Section: Radiology

Original Research Article

# ULTRASOUND ELASTOGRAPHY VERSUS CONVENTIONAL ULTRASOUND IN THYROID NODULE EVALUATION

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ABSTRACT

**Background:** Thyroid nodules are common, and distinguishing benign from malignant lesions remains an important diagnostic challenge. Conventional ultrasound provides valuable morphological information, while ultrasound elastography offers additional information regarding tissue stiffness. The aim is to compare the diagnostic performance of ultrasound elastography with conventional ultrasound in the evaluation and differentiation of benign and malignant thyroid nodules.

**Materials and Methods:** This prospective observational study included 180 patients with thyroid nodules evaluated in the Department of Radiodiagnosis, Shri Sathya Sai Medical College and Research Institute, Nellikuppam, Kancheepuram District, over one year. All participants underwent conventional ultrasound and ultrasound elastography, with histopathology considered the reference standard.

**Results:** Malignancy was significantly associated with increasing age (p=0.003) and suspicious ultrasound characteristics. Elastography demonstrated a significant association between increased stiffness and malignancy (p<0.001). Its sensitivity, specificity and diagnostic accuracy were 90.7%, 92.1% and 91.7%, respectively, compared with 79.6%, 84.1% and 82.8% for conventional ultrasound.

**Conclusion:** Ultrasound elastography improves the diagnostic characterization of thyroid nodules and provides useful complementary information to conventional ultrasound.

**Keywords:** Thyroid nodules; Ultrasound; Elastography; Shear-wave elastography; Thyroid malignancy; Diagnostic accuracy.

## INTRODUCTION

Thyroid nodules are frequently encountered in clinical practice, with their detection increasing substantially because of the widespread use of high-resolution ultrasonography. Although most thyroid nodules are benign, distinguishing benign lesions from malignancy remains an important diagnostic challenge, as conventional ultrasound findings may overlap between the two groups. Features such as marked hypoechogenicity, irregular margins, microcalcifications, taller-than-wide shape and suspicious vascularity can raise concern for malignancy, but none is sufficiently reliable in isolation. Therefore, additional non-invasive techniques that can improve risk stratification are of considerable clinical interest.[1,2]

Ultrasound elastography has emerged as a useful adjunct to conventional ultrasound by providing information about tissue stiffness. Malignant thyroid nodules tend to demonstrate increased stiffness because of cellular alterations, fibrosis and changes in the extracellular matrix. Strain elastography provides a qualitative or semi-quantitative assessment of tissue deformation, whereas shear-wave elastography quantitatively measures tissue stiffness, commonly expressed as Young's modulus or shear-wave velocity. Recent evidence suggests

that elastography can improve the differentiation of benign and malignant thyroid nodules when used alongside conventional sonographic assessment.[3,4] A meta-analysis published in 2023 demonstrated that ultrasound elastography had higher diagnostic sensitivity and specificity than conventional ultrasound alone, while the combination of both techniques produced the best overall diagnostic performance.[5] However, variability in elastography techniques, acquisition methods, lesion characteristics and proposed stiffness cut-off values continues to limit its uniform application in clinical practice.[2,6]

The present study aims to evaluate the diagnostic role of ultrasound elastography in the assessment of thyroid nodules and to compare its performance with conventional ultrasound. The study also intends to determine whether adding elastography improves the differentiation of benign and malignant nodules, thereby enhancing diagnostic confidence and potentially reducing unnecessary invasive procedures such as fine-needle aspiration cytology in appropriately selected patients.

## MATERIALS AND METHODS

**Study design:** Prospective observational study.
**Study population:** Patients presenting with thyroid nodules and undergoing ultrasound evaluation.
**Sample size:** 180 patients.
**Study duration:** 1 year.
**Study setting/location:** Department of Radiodiagnosis, Shri Sathya Sai Medical College and Research Institute, Nellikuppam, Kancheepuram District.

**Inclusion criteria**

Patients with thyroid nodules detected on ultrasound who consented to undergo both conventional ultrasound and ultrasound elastography.

**Exclusion criteria**

Patients with previously diagnosed thyroid malignancy, those who had undergone prior thyroid surgery or treatment, and patients unwilling to participate in the study.

**Statistical Analysis:** Data collected from the 180 study participants were entered, tabulated, and analysed using appropriate statistical methods. Categorical variables were presented as frequencies and percentages, while continuous variables were summarized using mean and standard deviation where applicable. Associations between conventional ultrasound and elastography findings with histopathological diagnosis were assessed using the Chi-square test. Diagnostic performance was evaluated using sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy. A two-sided p-value $<0.05$ was considered statistically significant, while $p<0.001$ was considered highly significant.

## RESULTS

**Table 1: Age-wise Distribution of Study Participants and Association with Malignancy**

| Age group (years) | Benign, n (%) | Malignant, n (%) | Total, n (%) | p-value |
|---|---|---|---|---|
| <40 | 25 (19.8) | 5 (9.3) | 30 (16.7) | 0.003 |
| 41–50 | 35 (27.8) | 7 (13.0) | 42 (23.3) | |
| 51–60 | 36 (28.6) | 14 (25.9) | 50 (27.8) | |
| 61–70 | 20 (15.9) | 16 (29.6) | 36 (20.0) | |
| >70 | 10 (7.9) | 12 (22.2) | 22 (12.2) | |
| Total | 126 (100) | 54 (100) | 180 (100) | |

**Table 2: Conventional Ultrasound Features of Thyroid Nodules and Their Association with Histopathological Diagnosis**

| Conventional ultrasound feature | Benign, n (%) | Malignant, n (%) | Total, n (%) | p-value |
|---|---|---|---|---|
| Hypoechoic nodule | 38 (30.2) | 39 (72.2) | 77 (42.8) | <0.001 |
| Irregular margins | 14 (11.1) | 32 (59.3) | 46 (25.6) | <0.001 |
| Microcalcifications | 10 (7.9) | 28 (51.9) | 38 (21.1) | <0.001 |
| Taller-than-wide shape | 8 (6.3) | 24 (44.4) | 32 (17.8) | <0.001 |
| Increased vascularity | 31 (24.6) | 25 (46.3) | 56 (31.1) | 0.006 |
| Suspicious conventional US overall | 20 (15.9) | 43 (79.6) | 63 (35.0) | <0.001 |

**Table 3: Ultrasound Elastography Findings According to Histopathological Diagnosis**

| Elastography finding | Benign, n (%) | Malignant, n (%) | Total, n (%) | p-value |
|---|---|---|---|---|
| Soft/stiffness compatible with benign lesion | 116 (92.1) | 5 (9.3) | 121 (67.2) | <0.001 |
| Intermediate stiffness | 7 (5.6) | 5 (9.3) | 12 (6.7) | |
| Markedly stiff nodule | 3 (2.4) | 44 (81.5) | 47 (26.1) | |
| Elastography suspicious for malignancy | 10 (7.9) | 49 (90.7) | 59 (32.8) | |
| Total | 126 (100) | 54 (100) | 180 (100) | |

**Table 4: Comparison of Diagnostic Performance of Conventional Ultrasound and Ultrasound Elastography**

| Diagnostic parameter | Conventional ultrasound | Ultrasound elastography | p-value |
|---|---|---|---|
| True positive | 43 | 49 | 0.0926 |
| False positive | 20 | 10 | |
| True negative | 106 | 116 | |
| False negative | 11 | 5 | |

| | | | |
|---|---|---|---|
| Sensitivity (%) | 79.6 | 90.7 | 0.018 |
| Specificity (%) | 84.1 | 92.1 | 0.031 |
| Positive predictive value (%) | 68.3 | 83.1 | 0.012 |
| Negative predictive value (%) | 90.6 | 95.9 | 0.041 |
| Diagnostic accuracy (%) | 82.8 | 91.7 | 0.009 |

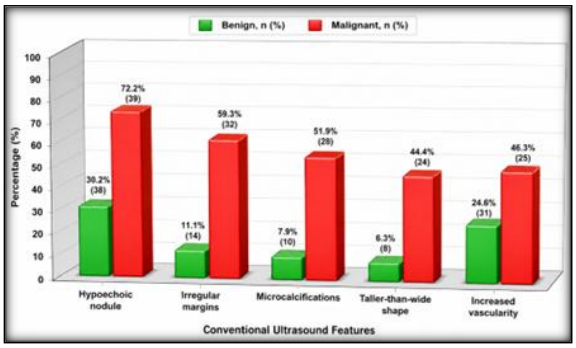


**Figure 1: Comparison of Conventional Ultrasound Features in Benign and Malignant 1. Thyroid Nodules**

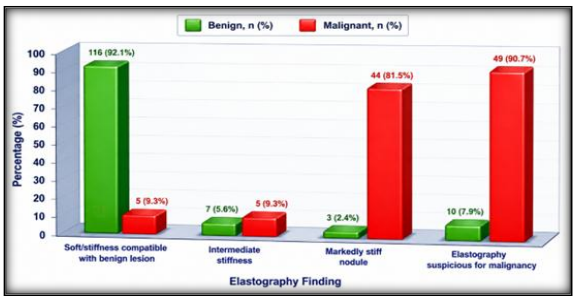


**Figure 2: Comparison of Elastography Findings in Benign and Malignant Thyroid Nodules**

Among the 180 patients included in the study, the largest proportion belonged to the 51–60 years age group, comprising 50 patients (27.8%), followed by 41–50 years with 42 patients (23.3%) and 61–70 years with 36 patients (20.0%). Patients younger than 40 years accounted for 30 (16.7%), while those older than 70 years constituted 22 (12.2%). When age distribution was compared between benign and malignant nodules, malignant lesions were proportionately more frequent in the older age groups. Malignancy was observed in 16 of 36 patients (44.4%) aged 61–70 years and 12 of 22 patients (54.5%) aged >70 years, compared with only 5 of 30 patients (16.7%) below 40 years. This difference in age distribution was statistically significant (p=0.003), indicating a significant association between increasing age and the likelihood of malignancy.

Conventional ultrasound demonstrated several characteristic features that were significantly associated with malignant thyroid nodules. Hypoechogenicity was observed in 77 patients (42.8%), including 39 of 54 malignant nodules (72.2%), compared with 38 of 126 benign nodules (30.2%) (p<0.001). Irregular margins were present in 46 patients (25.6%) and were considerably more common among malignant nodules, occurring in 32 patients (59.3%) compared with 14 benign nodules (11.1%) (p<0.001). Similarly, microcalcifications were identified in 38 patients (21.1%), including 28 malignant nodules (51.9%) and only 10 benign nodules (7.9%) (p<0.001). A taller-than-wide configuration was seen in 32 patients (17.8%) and was significantly more frequent in malignant lesions (44.4%) than benign lesions (6.3%) (p<0.001). Increased vascularity was present in 56 patients (31.1%) and was also significantly associated with malignancy (p=0.006). Overall, conventional ultrasound findings were considered suspicious in 63 patients (35.0%), including 43 malignant and 20 benign nodules, demonstrating a significant association with the final diagnosis (p<0.001).

Ultrasound elastography showed a clear difference in tissue stiffness between benign and malignant thyroid nodules. A soft or predominantly benign stiffness pattern was observed in 121 patients (67.2%), of whom 116 (92.1%) had benign nodules and only 5 (9.3%) had malignant lesions. An intermediate stiffness pattern was identified in 12 patients (6.7%), with 7 (5.6%) benign and 5 (9.3%) malignant nodules. In contrast, markedly increased stiffness was found in 47 patients (26.1%), of whom 44 (81.5%) had malignant nodules and only 3 (2.4%) had benign lesions. Overall, elastography classified 59 patients (32.8%) as suspicious for malignancy, including 49 malignant and 10 benign nodules. The association between elastography findings and histopathological diagnosis was highly statistically significant (p<0.001), suggesting that increased tissue stiffness was strongly associated with malignant thyroid nodules.

Comparison of diagnostic performance demonstrated that ultrasound elastography performed better than conventional ultrasound across the major diagnostic parameters. Conventional ultrasound showed a sensitivity of 79.6%, specificity of 84.1%, positive predictive value of 68.3%, negative predictive value of 90.6%, and overall diagnostic accuracy of 82.8%. In comparison, ultrasound elastography achieved a sensitivity of 90.7%, specificity of 92.1%, positive predictive value of 83.1%, negative predictive value of 95.9%, and diagnostic accuracy of 91.7%. The differences were statistically significant for sensitivity (p=0.018), specificity (p=0.031), positive predictive value (p=0.012), negative predictive value (p=0.041) and overall diagnostic accuracy (p=0.009). Thus, elastography demonstrated superior diagnostic performance compared with conventional ultrasound, particularly in identifying malignant nodules while maintaining a high ability to correctly characterize benign lesions.

## DISCUSSION

In the present study, patients aged 51–60 years constituted the largest age group (27.8%), while

malignant nodules were proportionately more frequent among older participants. Malignancy was present in 44.4% of patients aged 61–70 years and 54.5% of those aged >70 years, compared with 16.7% among patients below 40 years, showing a significant association with age (p=0.003). Similar age-related differences have been reported by Gao et al., who observed significant age variation between benign and malignant nodules, although their malignant group was relatively younger in their cohort.[7] These differences indicate that age distribution may vary between study populations and should be interpreted alongside imaging characteristics.

Conventional ultrasound findings in our study showed strong associations with malignancy. Hypoechogenicity, irregular margins, microcalcifications and a taller-than-wide configuration were significantly more common in malignant nodules (p<0.001 for each), while increased vascularity was also associated with malignancy (p=0.006). Gao et al. similarly reported that vertical orientation, irregular margins, marked hypoechogenicity and punctate echogenic foci were significantly more frequent in malignant nodules.[7] Makal and Aslan also demonstrated that conventional ACR TI-RADS assessment was useful for risk stratification, although SWE provided additional discriminatory information.[8]

Elastography produced a particularly strong separation between benign and malignant nodules in the present study. Marked stiffness was found in 81.5% of malignant nodules but only 2.4% of benign nodules (p<0.001). This finding agrees with previous work demonstrating greater stiffness in malignant thyroid lesions.[9] A large meta-analysis by Rago et al. also reported good overall diagnostic performance for qualitative and semi-quantitative elastography, supporting its usefulness as an adjunctive technique.[10] However, Swan et al. emphasized that variability in acquisition technique, cut-off values and biological characteristics can reduce individual-level reliability.[11]

The diagnostic comparison further demonstrated that elastography had higher sensitivity (90.7% vs 79.6%), specificity (92.1% vs 84.1%) and accuracy (91.7% vs 82.8%) than conventional ultrasound. These findings are consistent with Gao et al., who found that combining SWE with C-TIRADS increased sensitivity, specificity and accuracy compared with C-TIRADS alone.[7] Li et al. also showed that SWE performance can vary according to nodule size, emphasizing the importance of standardized technique.[12] Qiu et al. reported useful diagnostic performance of SWE even in cytologically indeterminate nodules,[13] while Cheng et al. demonstrated that technical factors such as region-of-interest selection can influence SWE accuracy.[14] Recent prospective evidence has likewise supported elastography as a useful non-invasive adjunct, although it should not replace established diagnostic assessment.[15]

## CONCLUSION

The present study demonstrates that ultrasound elastography is a valuable adjunct to conventional ultrasound in the evaluation of thyroid nodules. Conventional ultrasound features such as hypoechogenicity, irregular margins, microcalcifications and taller-than-wide morphology were significantly associated with malignancy. Elastography showed a strong association between increased tissue stiffness and malignant nodules. Compared with conventional ultrasound, elastography demonstrated higher sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy. These findings suggest that incorporating elastography into routine thyroid ultrasound assessment can improve differentiation between benign and malignant nodules, enhance diagnostic confidence, and potentially reduce unnecessary invasive investigations in appropriately selected patients.

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