ORIGINAL RESEARCH PAPER

Radio-Diagnosis

KEY WORDS: Thyroid nodule; Sonoelastography; Strain ratio; Ultrasonography; Diagnostic accuracy

ROLE OF SONOELASTOGRAPHY IN CHARACTERIZING THYROID NODULES: A PROSPECTIVE DIAGNOSTIC ACCURACY STUDY

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ABSTRACT

Background: Thyroid nodules are common in clinical practice, and while most are benign, 5–15% harbour malignancy. Conventional ultrasonography alone often cannot reliably distinguish benign from malignant nodules. Sonoelastography, which assesses tissue stiffness, has emerged as a promising adjunct. **Objective:** To evaluate the diagnostic accuracy of sonoelastography, alone and combined with strain ratio, in differentiating benign from malignant thyroid nodules, using histopathology as the reference standard. **Methods:** In this prospective observational study, 110 patients (18–70 years) with sonographically detected thyroid nodules underwent conventional B-mode ultrasonography followed by strain sonoelastography over 18 months at a tertiary-care teaching hospital. Elastography score (ES) and strain ratio (SR) were recorded for each nodule and correlated with fine-needle aspiration cytology and/or histopathology. **Results:** Of 110 nodules, 82 (74.5%) were benign and 28 (25.5%) malignant. Malignant nodules showed significantly higher ES and SR than benign nodules ($p<0.001$). An ES cutoff of ≥3 gave 92.9% sensitivity and 61.0% specificity; SR >2.8 gave 89.3% sensitivity and 78.0% specificity. Combining ES and SR improved accuracy to 88.2%, with sensitivity 96.4%, specificity 85.4%, and area under the ROC curve (AUC) 0.963. **Conclusion:** Sonoelastography is a valuable, non-invasive adjunct to conventional ultrasonography for thyroid nodule characterisation. Combined qualitative and quantitative elastographic assessment substantially improves diagnostic accuracy and may reduce unnecessary fine-needle aspiration cytology and surgery.

INTRODUCTION

Thyroid nodules are increasingly detected due to the widespread use of high-resolution ultrasonography, yet the majority remain clinically silent and benign. Conventional grayscale and Doppler ultrasonography provide useful morphological clues to malignancy — hypoechogenicity, microcalcification, irregular margins, absent halo, and a taller-than-wide shape — but overlapping features between benign and malignant nodules limit diagnostic certainty and often necessitate fine-needle aspiration cytology (FNAC). Sonoelastography, which evaluates tissue stiffness as a surrogate marker of malignancy, has been proposed as a non-invasive adjunct capable of improving pre-biopsy risk stratification. This study was undertaken to assess the diagnostic performance of qualitative elastography score and quantitative strain ratio, individually and in combination, in differentiating benign from malignant thyroid nodules, using histopathology or cytology as the reference standard.

MATERIALS AND METHODS

This prospective observational diagnostic accuracy study was conducted in the Department of Radiodiagnosis of a tertiary-care teaching hospital over 18 months, following institutional ethics committee approval and written informed consent. A consecutive sample of 110 patients aged 18–70 years with thyroid nodules identified on ultrasonography were enrolled; nodules with more than 50% cystic degeneration, dense eggshell calcification, diffuse thyroid disease without a discrete nodule, chronic thyroiditis, or prior thyroid surgery/radiotherapy were excluded. All patients underwent conventional B-mode ultrasonography (6–15 MHz linear transducer) followed by real-time strain sonoelastography, with elastograms colour-coded from red (soft) to blue (hard) and graded on a 4-point elastography score. Strain ratio was calculated by the ultrasound system by comparing strain within the nodule to adjacent normal parenchyma. FNAC and/or histopathology served as the reference standard. Data were analysed in SPSS; sensitivity, specificity, predictive values, diagnostic accuracy, and ROC/AUC were calculated, with $p<0.05$ taken as significant.

RESULTS

The mean age of participants was 43.8 ± 12.5 years, with marked female predominance (78.2%; F:M = 3.6:1). Nodules were most common in the right lobe (43.6%) and measured 1–2 cm in 38.2% of cases (mean 1.82 ± 0.94 cm). On histopathology, 82 nodules (74.5%) were benign and 28 (25.5%) malignant, papillary carcinoma being the commonest malignant subtype (71.4%). Conventional ultrasound features — hypoechogenicity, microcalcification, irregular margins, absent halo, and taller-than-wide shape — were all significantly associated with malignancy ($p<0.001$), microcalcification showing the strongest association ($\chi^2=62.139$). Elastography score correlated strongly with histopathology ($\chi^2=35.284$, $p<0.001$): all Score-1 nodules were benign, while 64.3% of Score-4 nodules were malignant. Mean strain ratio was significantly higher in malignant than benign nodules (4.20 ± 0.94 vs 2.48 ± 0.50; $p<0.001$).

Table 1 summarises diagnostic performance. An elastography score cutoff of ≥3 yielded high sensitivity (92.9%) and negative predictive value (96.2%) but modest specificity (61.0%). Strain ratio >2.8 improved specificity (78.0%) and overall accuracy (80.9%). Combining both parameters produced the best performance overall, with sensitivity 96.4%, specificity 85.4%, accuracy 88.2%, and AUC 0.963, outperforming either parameter alone.

Table 1. Diagnostic performance of elastography score (ES), strain ratio (SR), and their combination for differentiating malignant from benign thyroid nodules (histopathology as reference standard)

Parameter	ES ≥ 3	SR > 2.8	Combined (ES+SR)
Sensitivity	92.9%	89.3%	96.4%
Specificity	61.0%	78.0%	85.4%
PPV	44.8%	58.1%	69.2%
NPV	96.2%	95.5%	98.6%
Accuracy	69.1%	80.9%	88.2%
AUC	0.846	0.948	0.963

DISCUSSION

These findings confirm that sonoelastography adds meaningful diagnostic value beyond conventional grayscale and Doppler ultrasonography in thyroid nodule evaluation. The high sensitivity and negative predictive value of elastography score make it useful for confidently excluding malignancy in soft nodules, while the higher specificity of strain ratio helps

reduce false-positive referrals for FNAC. Consistent with prior reports on strain and shear-wave elastography, the combination of qualitative scoring with quantitative strain ratio produced the best overall discrimination (AUC 0.963), suggesting that the two techniques capture complementary information about tissue stiffness. Given its high negative predictive value, elastography-guided triage could allow low-stiffness nodules to be followed conservatively, sparing patients unnecessary biopsy. Limitations include the single-centre design, operator-dependence of strain elastography, and exclusion of nodules with extensive cystic change or dense calcification, which may limit generalisability; multicentre studies with shear-wave elastography are warranted to validate these cutoffs.

CONCLUSION

Sonoelastography is a valuable, non-invasive adjunct to conventional ultrasonography for characterising thyroid nodules. Combined use of elastography score and strain ratio significantly improves diagnostic accuracy over either parameter alone and may help reduce unnecessary invasive procedures, supporting its incorporation into routine thyroid ultrasound protocols.

Conflict of Interest: None declared.
Source of Funding: None.

REFERENCES

1. Aghaghazvini L, Maheronnaghsh R, Soltani A, Rouzrokh P, Chavoshi M. Diagnostic value of shear wave sonoelastography in differentiation of benign from malignant thyroid nodules. Eur J Radiol. 2020;126:108926.
2. Rubaltelli L, Stramare R, Tregnaghi A, Scagliori E, Cecchelero E, Mannucci M, et al. The role of sonoelastography in the differential diagnosis of neck nodules. J Ultrasound. 2009;12(3):93-100.
3. Esfahanian F, Aryan A, Ghajarzadeh M, Yazdi MH, Nobakht N. Application of sonoelastography in differential diagnosis of benign and malignant thyroid nodules. Int J Prev Med. 2016;7:55.
4. Yilmaz H, Akkus C, Damburaci N, Adibelli Z, Duran C. Sonoelastographic evaluation of recurrent thyroid nodules in patients with operated recurrent nodular goiters. Ultrasound Med Biol. 2022;48(2):209-216.
5. Shingare A, Maldar AN, Chauhan PH, Wadhwani R. Use of ultrasound elastography in differentiating benign from malignant thyroid nodules: a prospective study. J Diabetes Metab Disord. 2023;22:1-9.
6. Ophir J, Cespedes I, Ponnekanti H, Yazdi Y, Li X. Elastography: a quantitative method for imaging the elasticity of biological tissues. Ultrason Imaging. 1991;13:111-134.
7. Asteria C, Giovanardi A, Pizzocaro A, Cozzaglio L, Morabito A, Somalvico F, et al. US-elastography in the differential diagnosis of benign and malignant thyroid nodules. Thyroid. 2008;18:523-531.
8. Trimboli P, Guglielmi R, Monti S, Misischi I, Graziano F, Nasrollah N, et al. Ultrasound sensitivity for thyroid malignancy is increased by real-time elastography: a prospective multicenter study. J Clin Endocrinol Metab. 2012 ;97:4524-4530.
9. Bojunga J, Dauth N, Berner C, Meyer G, Holzer K, Voelkl L, et al. Acoustic radiation force impulse imaging for differentiation of thyroid nodules. PLoS One. 2012;7:e42735.
10. Friedrich-Rust M, Vorlaender C, Dietrich CF, Kratzer W, Blank W, Schuler A, et al. Evaluation of strain elastography for differentiation of thyroid nodules: results of a prospective DEGUM multicenter study. Ultraschall Med. 2016;37:262-270.