TIRADS Score and Strain Ratio in Elastography to Predict Malignant Thyroid Nodule and Correlation with Histopathology

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ABSTRACT

Thyroid nodules are a common clinical finding, and accurate differentiation between benign and malignant nodules is essential for appropriate clinical management. This study aimed to evaluate the diagnostic value of the Thyroid Imaging Reporting and Data System (TIRADS) and elastography strain ratio in predicting malignant thyroid nodules and to correlate the findings with histopathology. This study was conducted from 2023 to 2024 and included 30 patients with thyroid nodules referred for ultrasound TIRADS assessment and elastography. Nodules were categorized according to the TIRADS classification system (TIRADS 1–5), and real-time strain ratio (SR) was measured using elastography to assess tissue stiffness. The final diagnosis was confirmed by histopathology following near-total thyroidectomy. The mean age of the patients was 34.1 ± 9.54 years (range 18–55 years), with 80% females. TIRADS demonstrated a sensitivity of 33.33%, a specificity of 93.33%, and an overall accuracy of 63.33%. Elastography strain ratio showed higher diagnostic performance with a sensitivity of 80.00%, a specificity of 93.33%, and an accuracy of 86.67%. Elastography strain ratio appears to be a more reliable method than TIRADS alone for detecting malignant thyroid nodules and may improve diagnostic accuracy in clinical practice.

Keywords: Thyroid ultrasound, thyroid nodule, TIRADS, elastography strain ratio

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INTRODUCTION

Thyroid nodules are among the most common endocrine disorders, with a striking female predominance-occurring approximately four times more frequently in women than in men (1). The widespread use of high-resolution ultrasonography (USG) has markedly increased detection rates, with nodules identified in 20% to 76% of adults (2). USG remains the primary imaging modality due to its safety, accessibility, and ability to provide real-time tomographic visualization (3). While highly sensitive for detection, conventional USG alone has limited specificity in distinguishing benign from malignant nodules, necessitating complementary diagnostic strategies. Risk stratification systems such as the Thyroid Imaging Reporting and Data System (TIRADS) have been developed to standardize sonographic interpretation and improve diagnostic accuracy (4). TIRADS categorization provides a structured framework for evaluating nodules, reducing unnecessary biopsies and guiding clinical management. Elastography has further enhanced thyroid imaging by quantifying tissue stiffness, with malignant nodules typically demonstrating increased rigidity. The strain ratio derived from elastographic assessment has shown promise in differentiating benign from malignant lesions. However, imaging findings must be validated against histopathology, which remains the definitive diagnostic standard. This study was designed to evaluate the diagnostic performance of TIRADS scoring and elastographic strain ratio in differentiating malignant from benign thyroid nodules. By correlating imaging features with histopathological outcomes, the study aims to establish the reliability of these modalities and their potential to refine patient management strategies.

PATIENTS AND METHODS

This prospective observational study was conducted at the Bangladesh Institute of Thyroid and Molecular Imaging and Research (BITMIR) between 2023 and 2024. A total of 30 patients presenting with thyroid nodules were referred for comprehensive ultrasonographic evaluation, including TIRADS categorization and real-time elastography.

Each thyroid nodule was systematically classified according to the Thyroid Imaging Reporting and Data System (TIRADS). The categories were defined as follows: TIRADS 1, corresponding to a normal thyroid gland; TIRADS 2, benign nodules; TIRADS 3, probably benign nodules; TIRADS 4, nodules suspicious for malignancy; and TIRADS 5, nodules highly suggestive of malignancy. This standardized scoring system was applied to ensure uniform interpretation of sonographic features and to facilitate risk stratification.

In addition to conventional ultrasonography, real-time strain elastography was performed for all nodules. The strain ratio (SR) was calculated by comparing the stiffness of the nodule with that of adjacent reference tissue. Increased stiffness, reflected by higher SR values, was considered indicative of potential malignancy. Elastographic findings were recorded and correlated with the respective TIRADS categories to assess their combined diagnostic utility.

The final diagnosis for each patient was established through histopathological examination following near-total thyroidectomy. Histopathology served as the gold standard against which imaging-based assessments were validated. The correlation between TIRADS scores, elastographic strain ratios, and histopathological outcomes was analyzed to determine the accuracy and reliability of these imaging modalities in differentiating benign from malignant thyroid nodules.

Diagnostic performance was evaluated by calculating sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for both TIRADS scoring and elastographic strain ratio, individually and in combination. Sensitivity was defined as the proportion of histopathologically confirmed malignant nodules correctly identified by imaging, while specificity represented the proportion of benign nodules correctly classified. PPV and NPV were derived to assess the predictive accuracy of positive and negative imaging results, respectively.

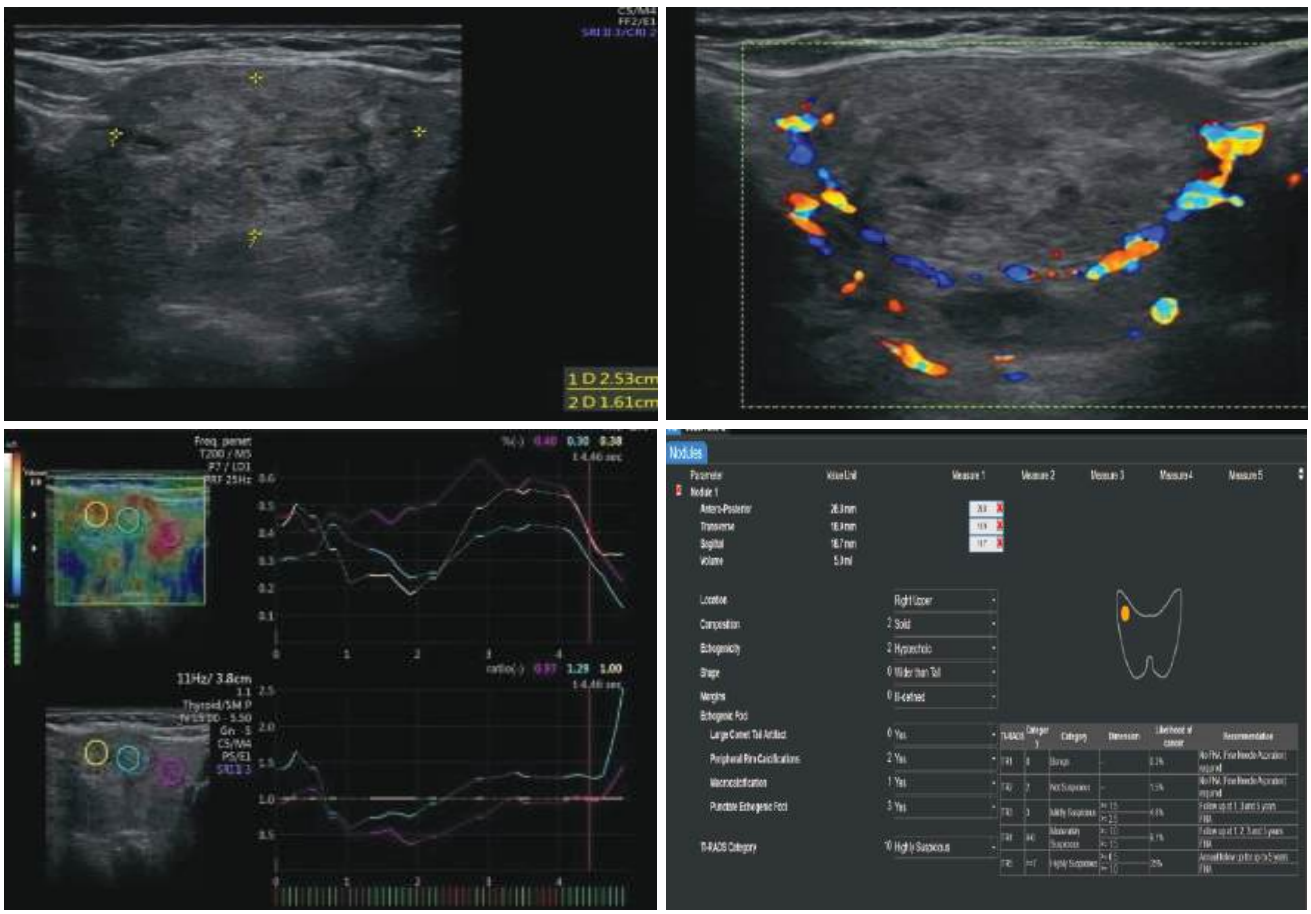

Figure 1: Representative image of a thyroid nodule showing ultrasound greyscale findings, doppler, and elastography strain ratio estimation. TIRADS scoring are shown in tabulated form in the lower right corner.

RESULTS

A total of 30 patients with thyroid nodules were included in the study. The mean age of the study population was 34.1 ± 9.54 years, with an age range from 18 to 55 years (figure 2). Females constituted 80% of the study population, while males accounted for 20%, yielding a male-to-female ratio of 1:2.6.

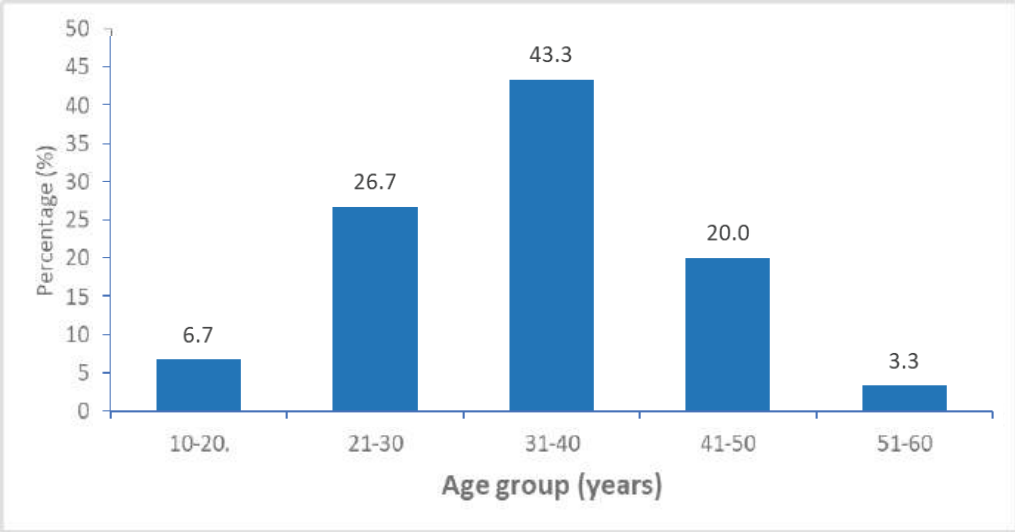

Figure 2: Age distribution of the study patients.

The diagnostic validity of the TIRADS scoring system was assessed against histopathological findings. TIRADS correctly identified 5 malignant nodules (true positives) and 10 benign nodules (true negatives). However, one benign nodule was misclassified as malignant (false positive), and 14 malignant nodules were missed (false negatives). The sensitivity of TIRADS in detecting malignancy was 33.33%, while specificity was 93.33%. The positive predictive value (PPV) was 83.33%, and the negative predictive value (NPV) was 58.33%. The overall diagnostic accuracy of TIRADS was 63.33%.

In comparison, elastography strain ratio demonstrated superior diagnostic performance. It correctly identified 12 malignant nodules (true positives) and 3 benign nodules (true negatives). The sensitivity of elastography was 80 %, with a specificity of 93 %. The PPV was 92.3 %, and the NPV was 82.4 %. The overall diagnostic accuracy of elastography strain ratio was 86.7 %.

When directly compared, elastography strain ratio proved to be a more reliable tool than TIRADS in discriminating malignant from benign thyroid nodules. Its higher sensitivity, specificity, PPV, and overall accuracy underscore its potential as a valuable adjunct to conventional ultrasonographic risk stratification.

Table 1. Diagnostic performance of TIRADS and Elastography Strain Ratio in detecting malignant thyroid nodules

Parameter	*TIRADS Score*	*Elastography Strain Ratio*
True Positive (TP)	5	12
True Negative (TN)	10	3
False Positive (FP)	1	0
False Negative (FN)	14	3
Sensitivity (%)	33.33	80.00
Specificity (%)	93.33	93.33
Positive Predictive Value (%)	83.33	92.31
Negative Predictive Value (%)	58.33	82.35
Overall Accuracy (%)	63.33	86.67

DISCUSSION

Thyroid nodules are highly prevalent in the general population, particularly among women, and their accurate characterization remains a clinical challenge. Ultrasonography (USG) is the cornerstone of thyroid imaging, but its limited specificity necessitates adjunctive tools to improve diagnostic precision. In this study, the diagnostic performance of the Thyroid Imaging Reporting and Data System (TIRADS) and elastography strain ratio was evaluated, using histopathology as the gold standard.

The findings demonstrated that TIRADS achieved high specificity (93.3%) but relatively low sensitivity (33.3%), consistent with prior reports that TIRADS is effective in ruling out benign nodules but less reliable in detecting malignancy when nodules exhibit atypical or overlapping sonographic features (4–6). The positive predictive value (83.3%) was acceptable, but the negative predictive value (58.3%) and overall accuracy (63.3%) highlight its limitations as a standalone tool.

In contrast, the elastography strain ratio showed markedly superior diagnostic performance, with a sensitivity of 80.0%, a specificity of 93.3%, a PPV of 92.3%, an NPV of 82.4%, and an overall accuracy of 86.7%. These results align with multiple studies demonstrating that elastography enhances diagnostic accuracy by quantifying tissue stiffness, a parameter strongly associated with malignancy (7–10). Malignant nodules typically exhibit increased rigidity due to desmoplastic reaction and altered extracellular matrix composition, making elastography a valuable adjunct to conventional USG (11,12).

Several studies have reported similar findings. Okasha et al. showed that combining TIRADS with strain ratio significantly improved diagnostic accuracy compared to either modality alone (13). Angelopoulos et al. demonstrated that elastography enhances the diagnostic yield of ACR-TIRADS, particularly in indeterminate nodules (14). Another study also reported that elastography cut-off values correlate strongly with histopathology, supporting its role in clinical decision-making (15).

Histopathology remains the definitive diagnostic standard, but reliance on surgical excision or fine-needle aspiration (FNA) for all nodules is impractical and invasive. Integrating elastography with TIRADS can reduce unnecessary biopsies while maintaining high diagnostic confidence (16–18). The present study reinforces this approach, showing that elastography strain ratio provides higher sensitivity and overall accuracy, making it a more reliable tool for malignancy detection.

In summary, while TIRADS offers structured risk stratification with high specificity, elastography strain ratio significantly improves sensitivity and overall diagnostic accuracy. The combined use of these modalities, validated against histopathology, can optimize patient management by reducing invasive procedures and improving early detection of malignant thyroid nodules.

However, this study has several limitations that should be acknowledged. First, the relatively small sample size of 30 patients may restrict the generalizability of the findings, and larger multicenter studies are needed to validate the diagnostic performance of TIRADS and elastography strain ratio. Second, the study population was drawn from a single institution, which may introduce selection bias and limit external applicability. Third, elastography measurements can be operator-dependent, and variability in technique or equipment calibration may influence strain ratio values. Finally, the study did not assess interobserver variability in TIRADS categorization or elastography interpretation, which is an important consideration for routine clinical practice. Despite these limitations, the findings provide valuable evidence supporting the role of elastography strain ratio as a complementary tool to TIRADS in improving diagnostic accuracy for thyroid nodules.

CONCLUSION

Thyroid nodules are highly prevalent, particularly among women, and their accurate characterization remains essential for guiding clinical management. This study demonstrated that while TIRADS scoring provides high specificity, its sensitivity and overall accuracy are limited when used alone. Conversely, the elastography strain ratio showed superior diagnostic performance, with markedly higher sensitivity, predictive values, and

overall accuracy when validated against histopathology. These findings underscore the value of elastography as a complementary tool to conventional ultrasonography, enhancing the ability to discriminate malignant from benign nodules.

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