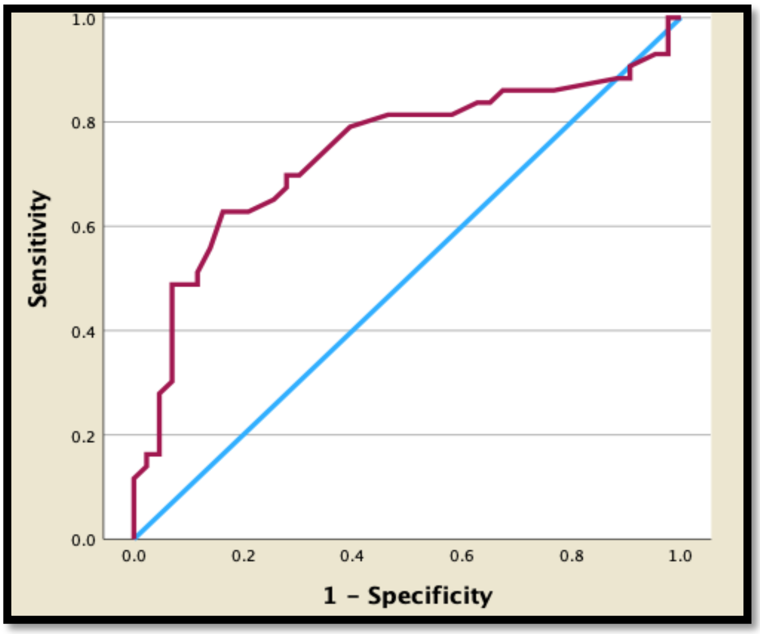

Figure 5: ROC Curve Analysis for Strain Ratio in Predicting Oligospermia

Discussion

This study evaluated the role of testicular ultrasound elastography (TUE) in assessing male infertility due to oligospermia, with a focus on the correlation between testicular stiffness and sperm count. The age distribution between healthy and oligospermic participants was comparable, showing no statistically significant difference, thus excluding age as a confounding factor. This is consistent with previous findings that testicular stiffness is generally unaffected by age in men under 50 years unless pathological changes are present. [11]

The resistive index (RI), an indicator of testicular vascular resistance, did not differ significantly between the two groups, supporting earlier reports that RI alone is not a sensitive marker for isolated oligospermia. [12,13] Studies reporting elevated RI values typically involve conditions such as varicocele, suggesting that RI changes may reflect overt structural pathology rather than subtle functional alterations. [10,11]

In contrast, elastographic parameters showed significant differences. The oligospermia group demonstrated higher strain ratios and lower strain values, indicating increased testicular stiffness. These results align with previous evidence that increased stiffness is associated with histopathological changes such as fibrosis and tubular atrophy in infertile men (20, 40). The significant negative correlations observed between strain value ($r = -0.456$) and strain ratio ($r = -0.282$) with sperm count in this study further support the relationship between reduced elasticity and impaired spermatogenesis.

Semen analysis revealed markedly reduced sperm count, motility, and normal morphology in the oligospermia group, consistent with WHO diagnostic criteria and prior studies reporting that oligospermia is frequently associated with poor motility and abnormal morphology. Although testicular volume was slightly lower in the oligospermia group, the difference was not statistically significant, confirming that volume alone is an insensitive marker for early spermatogenic dysfunction. [14,15]

Receiver Operating Characteristic (ROC) analysis demonstrated good diagnostic accuracy for both strain value (AUC = 0.731) and strain ratio (AUC = 0.740) in differentiating oligospermic from healthy individuals, in line with earlier findings. [16] These results indicate that TUE can serve as a reliable, non-invasive imaging tool in the evaluation of male infertility, capable of detecting microstructural testicular changes that may not be apparent with conventional ultrasound or Doppler indices.

Overall, the findings reinforce the value of testicular elastography as an adjunct to routine infertility assessment. While RI and testicular volume offer limited diagnostic discrimination in isolated oligospermia, elastographic parameters provide sensitive, quantitative evaluation of parenchymal alterations that correlate strongly with semen quality. Larger multicenter studies are recommended to establish standardized cut-off values and optimize its integration into clinical practice.

Conclusion

This study demonstrates that testicular ultrasound elastography is a promising, non-invasive diagnostic modality for evaluating male infertility associated with oligospermia. The significantly lower strain values and higher strain ratios observed in the oligospermia group, compared to healthy controls, reflect increased testicular stiffness, which is correlated with impaired spermatogenic function. Additionally, the strong negative correlation between strain values and sperm parameters suggests that elastography can effectively reflect testicular tissue changes associated with reduced sperm production.

Although no significant association was found between the resistive index and elastographic parameters, the ROC curve analysis confirmed the diagnostic potential of strain values and strain ratios, both of which showed statistically significant area under the curve (AUC) values. These findings reinforce the role of ultrasound elastography as a supportive tool in the comprehensive evaluation of male infertility, particularly in detecting underlying testicular parenchymal alterations in oligospermic patients. Further large-scale, multicenter studies are warranted to validate and standardize its clinical utility.

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