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Original Research Article

DIAGNOSTIC ACCURACY OF ELASTOGRAPHY IN PREDICTING MALIGNANT THYROID TUMOR WHILE TAKING HISTOPATHOLOGY AS GOLD STANDARD IN PATIENTS PRESENTING TO LADY READING HOSPITAL PESHAWAR

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ABSTRACT

Background: *Thyroid nodules are a common clinical finding, with a subset harboring malignancy. Strain elastography has emerged as a promising non-invasive imaging modality for assessing thyroid nodules. However, histopathology remains the gold standard for a definitive diagnosis. Evaluating the diagnostic accuracy of strain elastography can aid in improving preoperative assessment and reducing unnecessary biopsies.* ***Objective:*** *To assess the diagnostic accuracy of strain elastography in detecting malignant thyroid nodules, using histopathology as the gold standard.* ***Study Design:*** *Cross-sectional validation study.* ***Setting:*** *Radiology Department, Lady Reading Hospital, Peshawar.* ***Duration of Study:*** *27 August 2023 to 27 February 2024.* ***Methods:*** *A total of 110 patients aged 18 to 70 years with palpable thyroid nodules were included using consecutive sampling. Patients with prior thyroid surgery, chronic kidney disease, or pregnancy were excluded. Strain elastography was performed using a 7.5 MHz linear probe, with malignancy suspected based on features such as microcalcifications and irregular borders. Histopathological examination served as the reference standard. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated using a 2×2 contingency table. Statistical analysis was performed using SPSS version 21.* ***Results:*** *The study population had a mean age of 41.22 ± 15.08 years and a mean body mass index (BMI) of 25.75 ± 1.80 kg/m². Female patients comprised 54.5% of the cohort, while males accounted for 45.5%. Strain elastography identified malignancy in 53 patients (48.2%), whereas histopathology confirmed malignancy in 51 patients (46.4%). Among elastography-positive cases, 45 were true positives, and 8 were false positives. Among elastography-negative cases, 51 were true negatives, and 6 were false negatives. The diagnostic performance of strain elastography was as follows: Sensitivity: 88.24%, Specificity: 86.44%, Positive Predictive Value (PPV): 84.91%, Negative Predictive Value (NPV): 89.47%, Diagnostic Accuracy: 87.27%,* ***Conclusion:*** *Strain ultrasound elastography demonstrated high diagnostic accuracy in identifying malignant thyroid nodules, making it a reliable, non-invasive tool for clinical decision-making. Its integration into routine thyroid nodule assessment can enhance early detection while reducing unnecessary biopsies. Future research should focus on incorporating quantitative elastography techniques to refine diagnostic precision further.*

Keywords: Strain Ultrasound Elastography, Thyroid Nodule, Malignancy, Histopathology, Diagnostic Accuracy, Lady Reading Hospital

INTRODUCTION

The American Thyroid Association describes a thyroid nodule as a distinct lesion located within the thyroid gland. The radiological features are different from the adjacent thyroid parenchyma. Nodules can present as solitary, multiple, cystic, and solid formations. Nodules in the thyroid gland are common and are identified in about 5% to 7% of the overall adult population through physical examination alone. A wide range of disorders is linked to thyroid nodules, encompassing both benign and malignant circumstances that may display either indolent or highly aggressive clinical progressions (1-4). The familial prevalence of thyroid cancer is around 5% for papillary thyroid carcinoma as well as follicular thyroid carcinoma, while it ranges from 15% to 30% for medullary thyroid carcinoma. In recent decades, there has been a global rise in the incidence of papillary thyroid cancer, primarily attributed to improved early detection methods and advanced imaging technologies, which carry the risk of over detection (4, 5).

Ultrasound-guided elastography (USE) functions as a noninvasive assessment tool for evaluating the biomedical properties of tissues, such as elasticity. This tool proves helpful in multiple diagnostic scenarios, particularly in the evaluation of thyroid tumors. Various categories of USE are readily available. Strain USE, commonly referred to as real-time elastography, represents the most available variant available (6, 7). A study indicated that the occurrence of malignant thyroid tumors was 61.7%. The reported sensitivity of ultrasound elastography was 90.0%, while its specificity was 90.30% in diagnosing malignancy (8, 9).

The basic idea is that when subjected to compression, the softer components of tissue undergo deformation more readily than their more rigid counterparts. The extent of tissue distortion triggered by external force may be documented, allowing for the measurement of tissue stiffness or hardness (6, 10). Strain USE serves as a qualitative method for assessing tissue stiffness. Conversely, a semiquantitative analysis can be conducted through the strain ratio, which compares the stiffness for a target lesion against a reference of normal thyroid tissue utilising real-time elastography (6, 8). Benign tissue shows more excellent softness, elasticity, and flexibility compared to malignant tissue. USE assists in quantifying tissue elasticity, which facilitates the distinction between benign and malignancy (11).

This research aims to deliver a non-invasive, cost-effective, and readily accessible imaging method for diagnosing malignant thyroid nodules, facilitating the selection of suitable and appropriate treatment options to reduce the morbidity and mortality associated with the disease.

METHODOLOGY

The methodology of our study, designed to assess the diagnostic accuracy of strain ultrasound elastography in predicting malignant thyroid tumors with histopathology as the gold standard, was carried out with a cross-sectional validation approach. This research unfolded

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within the Radiology Department of Lady Reading Hospital in Peshawar, spanning from 27-08-2023 to 27-02-2024. We calculated the sample size using the WHO sample size calculator, basing our assumptions on a reported proportion of malignant thyroid tumors at 61.7%8, a sensitivity of 90.0%, and a specificity of 90.3%9 with an absolute precision of 10% and a 95% confidence level, which yielded a total of 110 participants. To gather this cohort, we employed a non-probability consecutive sampling technique, ensuring a practical and systematic selection process.

Eligible participants included individuals of any gender aged between 18 and 70 years who presented with suspected malignant thyroid tumors identified through palpable thyroid nodules of any size. We excluded pregnant patients, those with a history of thyroid surgery, and individuals with chronic kidney disease to maintain the study's focus and reduce confounding factors. The study commenced once we secured approval from the hospital's ethical board. Before enrollment, we informed each participant and their guardians about the study's purpose, potential benefits and inherent risks, after which they provided written consent to proceed. We then collected specific demographic details such as gender and address alongside a thorough evaluation of each patient's medical history and physical condition.

For the diagnostic phase, we subjected all suspected cases to strain ultrasound elastography performed using a high-resolution unit equipped with a 7.5 MHz linear array probe. This procedure enabled us to assess the presence of malignant thyroid tumors based on predefined criteria including micro-calcifications border irregularity hypo-echogenicity and abnormal cervical lymph nodes with results meticulously recorded. Subsequently, we referred these patients for histopathological examination where findings were documented under microscopic analysis, noting features such as nuclear expansion elongation overlapping glassy nuclei chromatin clearing and margination to confirm malignancy. A consultant radiologist with at least five years of post-fellowship experience oversaw the comparison of elastography and histopathology results, ensuring accuracy and reliability, and we logged all observations onto a pre-designed proforma tailored for this study.

Data analysis occurred using SPSS version 21, where we processed and interpreted the collected information. For quantitative variables like age, weight, height, and body mass index, we computed means and standard deviations to summarise the sample characteristics. Qualitative data, including gender elastography findings and histopathology outcomes, were expressed as frequencies and percentages to provide a clear picture of categorical distributions. To evaluate the diagnostic performance of strain ultrasound elastography, we constructed a 2x2 contingency table from which we derived sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy using histopathology as the reference standard. We further stratified these diagnostic metrics by age, gender, and body mass index to explore potential variations across subgroups, enhancing the depth of our analysis..

RESULTS

Our research involved 110 individuals whose average age was 41.22±15.080 years. Their body mass index averaged 25.7481±1.79650 kg/m².

As for gender, our study included 50 males (45.5%) and 60 females (54.5%) (Table 1). When assessing thyroid tumors via ultrasound elastography, 53 participants (48.2%) tested positive for malignancy, while 57 (51.8%) showed negative results (Table 2). On histopathology, 51 participants (46.4%) had confirmed malignant tumors, with 59 (53.6%) showing no malignancy (Table 3).

Digging deeper into the comparison between elastography and histopathology among the 53 participants with positive elastography results, 45 (84.9%) were confirmed positive on histopathology while 8 (15.1%) were negative. For the 57 participants with negative elastography findings, 6 (10.5%) were positive on histopathology, and 51 (89.5%) were negative. This gave us a sensitivity of 88.24%, meaning elastography correctly identified most true malignant cases, and a specificity of 86.44%, reflecting its ability to rule out malignancy accurately. The positive predictive value stood at 84.91%, showing the likelihood of a positive elastography result being truly malignant, while the negative predictive value was 89.47%, indicating reliability in negative results. Overall, the diagnostic accuracy of elastography in our study reached 87.27%, highlighting its strong performance against the histopathology standard (Table 4). Stratification of diagnostic accuracy with age, gender, and BMI can be seen from table no. 5 to table no. 7.

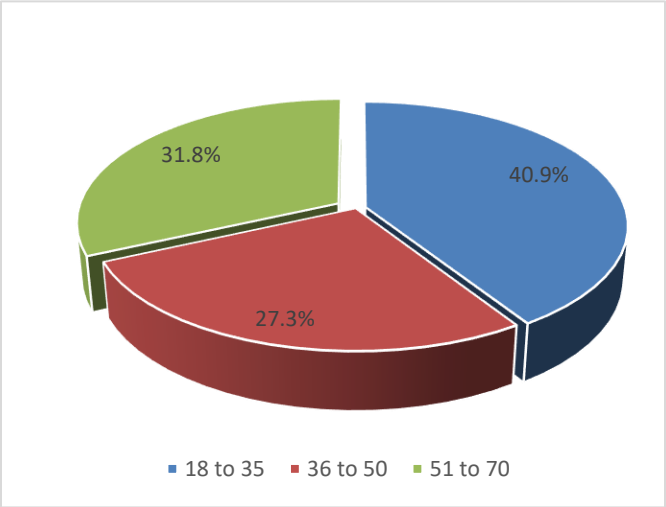

Figure 1: Age distribution (Years)

Table 1: Gender distribution

Gender	Frequency	Percent
Male	50	45.5
Female	60	54.5
Total	110	100.0

Table 2: Malignant thyroid tumor on ultrasound elastography

Malignant thyroid tumor on ultrasound elastography	Frequency	Percent
Positive	53	48.2
Negative	57	51.8
Total	110	100.0

Table 3: Malignant thyroid tumor on ultrasound histopathology

Malignant thyroid tumor on histopathology	Frequency	Percent
Positive	51	46.4
Negative	59	53.6
Total	110	100.0

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Table 4: Diagnostic accuracy of malignant thyroid tumors on ultrasound elastography

		Malignant thyroid tumour on histopathology		Total
		Positive	Negative	
Malignant thyroid tumour on ultrasound elastography	Positive	45	8	53
		84.9%	15.1%	100.0%
	Negative	6	51	57
		10.5%	89.5%	100.0%
Total		51	59	110
		46.4%	53.6%	100.0%

Sensitivity: *88.24%,* ***Specificity:*** *86.44%,* ***Positive Predictive Value:*** *84.91%,* ***Negative Predictive Value:*** *89.47%,* ***Diagnostic accuracy:*** *87.27%*

Table 5: Stratification of diagnostic accuracy of malignant thyroid tumor on ultrasound elastography with age

Age distribution (Years)	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy
18 to 35	83.33%	85.19%	78.95%	88.46%	84.44%
36 to 50	93.75%	78.57%	83.33%	91.67%	86.67%
51 to 70	88.24%	94.44%	93.75%	89.47%	91.43%

Table 6: Stratification of diagnostic accuracy of malignant thyroid tumor on ultrasound elastography with gender

Gender	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy
Male	91.30%	81.48%	80.77%	91.67%	86.00%
Female	85.71%	90.62%	88.89%	87.88%	88.33%

Table 7: Stratification of diagnostic accuracy of malignant thyroid tumor on ultrasound elastography with BMI

BMI (kg/m2)	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy
18 to 24.9	83.33%	30.23%	40.00%	76.47%	49.25%
> 24.9	92.59%	88.37%	83.33%	95.00%	90.00%

DISCUSSION

Our study evaluating the diagnostic accuracy of ultrasound elastography in detecting malignant thyroid tumors with histopathology as the gold standard involved 110 participants and provided robust findings. The cohort's mean age was 41.22 years (±15.080), with a body mass index averaging 25.7481 kg/m² (±1.79650). Age distribution showed 45 participants (40.9%) aged 18 to 35 years, 30 (27.3%) aged 36 to 50 years, and 35 (31.8%) aged 51 to 70 years. Gender composition included 50 males (45.5%) and 60 females (54.5%). Elastography identified malignancy in 53 participants (48.2%), while histopathology confirmed it in 51 (46.4%). Cross-tabulation revealed that of the 53 elastography-positive cases, 45 (84.9%) were malignant on histopathology, and 8 (15.1%) were benign. Among the 57 elastography-negative cases, 51 (89.5%) were benign, and 6 (10.5%) were malignant. This resulted in a sensitivity of 88.24%, specificity of 86.44%, positive predictive value of 84.91%, negative predictive value of 89.47% and diagnostic accuracy of 87.27%. These outcomes highlight elastography's potential, and comparing them with prior research offers valuable context.

Rago et al.. investigated elastography in 92 patients with indeterminate thyroid nodules, reporting a sensitivity of 97% and specificity of 100% using a 5-point elasticity scoring system (12). Their sensitivity surpasses our 88.24% likely due to their focus on indeterminate nodules where elastography may excel in resolving diagnostic uncertainty. Their perfect specificity (100%) significantly exceeds our 86.44%, possibly reflecting the scoring system's precision in a selected cohort with fewer benign variations, unlike our broader sample. This discrepancy suggests that targeting specific nodule types could maximise elastography's discriminatory power.

Hong et al.. assessed real-time elastography in 90 patients, finding a sensitivity of 88% and specificity of 90% (13). Their sensitivity aligns closely with ours (88.24%), reinforcing elastography's consistency in detecting malignancy. Their specificity is potentially higher than ours due to the use of a strain index alongside ultrasound, which might enhance benign-malignant differentiation. Our qualitative approach lacking such quantitative aids may explain the modest specificity gap hinting at the benefit of combined techniques.

Sebag et al.. evaluated shear wave elastography (SWE) in 146 nodules from 93 patients, reporting a sensitivity of 85.2% and specificity of 93.9% (14). Their specificity outpaces ours, likely due to SWE's quantitative stiffness measurements, which provide a more objective metric than our strain-based method. Our sensitivity (88.24%) is slightly higher, possibly tied to differences in nodule characteristics or operator experience. Their results underscore SWE's specificity advantage, suggesting technological upgrades could elevate our performance.

Our diagnostic accuracy of 87.27% fits within the 85–90% range observed in the studies above, though Rago et al.'s exceptional specificity (100%) elevates their overall performance. Their high sensitivity (97%) and perfect specificity likely stem from a focused cohort, while our broader sample introduced more variability, reflected in our false negatives (6 cases) and false positives (8 cases). These errors are consistent with challenges noted by Hong et al. and Sebag et al. in cystic or calcified nodules, suggesting that integrating quantitative measures or multimodal imaging as Hong et al. advocate could improve our outcomes.

CONCLUSION

In conclusion, our study demonstrates that ultrasound elastography is

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an effective and accurate modality for predicting malignant thyroid tumors, achieving a diagnostic accuracy of 87.27%. These findings, consistent with prior research, support its role as a valuable diagnostic tool with potential for enhancement through quantitative measures or multimodal imaging to refine its precision further.

DECLARATIONS

Data Availability Statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department Concerned. (Ref: No. 790/LRH/MTI)

Consent for publication

Approved

Funding

Not applicable

CONFLICT OF INTEREST

The authors declared an absence of conflict of interest.

AUTHOR CONTRIBUTION

MAQSOOD AHMAD (Post Graduate Resident)
Conception of Study, Data Collection, Development of Research Methodology Design, Study Design, Review of manuscript, final approval of manuscript.
Study Design, Review of Literature.
Conception of Study, Final approval of manuscript.
MUHAMMAD IMRAN KHAN (Assistant Professor)
Manuscript revisions, and critical input.
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