

## Role of Colour-Assisted Duplex Sonography in the Evaluation of Thyroid Diseases: A Cross-Sectional Study with Histopathological Correlation

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Conflict of interest: Nil

### Abstract

**Background:** Thyroid disease includes inflammatory, benign nodular, and malignant lesions. Grey-scale ultrasonography is the first-line imaging modality, while colour-assisted duplex sonography provides additional vascular and haemodynamic information that may improve lesion characterization.

**Methods:** This cross-sectional study was conducted in the Department of Radiodiagnosis over 18 months. A total of 70 thyroid lesions were evaluated using grey-scale ultrasonography, colour Doppler, and spectral Doppler. Morphological features, vascularity patterns, and Doppler indices were recorded. Final analysis was correlated with cytopathological and histopathological findings where available. Statistical analysis was performed using SPSS version 26, and a p value of <0.05 was considered statistically significant.

**Results:** The age range was 21-75 years, with a mean age of  $44.8 \pm 13.3$  years and a median age of 43.5 years. Females accounted for 58 cases (82.9%). Papillary thyroid carcinoma was the most common individual diagnosis, seen in 19 lesions (27.1%). Increased vascularity was the most frequent overall Doppler pattern, observed in 28 lesions (40.0%). All inflammatory thyroid lesions showed increased/internal vascularity. In contrast, common benign nodular and goitrous lesions showed either no vascularity or mild/peripheral vascularity, while papillary thyroid carcinoma showed predominantly increased/internal vascularity. Internal/increased vascularity was present in 19 of 21 malignant lesions (90.5%) compared with 14 of 49 benign/non-malignant lesions (28.6%) ( $p < 0.001$ ).

**Conclusion:** Colour-assisted duplex sonography is a useful adjunct in the evaluation of thyroid disease. Doppler vascularity patterns, interpreted together with grey-scale morphology, may help differentiate inflammatory thyroid lesions, benign nodular/goitrous lesions, and papillary thyroid carcinoma. Increased vascularity is not specific for malignancy and should not be interpreted in isolation.

**Keywords:** thyroid disease; colour Doppler; duplex sonography; thyroid nodules; papillary thyroid carcinoma; ultrasonography.

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### Introduction

Thyroid disorders are among the most common endocrine conditions and present with a broad spectrum of diffuse and focal abnormalities. Ultrasonography remains the first-line imaging modality because it is non-invasive, widely

available, repeatable, and capable of detailed structural assessment. Colour-assisted duplex sonography extends conventional grey-scale imaging by adding real-time vascular and haemodynamic information. [1,2]

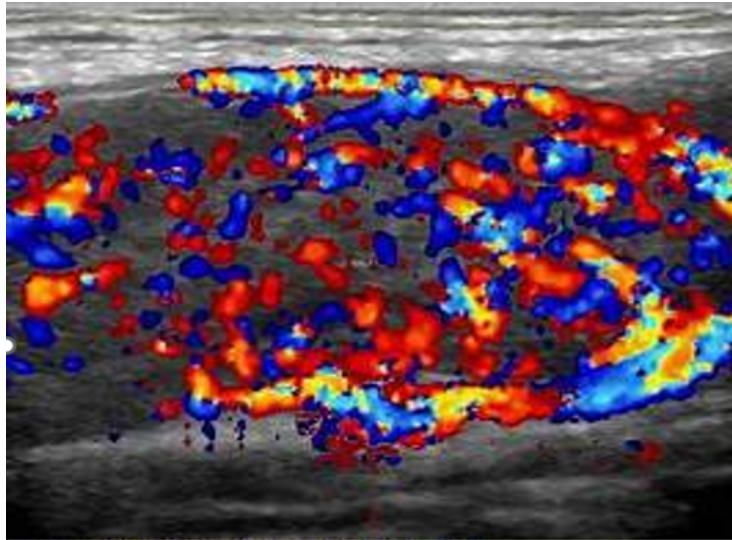


Figure 1: Diffuse parenchymal hypervascularity in Graves' disease

In routine practice, imaging is particularly important in two common clinical situations: differentiation of thyrotoxic states such as Graves' disease and thyroiditis, and risk stratification of thyroid nodules. Previous studies have shown that

thyroid arterial flow parameters may support differentiation of Graves' disease from destructive thyroiditis, while Doppler vascularity may add useful information to grey-scale assessment of thyroid nodules. [3-6]

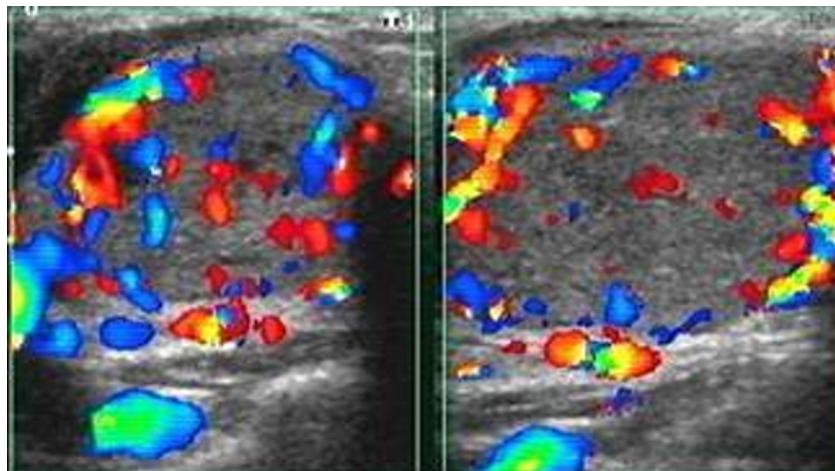


Figure 2: Color Doppler of thyroid nodules showing intranodular vascularity.

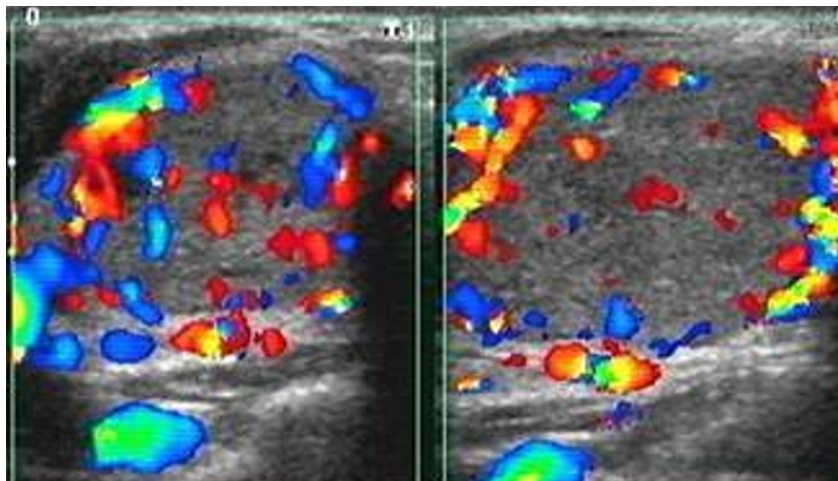


Figure 3: Thyroid nodule with mixed (central + peripheral) intranodular vascularity on Colour Doppler

The aim of this study was to evaluate the role of colour-assisted duplex sonography in thyroid disease, with particular emphasis on vascularity patterns across major thyroid pathologies and correlation with final diagnosis.

### Materials and Methods

**Study Design and Setting:** This was a cross-sectional study conducted in the Department of Radiodiagnosis, where cases were referred for thyroid ultrasonography as part of routine clinical care.

**Study Duration:** The study was conducted over a period of 18 months. Each case underwent ultrasound during the index visit. Where FNAC/HPE reports were pending, records were retrieved within approximately 2 weeks of the ultrasound examination.

**Participants:** Adult cases referred for thyroid ultrasonography with clinical suspicion of thyroid disease, including diffuse thyroid disease and thyroid nodules, were screened for inclusion.

**Inclusion Criteria:** Adults aged more than 18 years referred for thyroid ultrasonography with clinical suspicion of thyroid disease and willing to provide informed consent were included.

**Exclusion Criteria:** Cases with previous thyroidectomy, unwillingness for FNAC confirmation, or unwillingness for the procedure were excluded.

**Sample Size:** The final sample size was 70.

**Ultrasound and colour-assisted duplex protocol:** Thyroid ultrasound was performed using a high-frequency linear transducer, typically 7-15 MHz, on a machine with colour and spectral Doppler capability. Examination was performed in the supine position with neck extension using a pillow under the shoulders. The thyroid gland and cervical nodal stations were evaluated in transverse and longitudinal planes.

Grey-scale assessment included thyroid size, lobe dimensions, isthmus thickness, parenchymal echogenicity, echotexture, focal lesions, lesion composition, margins, echogenic foci, and cervical lymph node characteristics. Where nodules were present, TI-RADS categorization was recorded. Colour Doppler assessment included overall thyroid vascularity pattern in diffuse thyroid disease and vascularity pattern in thyroid nodules.

Spectral Doppler assessment was performed using the superior thyroid artery and/or inferior thyroid artery where visible, with angle correction  $\leq 60^\circ$  wherever possible. Peak systolic velocity, end-diastolic velocity, and resistive index were recorded, and at least three consistent waveforms were averaged for analysis.

**Reference Standard:** Final diagnosis was correlated with available clinical and laboratory data, along with FNAC and histopathological findings where available as part of routine care. No invasive procedure was performed solely for the study.

**Outcome Measures:** The primary outcome was assessment of the usefulness of colour and spectral Doppler parameters in the evaluation of thyroid diseases in routine practice. Secondary outcomes were description of typical duplex patterns across common thyroid disorders and correlation of duplex findings with FNAC and histopathological findings where available.

**Statistical Analysis:** Data were entered into Microsoft Excel and analysed using SPSS version 26. Continuous variables were presented as mean  $\pm$  SD or median depending on distribution. Categorical variables were presented as frequencies and percentages. Group comparisons were performed using Student's t-test or Mann-Whitney U test for continuous variables and chi-square or Fisher's exact test for categorical variables. ROC analysis was used where required to explore cut-offs for PSV/RI. A p value of  $<0.05$  was considered statistically significant.

**Ethical considerations:** The study was conducted after approval from the Institutional Ethics Committee. Written informed consent was obtained. Patient confidentiality was maintained throughout the study.

### Results

Baseline demographic and clinicopathological characteristics: A total of 70 thyroid lesions were evaluated. The age range was 21-75 years, with a mean age of  $44.8 \pm 13.3$  years and a median age of 43.5 years. Female cases predominated, accounting for 58 of 70 cases (82.9%). Papillary thyroid carcinoma was the most common individual diagnosis.

**Table 1: Baseline demographic and clinicopathological characteristics of the study population**

Variable	Value
Total thyroid lesions studied	70
Age range, years	21-75
Mean age, years	44.8 ± 13.3
Median age, years	43.5
Female, n (%)	58 (82.9)
Male, n (%)	12 (17.1)
Benign/non-malignant lesions, n (%)	49 (70.0)
Malignant lesions, n (%)	21 (30.0)
Most common individual diagnosis	Papillary thyroid carcinoma, 19 (27.1)

**Histopathological spectrum:** Histopathological examination showed a broad spectrum of lesions. Papillary thyroid carcinoma was identified in 19 lesions (27.1%). Among benign lesions, colloid

goitre was the most frequent diagnosis in 11 lesions (15.7%), followed by nodular goitre in 9 (12.9%), Hashimoto’s thyroiditis in 7 (10.0%), and multinodular goitre in 6 (8.6%).

**Table 2: Histopathological profile of thyroid lesions**

Diagnosis	n (%)
Papillary thyroid carcinoma	19 (27.1)
Colloid goitre	11 (15.7)
Nodular goitre	9 (12.9)
Hashimoto’s thyroiditis	7 (10.0)
Multinodular goitre	6 (8.6)
Other lesions	18 (25.7)
Total	70 (100.0)

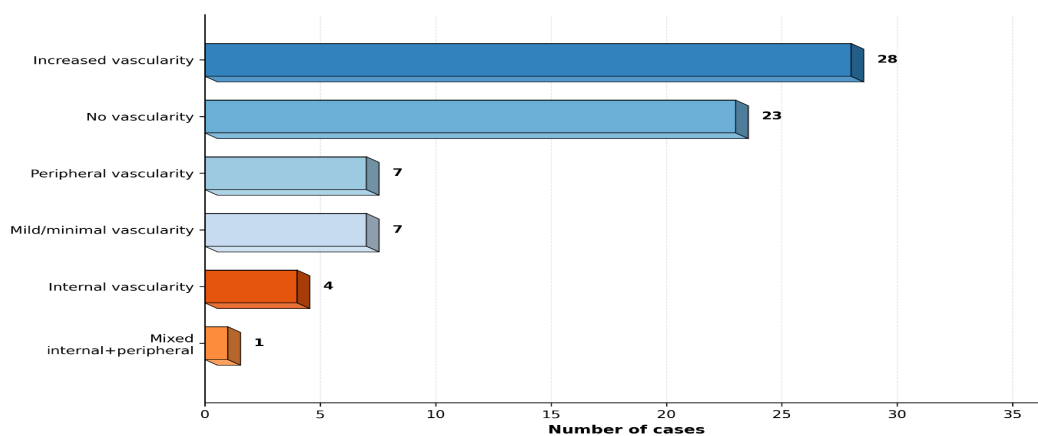
**Overall Doppler vascularity pattern:** On Doppler evaluation, increased vascularity was the most frequent overall pattern, observed in 28 lesions (40.0%), and followed by no vascularity in 23 lesions (32.9%). Peripheral vascularity and

mild/minimal vascularity were each seen in 7 lesions (10.0%).

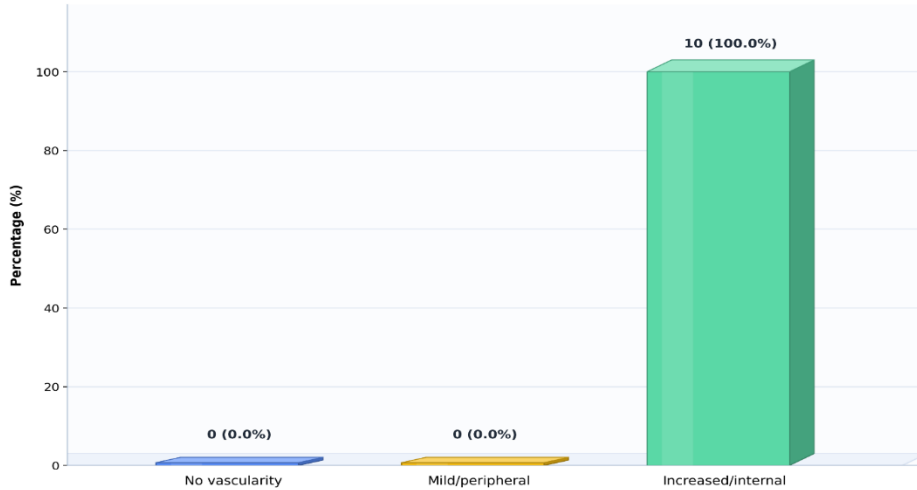
Internal vascularity was observed in 4 lesions (5.7%), and mixed internal plus peripheral vascularity in 1 lesion (1.4%).

**Table 3: Overall Doppler colour flow pattern of thyroid lesions**

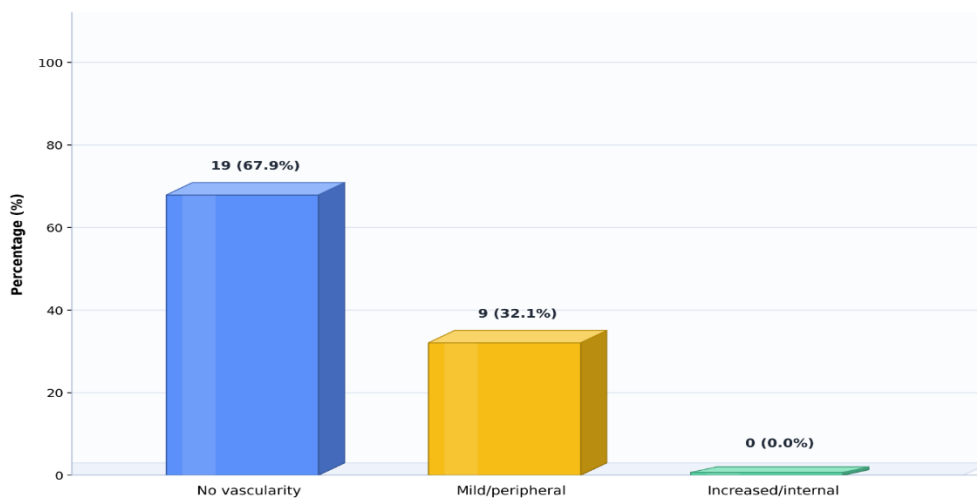
Doppler colour flow pattern	n (%)
Increased vascularity	28 (40.0)
No vascularity	23 (32.9)
Peripheral vascularity	7 (10.0)
Mild/minimal vascularity	7 (10.0)
Internal vascularity	4 (5.7)
Mixed internal + peripheral vascularity	1 (1.4)
Total	70 (100.0)



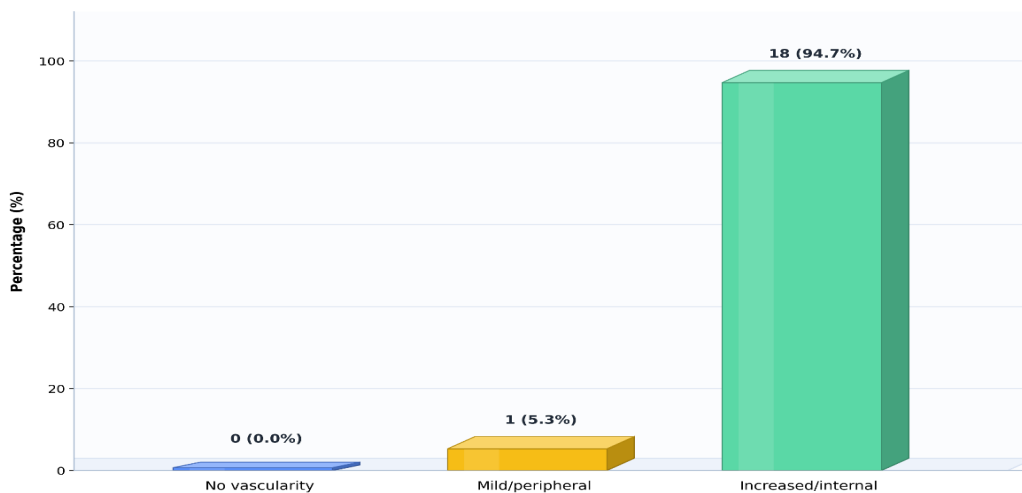
**Figure 4: Distribution of thyroid lesions according to Doppler colour flow pattern.**



**Figure 5: Distribution of Doppler vascularity in inflammatory thyroid lesions.**



**Figure 6: Distribution of Doppler vascularity in common benign nodular and goitrous lesions.**



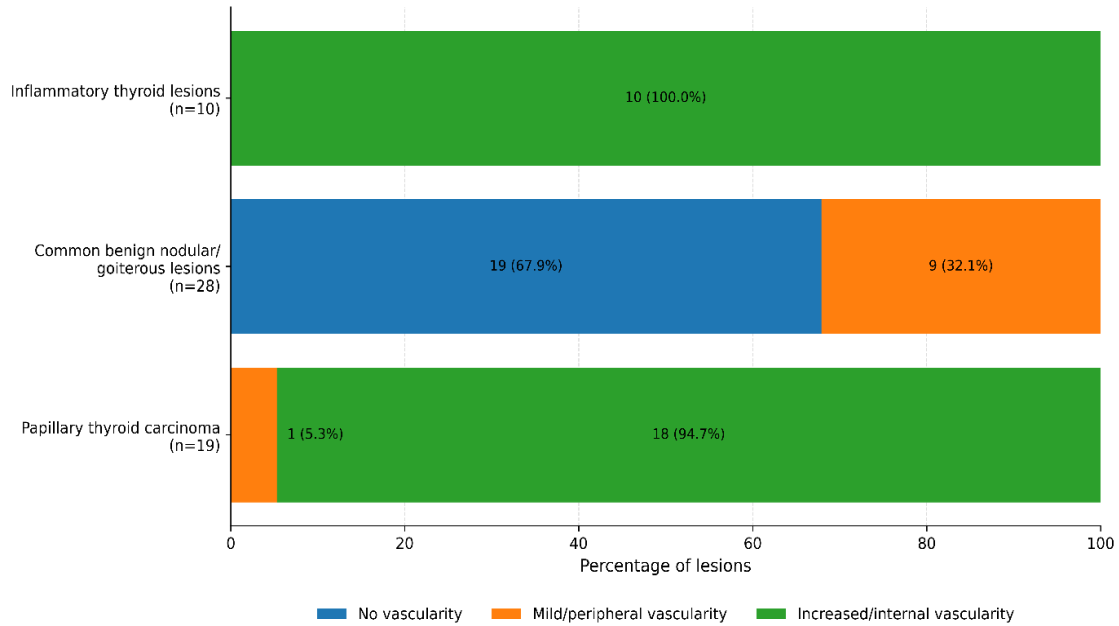
**Figure 7: Distribution of Doppler vascularity in papillary thyroid carcinoma.**

**Disease-wise vascularity pattern:** When vascularity was grouped as no vascularity, mild/peripheral vascularity, and increased/internal vascularity, distinct disease-wise differences were observed. All inflammatory thyroid lesions showed

increased/internal vascularity. Common benign nodular and goitrous lesions showed either no vascularity or mild/peripheral vascularity, whereas papillary thyroid carcinoma showed predominantly increased/internal vascularity.

**Table 4: Disease-wise distribution of Doppler vascularity in major histopathologically proven thyroid lesions**

Histopathological group	Total cases	No vascularity n (%)	Mild/peripheral vascularity n (%)	Increased/internal vascularity n (%)
Inflammatory thyroid lesions	10	0 (0.0)	0 (0.0)	10 (100.0)
Common benign nodular/goitrous lesions	28	19 (67.9)	9 (32.1)	0 (0.0)
Papillary thyroid carcinoma	19	0 (0.0)	1 (5.3)	18 (94.7)



**Figure 8: Disease-wise distribution of Doppler vascularity in major thyroid lesion groups.**

Internal/increased vascularity was present in 14 of 49 benign/non-malignant lesions (28.6%) and 19 of 21 malignant lesions (90.5%), whereas no/peripheral/minimal vascularity was seen in 35 of 49 benign/non-malignant lesions (71.4%) and 2 of 21 malignant lesions (9.5%). This association was statistically significant ( $p < 0.001$ ).

**Discussion**

**Principal findings:** This study showed that colour-assisted duplex sonography provided useful additional information in the evaluation of thyroid lesions. The study population was predominantly female and middle-aged. Papillary thyroid carcinoma was the most common individual diagnosis.

The principal finding was the clear variation in Doppler vascularity across major thyroid pathologies. Inflammatory thyroid lesions and papillary thyroid carcinoma were predominantly associated with increased/internal vascularity, whereas benign nodular and goitrous lesions were mainly associated with absent or mild/peripheral vascularity.

**Comparison with previous studies:** The demographic pattern observed in this study is

consistent with previous thyroid imaging studies showing female predominance and frequent occurrence in middle-aged adults. [6,8] papillary thyroid carcinoma was the most common malignant lesion, in keeping with previous thyroid nodule cohorts. [6,10]

The vascularity findings are also in broad agreement with previous reports. Tripura et al. and Palaniappan et al. reported that central or intranodular vascularity was more frequently associated with malignant thyroid nodules, whereas peripheral vascularity was more often associated with benign lesions. [6,8] Khadra et al. further emphasized that vascularity may increase suspicion for malignancy but should not be used in isolation. [9] In the present series, papillary thyroid carcinoma showed increased/internal vascularity in 94.7% of cases, while common benign nodular and goitrous lesions showed no increased/internal vascularity.

In inflammatory thyroid disease, Donkol demonstrated altered thyroid blood flow patterns in thyrotoxicosis, while Sarangi et al. and Li et al. showed the diagnostic value of thyroid arterial Doppler parameters in differentiating Graves' disease from destructive thyrotoxicosis. [3-5]

Although lesion-wise spectral Doppler outcomes were not analysed separately in the final results narrative, all inflammatory thyroid lesions in this study demonstrated increased/internal vascularity, supporting the value of Doppler assessment in diffuse inflammatory thyroid pathology.

**Clinical interpretation:** The present findings support the role of colour Doppler as an adjunct rather than a stand-alone diagnostic tool. Increased/internal vascularity may strengthen suspicion for malignancy in nodular lesions, particularly papillary thyroid carcinoma, but the same broad pattern may also occur in inflammatory thyroid lesions. Consequently, Doppler vascularity should always be interpreted together with grey-scale morphology and pathological correlation. This integrated approach is particularly relevant in routine practice, where imaging guides the decision to observe, sample, or escalate management. Previous work integrating Doppler with structured thyroid ultrasound assessment has also suggested improved risk stratification and more rational use of FNAC. [7,10]

**Strengths and Limitations:** A strength of this study is the inclusion of a broad histopathological spectrum of thyroid lesions with disease-wise assessment of Doppler vascularity. Correlation with final diagnosis enhances the clinical relevance of the imaging findings.

The study also has limitations. It was conducted at a single centre and included a relatively small sample. Several histopathological subgroups were represented by only a few lesions, limiting lesion-specific comparison. Ultrasound and Doppler are operator-dependent techniques, and variation in image acquisition and interpretation remains possible despite a standardized protocol.

### Conclusion

Colour-assisted duplex sonography is a useful imaging adjunct in the evaluation of thyroid disease. Distinct vascularity patterns were observed across inflammatory thyroid lesions, benign nodular/goitrous lesions, and papillary thyroid carcinoma. Increased/internal vascularity was common in papillary thyroid carcinoma but was also consistently present in inflammatory lesions, indicating that this feature is not specific for malignancy. The greatest diagnostic value of duplex sonography lies in combined interpretation of vascularity and grey-scale morphology rather than reliance on any single imaging feature.

### Declarations

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### Author contributions:

Dr. Tushar Malik contributed to study conceptualization, data collection, image acquisition, data analysis, and manuscript drafting.

Dr. Shankar Snehit Patil contributed to study supervision, methodological guidance, and interpretation of findings and critical revision of the manuscript.

### Ethics approval and consent to participate:

Institutional Ethics Committee approval was obtained. Written informed consent was obtained from all patients.

**Consent for publication:** Written informed consent was obtained from all patients. No identifying personal information has been included in this manuscript.

**Availability of data and materials:** The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

### References

1. Chung J. Clinical applications of Doppler ultrasonography for thyroid disease. *Ultrasonography*. 2020;39(2):89-97.
2. Chaudhary V, Bano S. Thyroid ultrasound. *Indian J Endocrinol Metab*. 2013;17(2):219-27.
3. Donkol RH. Role of Colour Doppler in differentiation of Graves' disease and thyroiditis. *Indian J Radiol Imaging*. 2013;23(4):302-7.
4. Sarangi PK, Sahoo AK, Pattnaik K. Diagnostic utility of mean peak systolic velocity of superior thyroid artery in Graves' disease and thyroiditis. *Indian J Radiol Imaging*. 2021;31(4):1088-95.
5. Li S, Li X, Wang Y, et al. A meta-analysis: diagnostic thresholds of peak systolic flow velocities in thyroid arteries to discriminate Graves' disease from destructive thyrotoxicosis. *Front Endocrinol (Lausanne)*. 2024; 15:1393126.
6. Tripura NG, Manna A, Mallik I, Samanta A. Role of ultrasonography and Colour Doppler in the evaluation of thyroid nodules: a cross-sectional study. *Cureus*. 2024;16(2):e54002.
7. Alamdaran SA, Azadeh M, Aghaei A, Naghizadeh MM, Heidari F. Diagnostic value of colour Doppler ultrasonography in distinguishing benign and malignant thyroid nodules. *J Med Radiat Sci*. 2024;71(3):291-300.
8. Palaniappan MK, Aiyappan SK, Ranga U. Role of grey scale, Colour Doppler and spectral Doppler in distinguishing malignant

- and benign thyroid nodules. J Clin Diagn Res. 2016;10(8):TC01-TC06.
9. Khadra H, Bakeer M, Arbid E. Is vascular flow a predictor of malignant thyroid nodules? A review. Gland Surg. 2016;5(6):576-82.
  10. Srinivas MNS, Amogh VN, Gautam MS, et al. Prospective evaluation of TI-RADS with Greyscale and Doppler in thyroid lesions. J Clin Imaging Sci. 2016; 6:5.