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Research Article

ROLE OF ULTRASONOGRAPHY IN DIFFERENTIATING BENIGN AND MALIGNANT THYROID NODULES: CORRELATION WITH FINE NEEDLE ASPIRATION CYTOLOGY

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Abstract

Background: Thyroid nodules are most frequently encountered in clinical practice. Thyroid nodules are abnormal growths of thyroid cells that form masses within the thyroid gland. Although the majority are benign, differentiating malignant from benign nodules is essential for appropriate management, to avoid unnecessary invasive procedures and to avoid deaths. High-resolution ultrasonography (USG) is the primary imaging modality for the evaluation of thyroid nodules because of its accessibility, non-invasive nature, lack of ionizing radiation and ability to identify sonographic features suggestive of malignancy. Fine Needle Aspiration Cytology (FNAC) remains the reference standard for preoperative diagnosis.

Objective: To evaluate the role of ultrasonography in differentiating benign and malignant thyroid nodules using FNAC as the reference standard.

Materials and Methods: This prospective observational study was conducted in the Department of Radio Diagnosis, Kidwai Memorial Institute of Oncology, Bengaluru,
over a period of two years from December 2020 to December 2022. A total of 100 patients with thyroid nodules detected clinically or on imaging were included. All patients underwent high-resolution ultrasonography using a high-frequency linear transducer, followed by FNAC for cytopathological confirmation. Sonographic features including composition, echogenicity, margins, shape, calcifications, vascularity, and associated cervical lymphadenopathy were evaluated.

Results: Among the 100 thyroid nodules evaluated, 53(53%) were benign and 47(47%) were malignant on FNAC. Benign nodules were commonly associated with mixed solid-cystic composition, smooth margins, iso echogenicity, and wider-than-tall shape. Malignant nodules predominantly demonstrated solid composition, hypoechogenicity, irregular margins, micro calcifications, taller-than-wide shape, and suspicious cervical lymphadenopathy. Ultrasonographic findings showed good correlation with FNAC in differentiating benign and malignant thyroid nodules.

Conclusion: High-resolution ultrasonography is an effective first-line imaging modality for the evaluation of thyroid nodules. Characteristic sonographic features correlate well with FNAC findings and aid in distinguishing benign from malignant thyroid nodules, thereby facilitating appropriate clinical management.

Keywords: Thyroid nodule, Ultrasonography, Fine Needle Aspiration Cytology, Thyroid malignancy, Cytopathology.

INTRODUCTION

Thyroid nodule is any lesion in the thyroid gland that is discrete and is radiologically distinct from the surrounding thyroid parenchyma [(1).]. Thyroid nodules (TNs) are abnormal growths of thyroid cells that form solid, fluid-filled, or mixed masses within the thyroid gland. TNs are common and are found in 20% to 76% of the population [(2).] Nodular thyroid disease is detected in 3-7% of the adult population worldwide. They are common in females with a ratio of 5:1 and prevalence mainly depends on the age, gender, iodine intake, diet (goitrogens), therapeutic and environmental exposure. The majority of these cases are clinically occult but readily detected by high-resolution ultrasonography (USG)[(3,4)]. The widespread use of high-resolution ultrasonography has resulted in increased detection of palpable as well as incidental thyroid nodules. Gray-scale ultrasonography (GSU) imaging features of TNs are reliable in differentiating benign from malignant nodules [(2,5)].

High-resolution ultrasonography is the imaging modality of choice for the initial evaluation of thyroid nodules because it is non-invasive, readily available, cost-effective, and free from ionizing radiation. It provides detailed information regarding the morphology of thyroid nodules, including size, composition, echogenicity, margins, shape, calcifications, vascularity, and cervical lymph node status. These sonographic characteristics play an important role in estimating the risk of malignancy and selecting nodules for further cytological evaluation [(6)].

Several ultrasonographic features have been reported to be associated with thyroid malignancy. Solid composition, marked hypo echogenicity, irregular or lobulated margins, microcalcifications, taller-than-wide shape, and suspicious cervical lymphadenopathy are considered important predictors of malignant disease [(7)]. Conversely, purely cystic or predominantly cystic nodules, spongiform appearance, smooth margins, wider-than-tall configuration, and comet-tail artefacts are more commonly associated with benign lesions[(8)]. However, no single ultrasonographic feature is sufficiently accurate to reliably distinguish benign from malignant thyroid nodules, making cytological confirmation necessary [(9)].

Fine Needle Aspiration Cytology (FNAC) is considered the reference standard for the preoperative evaluation of thyroid nodules because of its high diagnostic accuracy, simplicity, safety, and cost-effectiveness [(10)]. It has significantly reduced unnecessary thyroid surgeries by reliably differentiating benign from malignant lesions. However, FNAC is an invasive procedure and may occasionally yield non-diagnostic or indeterminate results due to sampling limitations [(11)]. Therefore, careful ultrasonographic assessment remains essential for selecting appropriate nodules for biopsy and improving diagnostic yield.

Correlation of ultrasonographic findings with FNAC enhances diagnostic confidence and facilitates appropriate management of patients with thyroid nodules. Identification of suspicious ultrasound features enables early detection of thyroid malignancy while minimizing unnecessary invasive procedures in patients with benign disease [(12)].

The present study was undertaken to evaluate the role of ultrasonography in differentiating benign and malignant thyroid nodules by correlating sonographic findings with Fine Needle Aspiration Cytology in patients presenting with thyroid nodules at a tertiary care oncology centre.

The aim of this study is to evaluate the role of ultrasonography in differentiating benign and malignant thyroid nodules using Fine Needle Aspiration Cytology as the reference standard.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Radiodiagnosis, Kidwai Memorial Institute of Oncology, Bengaluru, from December 2020 to December 2022, after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants.

A total of 100 patients with clinically palpable thyroid swellings or thyroid nodules detected on imaging were included in the study. Patients were referred from various clinical departments for ultrasonographic evaluation. All patients underwent detailed clinical examination and relevant laboratory investigations as advised by the treating physician.

INCLUSION CRITERIA

1. Patients with thyroid nodules detected clinically and on ultrasonography.
2. Patients who underwent ultrasound evaluation followed by FNAC.
3. Patients with complete ultrasound imaging and cytological records.

EXCLUSION CRITERIA

1. Patient with thyroid nodule who is refusing for USG guided FNAC.
2. Post-surgical cases.
3. Post Radiotherapy.
4. Inconclusive /unsatisfactory histopathology report.
5. Diffuse thyroid disease.

Ultrasonography of the thyroid was performed using a GE logic P9 ultrasound machine equipped with a 4-12 MHz high-frequency linear-array transducer. Patients were examined in the supine position with the neck extended. Both thyroid lobes, the isthmus, and cervical lymph nodes were evaluated in longitudinal and transverse planes.

The following sonographic features were assessed for each thyroid nodule:

* Number of nodules (solitary/multiple)
* Composition (solid, cystic, or mixed)
* Echogenicity
* Margins
* Shape
* Calcifications
* Presence of cervical lymphadenopathy

Following ultrasonographic evaluation, Fine Needle Aspiration Cytology (FNAC) was performed under aseptic precautions in all patients. Cytological findings were considered the reference standard for diagnosis. Ultrasonographic findings were correlated with FNAC results to differentiate benign from malignant thyroid nodule

s.

RESULTS

AGE DISTRIBUTION:

Our study group included patients between 12 and 75 years of age. The mean age of presentation was 50.16 years. The most common age group affected belonged to 41-50 years (30%) and the least common age group affected was 71-80 years (6%) (Table 1).

TABLE 1: DISTRIBUTION OF THYROID NODULES ACCORDING TO AGE GROUP

AGE RANGE	BENIGN	MALIGNANT	TOTAL
0-30	4	8	12
31-40	5	7	12

41-50	15	14	29
51-60	16	7	23
61-70	10	8	18
>70	3	3	6
Grand Total	**53**	**47**	**100**

Maximum benign nodules were observed between 51 – 60 years of age (16%).

Maximum malignant nodules were observed between 41 – 50 years of age(15%). Least number of benign nodules were noted in< 30 years and > 70 years age (3 each of 53 benign nodules) and least number of malignant nodules were noted in >70 years age (3 out of 47 malignant nodules).

GENDER DISTRIBUTION:

Our study included a total of 100 patients of which 79% (N=79) were females and 21% (N=21) were males.

Of the 79 nodules in female patients, 47 nodules were benign and 32 nodules were malignant. Out of the 21 nodules diagnosed in male patients 6 were benign and 15 were malignant on FNAC. Overall, 89 % of benign nodules were seen in female patients and 11 % in males. Among the malignant nodules, 68 % were seen in females and 32 % were seen in males. However, the frequency of malignant nodules occurring in male individuals was higher compared to females. In females, about 59% of nodules were benign and 41 % were malignant. Whereas in males about 29% of nodules were benign and 71% were malignant.

ULTRASONOGRAPHIC FINDINGS

Benign thyroid nodules commonly demonstrated mixed solid-cystic composition, iso echogenicity, smooth margins, and a wider-than-tall configuration. In contrast, malignant nodules were predominantly solid, hypoechoic, exhibited irregular or lobulated margins, microcalcifications, and a taller-than-wide shape. Suspicious cervical lymphadenopathy was more frequently associated with malignant lesions. These sonographic characteristics showed a significant association with malignancy.

1. **Nodule composition**

In our study majority of the nodules had solid composition (65% of total nodules) and solid composition was more predominant in malignant nodules (Table 2). In our study, none of the completely cystic or spongiform nodules were malignant, this feature was consistent with other studies. In our study 88% (24 of 27) of the papillary carcinomas were of solid composition and rest 12 % had mixed solid cystic composition (3 of 27).

Table 2: COMPOSTION OF NODULES

COMPOSITION OF NODULES	BENIGN	MALIGNANT
MIXED	**24**	**5**
SOLID	**23**	**42**

SPONGIFORM	**6**	**0**
Grand Total	**53**	**47**

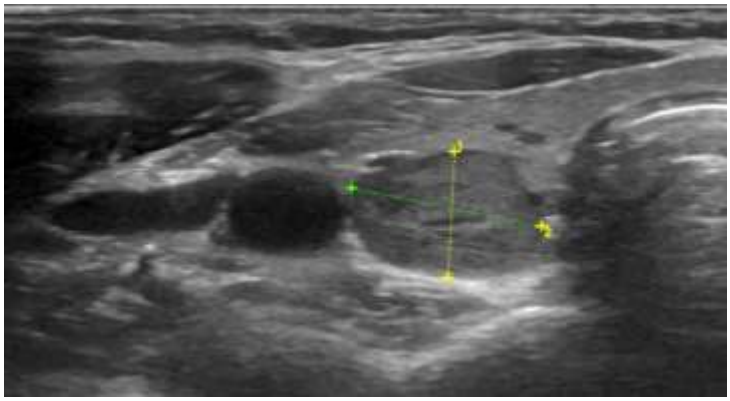


Fig 1: USG of thyroid gland shows well defined solid hypoechoic nodule in right lobe with smooth margins. FNAC proved as Follicular lesion of undetermined significance which can be follicular adenoma or carcinoma.

2. Echogenicity of the nodule:

4 descriptors are used for echogenicity of the nodule according to ACR TIRADS. A nodule can be anechoic, isoechoic, hyperechoic or hypoechoic. This echogenicity of the nodule is compared with respect to the surrounding thyroid parenchyma. In case of a very hypoechoic nodule, the echogenicity should be less than that of surrounding strap muscles.

In our study most of the anechoic, Isoechoic/hyper echoic nodules were benign mostly colloid and adenomatous nodules whereas most of hypoechoic (80%) ,very hypoechoic nodules were malignant predominantly papillary carcinomas. 36 % of benign nodules were hypoechoic. 2 cases of very hypoechoic nodules were noted in our study both were malignant(Follicular carcinoma and metastatic carcinoma). Echogenicity of the nodule also had a p value of <0.001 in our study and was significant.

Table 3: ECHOGENICITY OF NODULES

ECHOGENICITY	BENIGN	MALIGNANT	Total
ANECHOIC	1	0	1
HYPOECHOIC	20	38	58
ISOECHOIC	32	7	39
VERY HYPOECHOIC	0	2	2

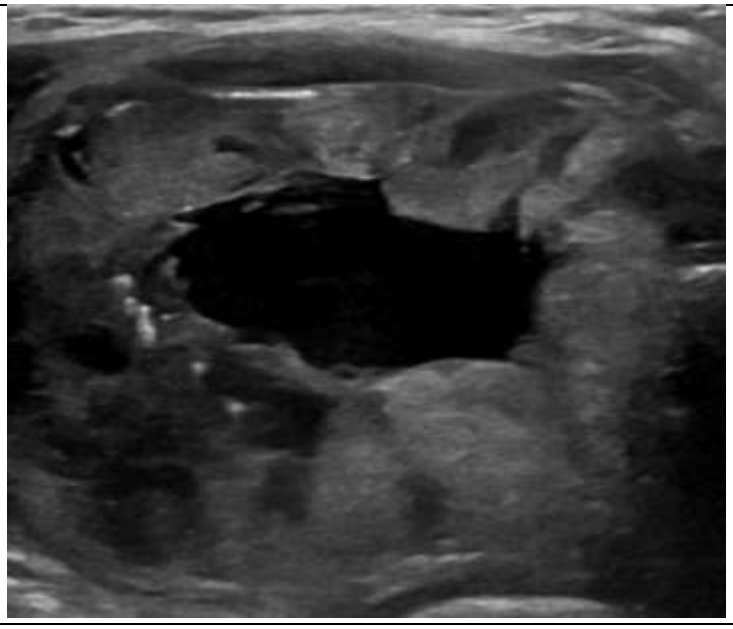
Grand Total	**53**	**47**	**100**

3. Shape of the nodule:

In ACR TIRADS two descriptors were included under shape of the nodule which were either wider than tall or taller than wide where as in K TIARDS non parallel orientation/ taller than wider shape is one of 3 suspicious features. In our study 96 of 100 nodules were wider than taller where as 4 of 100 nodules were taller than wide. In our study All 4 taller than wider nodules were malignant which is similar to study conducted by Shi et al[69] and chen et al [11]. This implies that taller than wide is very specific descriptor for a malignant nodule.

Table 4: SHAPE OF NODULES

SHAPE OF THE NODULE	BENIGN	MALIGNANT	Grand Total
TALLER THAN WIDE NODULE	0	4	4
WIDER THAN TALL NODULE	53	43	96
Grand Total	**53**	**47**	**100**



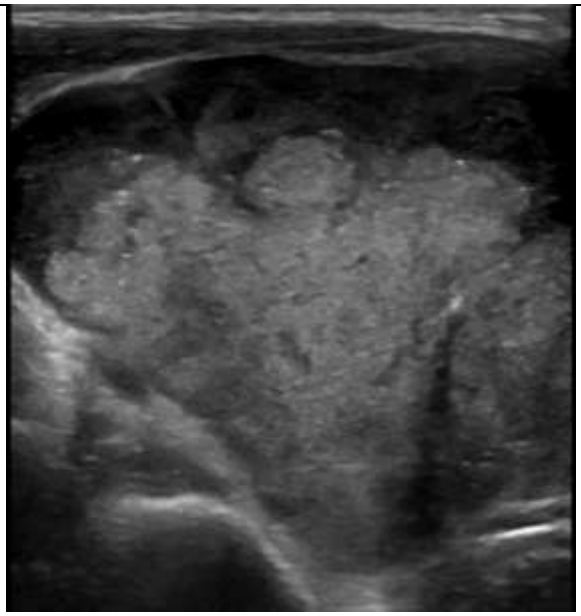


Fig 2: USG of thyroid gland showing well defined wider than taller solid cystic nodule in with smooth margins in right lobe with comet tail artefacts .FNAC proved as colloid nodule.	**Fig 3: USG of thyroid gland shows ill defined irregular solid hypoechoic taller than wider nodule in right lobe with micro calcifications. FNAC proved as Papillary carcinoma of thyroid.**

4. Margin of the nodule:

In ACR TIRADS 2017, the descriptors for margin include - Smooth, ill defined, lobulated/ irregular and extra-thyroid extension .In our study most of the benign nodules (52.8%) showed smooth margins. Whereas 30 out of 47 nodules with irregular/ lobulated margin belonged to malignant group (Table 4). Most of the nodules with irregular/lobulated margins were papillary carcinomas. Five nodules demonstrated extra thyroid extension and all of them were malignant (3 papillary carcinoma, 1 each of medullary and follicular carcinoma) (Figure 4). The extrathyroidal extension may represent aggressive nature of tumour, local spread, long standing tumour with late presentation.

Table 5: MARGIN OF NODULES

MARGINS	BENIGN	MALIGNANT	Total
EXTRATHYROIDAL	0	5	5
ILLDEFINED	20	6	26
LOBULATED / IRREGULAR	5	30	35
SMOOTH	28	6	34
Grand Total	**53**	**47**	**100**

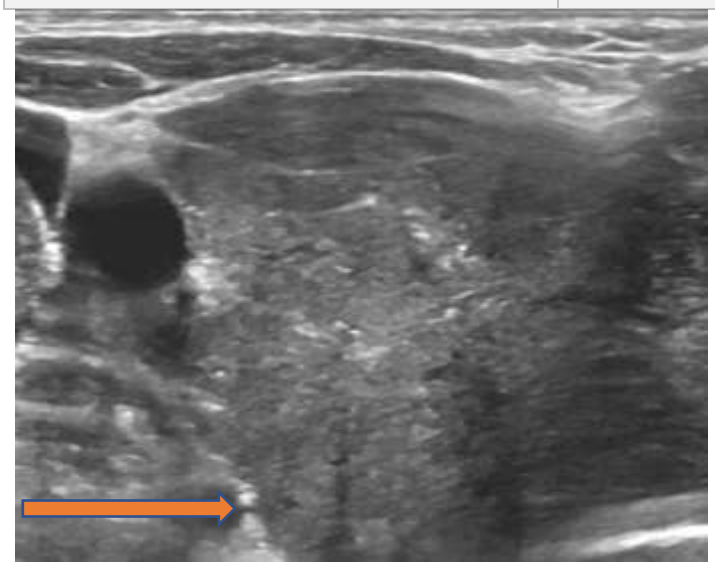


Fig 4: USG of thyroid gland shows ill-defined irregular solid hypoechoic nodule in right lobe withmicrocalcifications and extrathyroidal extensions. FNAC proved as Medullary carcinoma of thyroid.

5. Echogenic Foci

Various types of calcification include punctate micro calcification, macrocalcification ,peripheral rim calcification and comet tail artefacts .Microcalcification refers to calcifications <1mm, most often round calcifications, may have small comet tail artefacts.[56] In ACR TIRADS microcalcification has a score of 3 where as in K TIRADS micro calcification is one of suspicious feature .In our study comet tail artefact was a feature of benign nodule mainly colloid nodule where as punctate echogenic foci/ microcalcifications was found to be more in favour of malignancy. Only 6 out of 53 benign nodules had microcalcifications. Whereas, 26 out of 47 malignant nodules had microcalcification. Of these, majority of the nodules were proven to be papillary carcinoma, one nodule each belonged to follicular carcinoma and medullary carcinoma. Remaining 6 out of 30 nodules with microcalcifications, 3 were colloid nodules, 2 were adenomatous nodule and 1 was follicular adenoma.

Table 6: CALCIFICATIONS IN NODULES

CALCIFICATION	BENIGN	MALIGNANT	TOTAL
COMET TAIL	8	0	8
MACROCALCIFICATION	4	3	7
NONE	35	18	53
PUNCTATE MICROCALCIFICATION	6	26	32
Grand Total	53	47	100

6. Correlation of Ultrasonography with FNAC

FNAC revealed 53 (53%) benign and 47 (47%) malignant thyroid nodules. Benign lesions were more common than malignant lesions in the study population (Table 6).

Ultrasonographic findings showed good correlation with FNAC in differentiating benign from malignant thyroid nodules. Sonographic features such as solid composition, hypo echogenicity, irregular margins, microcalcifications, taller-than-wide shape, and cervical lymphadenopathy were more frequently associated with malignant lesions, whereas mixed cystic-solid composition, smooth margins, and iso echogenicity were predominantly observed in benign nodules.

Table 7: CORRELATION OF ULTRASONOGRAPHY WITH FNAC

	FNAC (Malignant)	FNAC (Benign)	Total

ULTRASOUND (Malignant)	45	21	66
ULTRASOUND (Benign)	2	32	34
Total	47	53	100

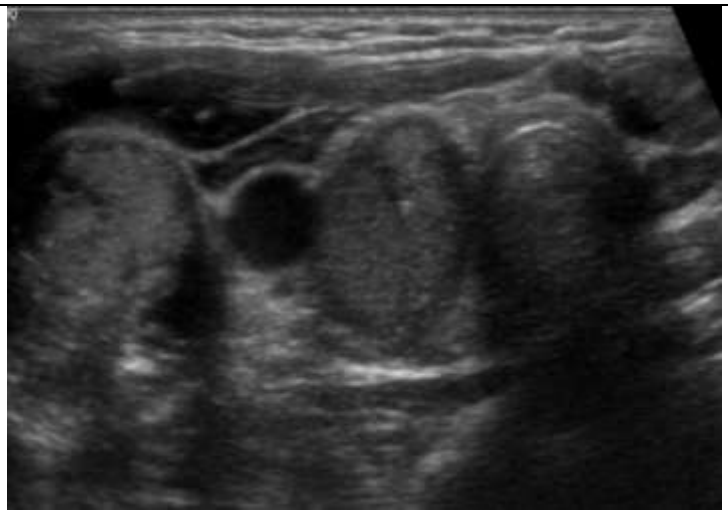


Fig 5: USG showing a solid, hypoechoic nodule, with irregular margins and punctate microcalcifications causing acoustic shadowing-highly suspicious for malignancy on USG. FNAC – Papillary carcinoma.

DISCUSSION

In the present study, patients ranged from 12 to 75 years of age, with a mean age of 50.16 years. The highest number of patients belonged to the 41-50 years age group. Maximum benign nodules were observed between 51 – 60 years of age (16%). Maximum malignant nodules were observed between 41 – 50 years of age (15%). Kalyan Sekhar et al [13] in their study majority of the patients were among 30-45 years and the next common age group was among 15-30 years. In the study by Bairi et al [14] the maximum number of cases were seen in the age group of 31-40 years and 41-50 years.

A marked female predominance (79%) was observed in the present study, with a female-to-male ratio of 3.7:1. Similar female predominance has been reported by Kalyan Sekhar et al [13] with majority of the patients being female at 66.6% compared to males 33.3 %. Sharma et al [15] in their study observed a marked female preponderance with 118 females and 20 males.

Most thyroid nodules in the present study were solid, and solid composition was more frequently associated with malignant lesions. None of the spongiform or completely cystic nodules were malignant. Among benign lesions, mixed solid-cystic nodules were the predominant pattern.

Regarding echogenicity, the majority of hypoechoic and markedly hypoechoic nodules were malignant, whereas most isoechoic and hyperechoic nodules were benign. Similar observations have been reported in previous studies, where hypo echogenicity was consistently identified as a significant predictor of thyroid malignancy. In the study by Kalyan Sekhar et al [13] all the malignant nodules were profoundly hypoechoic with the absence of well-defined peripheral halo.

Irregular or lobulated margins, microcalcifications, taller-than-wide configuration, and suspicious cervical lymphadenopathy were more frequently observed in malignant nodules. Conversely, smooth margins, wider-than-tall shape, and mixed cystic composition were predominantly associated with benign lesions.

In the present study ultrasonography was able to correctly identify 45 out of 47 malignancies and 32 out of 53 benign nodules. In the study by Sharma et al [15] ultrasonography was able to correctly identify 10 out of 14 malignancies and 118 out of 124 benign nodules, which correlated well with the findings of the present study.

Correlation of ultrasonographic findings with FNAC demonstrated that characteristic ultrasound features can reliably differentiate benign from malignant thyroid nodules and aid in selecting patients requiring cytological evaluation. Ultrasonography is non-invasive, widely available, and provides valuable pre-procedural information, thereby reducing unnecessary invasive investigations in patients with benign thyroid disease.

The present study had certain limitations. The sample size was relatively small, a few benign-appearing nodules with unavailable cytological diagnosis after repeat aspiration were excluded, and histopathological confirmation was not available for all cases. Furthermore, as the study was conducted at a tertiary oncology referral centre, the proportion of malignant nodules was higher than that expected in the general population, which may limit the generalisability of the findings.

CONCLUSION

High-resolution ultrasonography is a valuable first-line imaging modality for the evaluation of thyroid nodules. Sonographic features such as solid composition, hypoechogenicity, irregular or lobulated margins, microcalcifications, taller-than-wide shape, and suspicious cervical lymphadenopathy were more frequently associated with malignant thyroid nodules, whereas mixed solid-cystic composition, iso echogenicity, smooth margins, and wider-than-tall configuration were commonly observed in benign lesions.

The present study demonstrated good correlation between ultrasonographic findings and Fine Needle Aspiration Cytology, supporting the role of ultrasonography in differentiating benign from malignant thyroid nodules. Careful assessment of sonographic characteristics can aid in identifying nodules requiring FNAC, thereby facilitating early diagnosis, appropriate clinical management, and reducing unnecessary invasive procedures in patients with benign thyroid disease.

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