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Diagnostic Accuracy of Fine Needle Aspiration Cytology and Shear Wave Elastography in Diagnosis of Malignant Thyroid Nodules Taking Post-Operative Histopathology as Gold Standard

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ABSTRACT

Background: Precise diagnosis of malignant thyroid nodule is a very important aspect in directing the clinical approach, and in preventing unnecessary surgeries. This had been the standard diagnostic modality for a long time; Fine needle aspiration cytology (FNAC). yet, its loopholes in indeterminate cytological categories have generated an interest in non-invasive such as shear wave elastography (SWE) which measures tissue stiffness. **Aim:** To compare the diagnostic accuracy of FNAC and SWE for diagnosis of the malignant thyroid nodules, compared to a histopathology reference standard. **Methods:** This cross-sectional study was undertaken at the Department of Radiology, Lahore General Hospital in six months. 170 patients aged 20–60 years with ultrasound suspicious thyroid nodules were examined. Each patient received SWE performed by an experienced radiologist, FNAC and later histopathological confirmation. Diagnostic performance was estimated within the boundaries of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy. Analysis of Data was performed in SPSS version 22.0. **Results:** SWE showed superior diagnostic performance with a specificity of 98.6%, sensitivity of 69.2%, PPV of 90.0%, NPV of 94.8%, and an overall diagnostic accuracy of 94.1%. SWE score 4 was highly predictive of malignancy, while score 1 reliably excluded it. In contrast, FNAC achieved 80% sensitivity and 85% specificity when Bethesda categories B3–B6 were considered malignant. Diagnostic performance of FNAC improved to 100% sensitivity and 90% specificity when only B5–B6 were classified as malignant. Histopathology confirmed that solitary nodules were more often malignant than multiple nodules. **Conclusion:** SWE demonstrated better overall diagnostic accuracy and non-invasiveness compared to FNAC, particularly in stratifying benign versus malignant nodules. While FNAC remains essential for cytological confirmation, SWE offers substantial advantages in specificity and can effectively guide biopsy decisions, especially in clearly benign or highly suspicious cases.

INTRODUCTION

Thyroid nodule is a localised well-defined region with changed echogenicity radiologically different than the surrounding thyroid gland (Hazem et al., 2021). The incidence of malignancy in paediatric thyroid nodules is greater than in adults, with cancer identified in roughly 10% of adult thyroid nodules and between 22% and 26% in children (Borysewicz-Sańczyk et al., 2024). A nodule within this gland may be palpable in the neck or detected only by ultrasonography. It is worrying in the event that a thyroid nodule is malignant. It requires initial detailed investigations and correct decision of the management. Most of the thyroid nodules are benign; however, in approximately 5–15% cases malignancy has been reported in a few studies (Baz et al., 2021; Yoo et al., 2021). Risk factors for malignancy are age, gender (predominance in females), and family history and past irradiation (Mena et al., 2023).

Two thirds of all cases of thyroid cancer occur between 20– 55 years, anaplastic thyroid cancer after 60 years and medullary thyroid cancer in infants and adolescents with the RET (rearranged during transfection) proto-oncogene mutation (Jesrani et al., 2021). Given the potential for malignancy, appropriate diagnostic stratification is essential to prevent unnecessary surgery while ensuring timely intervention in malignant cases (Aghaghazvini et al., 2020). Fine Needle Aspiration Cytology (FNAC) remains the first-line investigation in the diagnostic

algorithm for thyroid nodules due to its simplicity, low cost, and relatively high sensitivity and specificity (Chambara et al., 2022). Introduced in the mid-20th century, FNAC has since been refined with the Bethesda System, which classifies cytological findings into six categories to guide clinical management (Zhang et al., 2022).

The diagnostic sensitivity of FNAC for thyroid malignancies ranges between 65% and 98%, while specificity ranges from 72% to 100%, depending on the operator's expertise and cytological criteria used (Nattabi et al., 2022). However, FNAC has limitations, including a non-negligible rate of indeterminate results, which comprises up to 30% of all biopsies, posing a diagnostic challenge (Rajabzadeh et al., 2023). Indeterminate cytology often leads to diagnostic surgery, exposing patients to potential morbidity for ultimately benign disease (Qiu et al., 2020). Furthermore, sampling error and cellular heterogeneity within nodules can result in false negatives, reducing the reliability of FNAC in some clinical contexts (Chen et al., 2022).

Shear Wave Elastography (SWE), an advanced form of ultrasound elastography, an increasingly non-invasive imaging modality quantitatively measuring tissue stiffness, is often increased for malignant nodules by desmoplastic reactions and cellular density (Naleini et al., 2022). Via generation of the shear waves and measuring their speed through tissue, SWE gives objective and reproducible stiffness measured in kilopascals (kPa) values. This method has potential towards discriminating between benign and malignant thyroid lesions, and in addition to traditional ultrasonographic features (Yang et al., 2020). Several studies have indicated SWE has an excellent diagnostic performance, with a sensitivity reported between 80% and 95% and a specificity varying between 75% and 90%, a level equal or even better than FNAC in nodules with indeterminate cytology (Chen et al., 2022; Rajabzadeh et al., 2023). The real time imaging quality of SWE facilitates thorough assessment of lesions, thus increasing its value for guiding clinical practice, and possibly eliminating invasive biopsies (Abdallah et al., 2024).

Furthermore, the capacity of SWE to evaluate the whole nodule and not a sample as is the case with FNAC may reduce the effects of tissue heterogeneity (Baz et al., 2021). The growing adoption of elastography for the evaluation of thyroid nodules is representative of a more general trend toward multimodal testing which integrates anatomical and functional imaging in order to enhance diagnostic precision. Several studies have indicated that the yield of diagnosis can greatly be improved by the fusion of SWE with B-mode ultrasonography over use of either technique. The role of SWE in the ACR thyroid Imaging Reporting and Data System (TI-RADS) continues to take shape as evidence accumulates (Hazem et al., 2021; Jesrani et al., 2021). Notwithstanding encouraging findings, variations in SWE cut-off values, machine settings as well as operator proficiency, play role in influencing the diagnostic performance thereby requiring standardization to insure wide scale usage. Additionally, the presence or absence of calcifications, or cystic degeneration, proximity to vascular structures may impact the measurements of stiffness and thereby potentially confound results (Aghaghazvini et al., 2020; Chambara et al., 2022). Therefore, purpose of SWE inclusion into clinical practice involves close judgment of technique and interpretation.

Repeat biopsy is a cumbersome procedure and it is a healthcare system's financial burden for the patient as well, considering the lack of resources like in Pakistan (Nattabi et al., 2022; Qiu et al., 2020). In a recent study, sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of shear wave elastography in differentiating between benign and malignant thyroid nodules with histopathology as gold standard was 88%, 90%, 81%, 93% and 90% respectively (Abdallah et al., 2024). The of this study is to determine diagnostic accuracy of fine needle aspiration cytology and shear wave elastography in diagnosis of malignant thyroid nodules taking post-operative histopathology as gold standard. Previously no single study was done in which both modalities were compared with histopathology in same set of patients. This study will help in determining most accurate test for diagnosis of malignant thyroid nodule.

METHODOLOGY

Study Design and Sample Population

This cross-sectional validation study was conducted at the Department of Radiology, Lahore General Hospital, Lahore. The study was carried out over a minimum duration of six months following the approval of the research synopsis by the institutional review board. A non-probability consecutive sampling technique was employed to recruit eligible patients from the radiology department. A total of 170 patients were included in the study. The sample size was calculated using a sensitivity and specificity calculator, maintaining a 95% confidence level. The parameters used for sample size estimation included a reported prevalence of malignant thyroid nodules of 53.4%, a sensitivity of FNAC of 83% with a 10% margin of error, and a specificity of 92% with a 6% margin of error (Chen et al., 2022).

Inclusion and Exclusion Criteria

The individuals aged between 20 and 60 years, of either gender, who presented with neck swelling and underwent neck ultrasound that revealed a suspicious solid thyroid micro-nodule were enrolled. Suspicion was based on the presence of one or more sonographic features, including micro-calcifications, intramodular vascularity, irregular or microlobulated margins, a taller-than-wide shape, and the absence of a halo sign (defined as the absence of an anechoic or hypoechoic rim around the nodule). All eligible patients were referred from the surgery outpatient department. Patients were excluded if they had cystic thyroid nodules without any solid component as confirmed on ultrasound. Those with a history of chemotherapy for malignant thyroid disease or patients with recurrent thyroid swellings, as documented in their medical records or obtained through history, were also excluded. Furthermore, individuals who declined consent for histopathological confirmation were not included in the final analysis.

Data Collection

During data collection phase, demographic details such as age, sex and time of swelling of the thyroid were noted for each participant. All enrolled patients had performed Shear Wave Elastography (SWE), which was carried out by a consultant radiologist with a minimum of five years post fellowship experience. After SWE assessment, the patients were referred to the surgical department for Fine Needle Aspiration Cytology (FNAC) and all specimens were finally referred for histopathological examination, in a reference to the standard for confirming the presence or absence of malignancy. The diagnostic pathway was aimed for each step following a careful coordination so as to maintain procedural consistency and reliability of findings.

Data Analysis

The entered data was analysed using the Statistical Package for the Social Sciences (SPSS) version 22.0. Mean and standard deviation were computed for continuous variables including; age and duration of thyroid swelling. Categorical data which included, gender and diagnostic outcomes from SWE, FNAC and histopathology were analyzed using frequencies and percentages. Diagnostic rates of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and total diagnostic accuracy were calculated for both SWE and FNAC using the construction of 2×2 contingency tables with histopathology reference. Stratification split up by age, gender and length of thyroid swelling were conducted to measure the possible effect of confounding variables. To determine the robustness of test performance, post-stratification diagnostic accuracy was computed.

Ethical Considerations

This study was approved by the Institutional Review Board (IRB) of Lahore General Hospital, Lahore before its implementation. All participants were fully briefed about the objectives, procedures and risk and benefit of the study. Written informed consent was obtained from each patient before enrolment, as the participants were volunteers. Confidentiality and privacy were ensured throughout the research process by anonymizing patient data, accessing only to authorised agents. The research was carried out strictly in line with the ethical guideline set up by Declaration of Helsinki and respective national regulations on research on human beings. Participants could leave the study at any time and this would have no effect on their normal medical treatment.

RESULTS

Demographic Profiling

The demographic profile of the study population revealed that the majority of patients fell within the middle age group of 34 to 46 years, accounting for 37.1% (n=63) of the total sample. The youngest age group, between 20 and 33 years, comprised 30.6% (n=52), while patients aged 47 to 60 years represented 32.3% (n=55) of the cohort. This distribution suggests a relatively even spread of cases across adult age groups, with a slight predominance in the middle-aged category. Gender distribution showed a notable female predominance, with females constituting 62.9% (n=107) of the participants compared to 37.1% (n=63) males. This gender disparity aligns with the well-established epidemiological trend of thyroid disorders being more prevalent among females, possibly due to hormonal influences and autoimmune susceptibilities. These demographic findings provide a foundational context for interpreting diagnostic trends and disease prevalence in the subsequent analyses.

Table 1

Demographic Characteristics of Study Participants (n = 170)

Variable	Categories	Frequency (n)	Percentage (%)
Age (years)	20–33	52	30.6%
	34–46	63	37.1%
	47–60	55	32.3%
Gender	Male	63	37.1%
	Female	107	62.9%

Thyroid Nodule Characteristics and Histopathological Outcomes

The analysis of thyroid nodule characteristics and corresponding histopathological outcomes demonstrated that solitary thyroid nodules were more commonly observed, present in 57% (n=97) of patients. Among these, 66% (n=64) were confirmed as benign on final histopathology, while 34% (n=33) were identified as malignant, underscoring the substantial risk of malignancy even in solitary lesions. Conversely, multiple thyroid nodules were identified in 43% (n=73) of the cohort. Of these, a larger proportion—75.3% (n=55)—were histologically benign, suggesting a lower relative malignancy risk in multinodular presentations.

However, malignancy was still notable among this group, with 12.3% (n=9) of cases diagnosed as papillary carcinoma and another 12.3% (n=9) as follicular carcinoma. These findings challenge the traditional assumption that solitary nodules carry a higher risk of malignancy, highlighting the need for vigilant evaluation of both solitary and multiple nodules, regardless of their sonographic appearance or clinical presentation.

Table 2

Distribution of Thyroid Nodule Type and Final Histopathology (n = 170)

Nodule Type	Histopathology Outcome	Frequency (n)	Percentage (%)
Solitary Nodule Total = 97 patients (57%)	Benign	64	66.0%
	Malignant	33	34.0%
Multiple Nodules Total = 73 patients (43%)	Benign	55	75.3%
	Papillary Carcinoma	9	12.3%
	Follicular Carcinoma	9	12.3%

Prevalence of Malignancy in Thyroid Nodule According to SWE Elastography Score

Table 3 presents the prevalence of malignancy in thyroid nodules according to shear wave elastography (SWE) scoring among the 170 patients included in the study. The findings demonstrate a clear positive correlation between increasing SWE scores and the likelihood of malignancy. None of the patients with an elastography score of 1 (n=50) were found to have malignant lesions, indicating a high negative predictive value in this group. Among patients with score 2 (n=60), only 3.3% (n=2) had confirmed malignancy, while score 3 (n=40) showed an increased malignancy rate of 15% (n=6). Notably, the

highest SWE score (score 4) was strongly predictive of malignancy, with 90% (n=18 out of 20) of those nodules being histologically confirmed as malignant. This trend underscores the diagnostic utility of SWE scoring in stratifying malignancy risk, particularly in nodules with higher elasticity scores, and supports its role as a non-invasive adjunctive tool in clinical decision-making.

Table 3

Prevalence of Malignancy in Thyroid Nodule as Per SWE Elastography Score (n = 170)

Elastography Score	Total Patients (n)	Malignant Cases (n)	Percentage Malignant (%)
Score 1	50	0	0.0%
Score 2	60	2	3.3%
Score 3	40	6	15.0%
Score 4	20	18	90.0%
Total	170	26	—

Correlation of Elastography Score and Final Histopathology

Table 4 examines the statistical relationship between SWE elasticity scores and final histopathology results. A significant association was observed, with increasing SWE scores correlating with higher malignancy rates confirmed on surgical biopsy ($p < 0.001$). Among 170 patients, 144 (84.7%) were found to have benign nodules, while 26 (15.3%) were confirmed malignant. All nodules with an elastography score of 1 were benign (100%). Score 2 nodules were predominantly benign (96.7%), with only two malignancies observed. In contrast, 15% of nodules with score 3 and a striking 90% of those with score 4 were malignant, suggesting a substantial increase in risk at higher stiffness levels. This strong statistical significance affirms that SWE is highly effective in predicting malignancy and that elastography scoring can reliably guide the clinical stratification of patients for further cytological or surgical assessment.

Table 4

Relationship Between Elastography Score and Final Histopathology (n = 170)

Elastography Score	Benign (n, %)	Malignant (n, %)	p-value
Score 1	50 (100.0%)	0 (0.0%)	
Score 2	58 (96.7%)	2 (3.3%)	
Score 3	34 (85.0%)	6 (15.0%)	
Score 4	2 (10.0%)	18 (90.0%)	<0.001
Total	144 (84.7%)	26 (15.3%)	

Diagnostic Accuracy of FNAC Bethesda System for Diagnosis of Malignancy

Table 5 details the diagnostic accuracy of fine needle aspiration cytology (FNAC), categorized by the Bethesda classification system, in predicting thyroid malignancy. When comparing Bethesda categories B3 to B6 (suspicious to malignant) against benign B2 nodules, the sensitivity was 80%, and specificity was 85%, resulting in a positive predictive value (PPV) of 51.6% and a negative predictive value (NPV) of 95.9%. This combination yielded an overall diagnostic accuracy of 84.1% and an area under the curve (AUC) of 0.82 ($p = 0.01$), indicating good discriminatory power. When a stricter grouping of only Bethesda B5 and B6 was compared to B2–B4, FNAC demonstrated 100% sensitivity, 90% specificity, 65% PPV, and 100% NPV, with an AUC of 0.95 and a highly significant p-value of 0.001. These results affirm that FNAC is highly effective, particularly when using more definitive Bethesda categories (B5–B6), although its predictive accuracy is slightly lower when including indeterminate categories (B3–B4). Thus, FNAC remains a valuable diagnostic modality, particularly when its cytological findings are definitive.

Table 5

Diagnostic Accuracy of FNAC Bethesda System for Diagnosis of Malignancy (n = 170)

FNAC Grouping	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	AUC	p-value
B3–B6 vs. B2	80.0	85.0	51.6	95.9	84.1	0.82	0.01
B5–B6 vs. B2–B4	100.0	90.0	65.0	100.0	91.2	0.95	0.001

Note: FNAC results were categorized based on Bethesda groups. Histopathology was the gold standard.

Diagnostic Accuracy of SWE Scoring for Malignancy

Table 6 presents the diagnostic performance of shear wave elastography (SWE) scoring alone in detecting malignant thyroid nodules. By isolating score 4 as the diagnostic cutoff, SWE demonstrated a sensitivity of 69.2%, indicating that it correctly identified approximately two-thirds of malignant cases. More impressively, it showed a specificity of 98.6%, meaning that almost all benign cases were correctly classified. The positive predictive value (PPV) was 90%, while the negative predictive value (NPV) was 94.8%, reflecting a high level of diagnostic certainty. The global diagnostic accuracy numbered 94.1%, area under the curve (AUC) being 0.95, p value being highly significant (<0.001). These findings demonstrate that SWE, and especially the highest score of elasticity, have a very high discriminating capability and are capable of distinguishing malignant from benign nodules. It is most valuable in the exclusion of unwarranted FNACs in the obviously benign cases, yet still retaining a high diagnostic output in the search for malignancies.

Table 6

Diagnostic Accuracy of SWE Scoring for Malignancy (n=170)

SWE Grouping	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	AUC	p-value
Score 4 vs. 1–3	69.2	98.6	90.0	94.8	94.1	0.95	<0.001

DISCUSSION

This research was designed to assess the diagnostic performance of FNAC and SWE for diagnosing malignant thyroid nodules, compared to the histopathology as such gold standard method. It determined that SWE score 4 had 90% prevalence of malignancy and was highly predictive of cancer with measures of sensitivity (69.2%), specificity

(98.6%), positive predictive value (90%) and negative predictive value (94.8%) and overall diagnostic accuracy of 94.1%. These observations are extremely consistent with the findings of Baz et al., (2021) with a specificity of 95.8%, NPV of 93.2% and diagnostic accuracy of SWE at similar elasticity score cutoffs of 91.3%. Similarly, Sebag et al (2010) applied SWE to differentiate benign from malignant thyroid nodules and showed that this technique had 94.5% specificity and NPV of 97.2%. This proves that high SWE scores are highly related to histologically proven malignancies.

Our findings shown that, patients who scored 1 on the SWE had 0% malignancy and those scoring 2 only had 3.3% malignancy, which is evidence of superb performance of SWE in ruling out malignancy at low elasticity value. In accordance with Yang et al., (2020), finding in a cohort of 128 patients NPV reached 100% for SWE score 1, low values of elasticity correlate strongly with benign pathology. Likewise, Naleini et al., (2022) observed that nodules with SWE scores below 2.5 kPa rarely harboured malignancy, further validating the utility of SWE in excluding cancer in clearly soft nodules. On the other hand, FNAC demonstrated 80% sensitivity and 85% specificity when comparing Bethesda categories B3–B6 to B2, with improved sensitivity (100%) and specificity (90%) when only Bethesda B5–B6 were used for malignancy prediction. These results are broadly consistent with recent comparative analysis (Naleini et al., 2022; Yang et al., 2020), who reported that FNAC typically achieves a sensitivity of 83–92% and specificity of 89–95% in differentiating malignant thyroid lesions.

Our findings also correlate with a large meta-analysis by Mahmoud et al., (2024), which documented pooled sensitivity and specificity for FNAC at 89% and 96%, respectively. However, in categories B3 and B4 (indeterminate cytology), the diagnostic yield is known to be significantly lower, which may explain the relatively reduced PPV (51.6%) seen in our study when these categories were included. The high specificity and PPV of SWE, particularly in score 4 lesions, provide a strong argument for its role in reducing unnecessary biopsies (Mahmoud et al., 2024). For instance, Yang et al., (2020) highlighted that SWE could potentially avoid 30–40% of FNACs in patients with low-risk sonographic profiles. This perspective is supported by our study, where none of the patients with SWE score 1 had malignancy, thus indicating that FNAC might be deferred in this group. Moreover, our results support a recent comparative study (Yavuz et al., 2021), who recommended using SWE as a gatekeeping tool prior to FNAC in low-suspicion nodules.

While SWE demonstrated excellent specificity, its lower sensitivity (69.2%) compared to FNAC's 100% (for Bethesda B5–B6) suggests that SWE may miss some malignancies, especially in nodules with intermediate stiffness. This limitation was similarly noted by Qiu et al., (2023), who found that SWE may underperform in detecting follicular carcinomas, which often show intermediate or soft elasticity. This could explain why in our study, malignancies were still observed in SWE scores 2 and 3, albeit at low frequencies (3.3% and 15%, respectively). These findings reinforce the idea that SWE is best used in conjunction with FNAC rather than as a standalone diagnostic tool. In contrast to SWE's strong performance in predicting score 4 malignancies, FNAC's value lies in its cytological precision, especially in Bethesda category B5 (suspicious for malignancy) and B6 (malignant) (Qiu et al., 2023). In our cohort, B5–B6 categorization yielded perfect sensitivity and NPV (both 100%) and a high AUC of 0.95, making FNAC superior in directly confirming malignancy. This echoes the results by Filho et al., (2020), who found that FNAC had an AUC of 0.96 and outperformed imaging alone in specificity and PPV. Therefore, when FNAC yields definitive cytology, it remains the gold standard for pre-operative evaluation (Filho et al., 2020).

Interestingly, the diagnostic accuracy of SWE in our study (94.1%) slightly surpassed that of FNAC when the latter included indeterminate categories (accuracy of 84.1%). This finding matches with a multi-centre analysis (Hazem et al., 2021), who reported that SWE had higher reproducibility and fewer false positives compared to FNAC, particularly in non-diagnostic or atypical samples. In resource-limited settings, where repeat FNACs may be impractical, SWE thus offers a valuable adjunctive role, improving triage and reducing invasive procedures. Another important consideration is patient tolerance and procedural invasiveness. FNAC, though minimally invasive, still causes discomfort and has a risk of non-diagnostic results. SWE, being entirely non-invasive and repeatable, offers clear advantages in terms of patient compliance and procedural feasibility. This was noted in recent studies (Baz et al., 2021; Yoo et al., 2021), who emphasized that SWE improves patient throughput and decreases anxiety, especially in repeated follow-up evaluations for indeterminate nodules.

Limitations

Several limitations were acknowledged in this study. Firstly, the study was conducted at a single tertiary care centre with a limited sample size of 170 patients, which may not fully represent the general population. Secondly, SWE interpretation was operator-dependent, and despite standardization, subtle variations in technique could influence stiffness measurements. Thirdly, FNAC interpretations were limited by cytological ambiguity in Bethesda categories III and IV, which remain diagnostically challenging. Additionally, histopathological confirmation was not uniformly available for all FNAC categories, as surgery was not performed on clearly benign nodules, potentially introducing verification bias. Finally, lack of long-term follow-up data precluded assessment of nodule progression or diagnostic revisions over time.

CONCLUSION AND RECOMMENDATIONS

This study demonstrates that SWE performed better in most diagnostic parameters for evaluating malignant thyroid nodules than FNAC. SWE showed markedly higher specificity (98.6%), positive predictive value (90%), negative predictive value (94.8%), and overall diagnostic accuracy (94.1%) compared to FNAC, particularly when intermediate cytological categories were included. SWE score 4 was strongly predictive of malignancy, while score 1 reliably excluded it, highlighting SWE's strength in both ruling in and ruling out malignancy. In contrast, FNAC's

diagnostic performance significantly improved only when Bethesda categories B5 and B6 were isolated, reaching 100% sensitivity and negative predictive value, thereby confirming its continued value in definitive cytological diagnosis. While SWE offers a more consistent and non-invasive diagnostic profile, FNAC retains its critical role where cytological precision is necessary. Overall, SWE has emerged as a highly reliable, non-invasive tool that can enhance or, in selected cases, even replace FNAC in the initial assessment of thyroid nodules. It is recommended that shear wave elastography be integrated as an adjunctive diagnostic tool in routine thyroid nodule evaluation, particularly in patients with low-risk or indeterminate features on ultrasound. Its high specificity can reduce unnecessary FNACs in nodules with very low or very high SWE scores. Moreover, FNAC should continue to be the definitive tool for cytological diagnosis, especially in nodules with intermediate or equivocal SWE findings. Future multi centre studies with larger and more diverse populations are recommended to validate these results and to establish standardized SWE scoring thresholds.

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