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Original Research Article

# Correlation between Thyroid Imaging Reporting and Data System (TIRADS) and Bethesda System for Reporting Thyroid Cytopathology in Patients with Thyroid Lesions

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**Abstract**

Thyroid nodules are a common clinical entity, with benign lesions far outnumbering malignant ones, yet the primary challenge in clinical practice lies in reliably distinguishing benign from malignant nodules. The Thyroid Imaging Reporting and Data System (TIRADS) provides a standardized ultrasonographic risk stratification framework, while the Bethesda System for Reporting Thyroid Cytopathology offers a uniform cytological classification and malignancy risk estimate. This record-based cross-sectional study conducted in the Department of Pathology, S.P. Medical College, Bikaner, from March 2024 to February 2026, evaluated the correlation between TIRADS categories and Bethesda cytological categories in patients with thyroid nodules who underwent fine-needle aspiration cytology (FNAC). A total of 100 consecutive FNAC cases of thyroid lesions with prior radiological TIRADS scoring were included. Demographic data, ultrasonographic TIRADS category, Bethesda cytology category, and detailed cytological diagnosis were extracted from records and analyzed using standard descriptive statistics and Chi-square test. The majority of nodules were TIRADS 2 (63%) and Bethesda II (82%), indicating a predominance of radiologically and cytologically benign lesions. Malignancy (Bethesda V and VI) was present in 10% of cases overall, with malignancy rates of 75% and 100% in TIRADS 4 and TIRADS 5 categories respectively. A highly significant association was observed between TIRADS and Bethesda categories ($\chi^2 = 183.21$, df = 16, $p < 0.001$), with complete concordance in TIRADS 1, 2, 4, and 5 categories and reduced concordance (70%) in TIRADS 3. The findings demonstrate that TIRADS is a reliable non-invasive tool for risk stratification of thyroid nodules and shows strong correlation with cytological outcomes, particularly at the extremes of risk. TIRADS 1 and 2 nodules can be managed conservatively in most cases, whereas TIRADS 4 and 5 nodules warrant aggressive diagnostic and therapeutic interventions. TIRADS 3 lesions remain a diagnostically heterogeneous group requiring close correlation with FNAC. A combined approach using both TIRADS and Bethesda systems optimizes diagnostic accuracy and supports rational, evidence-based management of thyroid nodules.

**Keywords:** Cytology, Thyroid Nodules, Bethesda System, TIRADS.

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## Introduction

Thyroid nodules are frequently encountered in routine clinical practice, with an incidence of 4–7% on palpation and a much higher prevalence of 50–60% when assessed by ultrasonography.[1] The widespread availability and utilization of imaging modalities have led to increased detection of non-palpable thyroid nodules, many of which are incidentally identified. Although the majority of thyroid nodules are benign, the key clinical concern is to reliably exclude or confirm malignancy to avoid unnecessary surgical interventions and to ensure timely treatment for malignant lesions. [2] Fine-needle aspiration (FNA) has emerged as the first-line diagnostic modality for preoperative evaluation of thyroid nodules due to its simplicity, safety, diagnostic accuracy, and cost-effectiveness. [3] The Bethesda System for Reporting Thyroid Cytopathology standardizes cytology reporting, provides defined diagnostic categories, and assigns estimated malignancy risks and management recommendations, thereby enhancing communication among clinicians and pathologists.

Parallel to cytological standardization, [4] TIRADS, initially proposed by Horvath et al., introduced an ultrasonographic risk stratification system based on nodule composition, echogenicity, margins, shape, and presence of calcifications or extrathyroidal extension. [5]

American Thyroid Association guidelines recognize Bethesda cytology categories as the standard for FNAC reporting, and the American College of Radiology endorses TIRADS for imaging-based risk stratification.[4,5] Integrating these two systems offers the potential for a robust, stepwise diagnostic pathway, where imaging guides selection of nodules for FNAC and cytology refines risk assessment and management. However, the degree of concordance between TIRADS categories and Bethesda cytological outcomes requires validation in diverse clinical settings.

The present study was undertaken to evaluate the correlation between TIRADS and Bethesda systems in patients with thyroid nodules presenting to a tertiary care center in Western India. Specifically, it assessed how ultrasonographic categories relating to malignancy risk corresponded to cytological categories, quantified concordance, and estimated malignancy rates across TIRADS strata. The findings aim to inform local clinical practice and contribute to the growing evidence base supporting integrated radiological–cytological assessment of thyroid nodules.

## Material and Methods

**Study Design and Setting:** This was a record-based cross-sectional observational study conducted in the Department of Pathology, S.P. Medical College, Bikaner, and PBM and associated group of hospitals. The study was conducted from a period of two years between 1 March 2024 to 28 February 2026.

**Study Population and Eligibility Criteria**: The study included all patients with thyroid lesions who underwent FNAC and whose smears were received in the Department of Pathology during the specified period, provided that the corresponding thyroid nodules had been categorized according to the TIRADS system on ultrasonography. FNAC smear slides, requisition forms, and medical records were used as the primary data sources.

**Inclusion criteria were:**

- Patients with thyroid nodules for whom ultrasonographic evaluation had been performed and a TIRADS score assigned.
- Availability of FNAC smears and cytology reports for those nodules.

Exclusion criteria were:

- Thyroid lesions without documented TIRADS categorization.
- Inadequate or poorly preserved FNAC specimens with significant handling artefacts.
- Autolysed or non-diagnostic smears.

A total of 100 eligible cases fulfilling the inclusion criteria were included in the analysis.

**Data Collection Procedures:** Clinical details such as age, sex, clinical presentation, and relevant history were obtained from FNAC requisition forms and patients' medical records and entered into a structured proforma. Radiological data comprising TIRADS category for each thyroid nodule were retrieved from ultrasound reports. FNAC smear slides were reviewed where necessary, and cytology reports were used to assign Bethesda categories and specific cytological diagnoses such as colloid/nodular goiter, thyroiditis, follicular lesions, suspicious for malignancy, and malignant lesions.

FNAC of thyroid nodules was performed following standard technique, typically using a Cameco syringe holder with 5–10 ml disposable syringes and needles of 22–27 gauge, under aseptic precautions. Aspirated material was spread onto 4–5 glass slides; 2–3 were wet-fixed in 95% ethanol for Haematoxylin–Eosin staining, and additional slides were prepared for special stains where indicated. Stained smears were examined under light microscopy by experienced cytopathologists and reported as per the Bethesda system.

**Variables and Operational Definitions**

- **TIRADS category:** Ultrasonographic risk stratification based on standard criteria, classified into TIRADS 1–5.
- **Bethesda category:** Cytological classification into Bethesda II (benign), III (AUS/FLUS), IV (follicular neoplasm/suspicious for follicular neoplasm), V (suspicious for malignancy), and VI (malignant).
- **Malignancy for statistical purposes:** For malignancy-rate analysis, Bethesda V and VI were grouped together as "malignant," reflecting their high risk and similar clinical management.

**Statistical Analysis:** Data were entered into Microsoft Excel and analyzed using standard descriptive statistics including frequency, percentage, mean, and standard deviation.

Age distribution, sex distribution, TIRADS categories, Bethesda categories, and cytological diagnoses were summarized in tables and graphs.

Cross-tabulation of TIRADS versus Bethesda categories was performed to evaluate distribution patterns and concordance.

The association between TIRADS and Bethesda categories was assessed using the Chi-square test, with statistical significance defined as $p < 0.05$. In this study, a Chi-square value of 183.21 with 16 degrees of freedom and $p < 0.001$ was observed, indicating a highly significant association.

Malignancy rates across TIRADS categories were calculated as the proportion of cases in each TIRADS category that were classified as Bethesda V or VI.

## Results

**Demographic Characteristics:** The study comprised 100 cases of thyroid nodules evaluated by both ultrasonography (TIRADS) and FNAC (Bethesda). The mean age of the study population was 42.33 years. The highest proportion of cases occurred in the 41–50 years age group (28%), followed by the 31–40 years group (24%), together accounting for 52% of the total study population. [Figure 1] Only 5% of cases were ≤20 years of age, and 8% were >60 years, indicating that thyroid nodules were predominantly seen in middle-aged individuals. There was a marked female predominance, with 89% of cases in females and 11% in males, corresponding to an approximate female-to-male ratio of 8:1. [Figure 2] This gender distribution was statistically significant ($\chi^2 = 60.84$, df = 1, $p < 0.0001$), highlighting increased susceptibility of females to thyroid nodules.

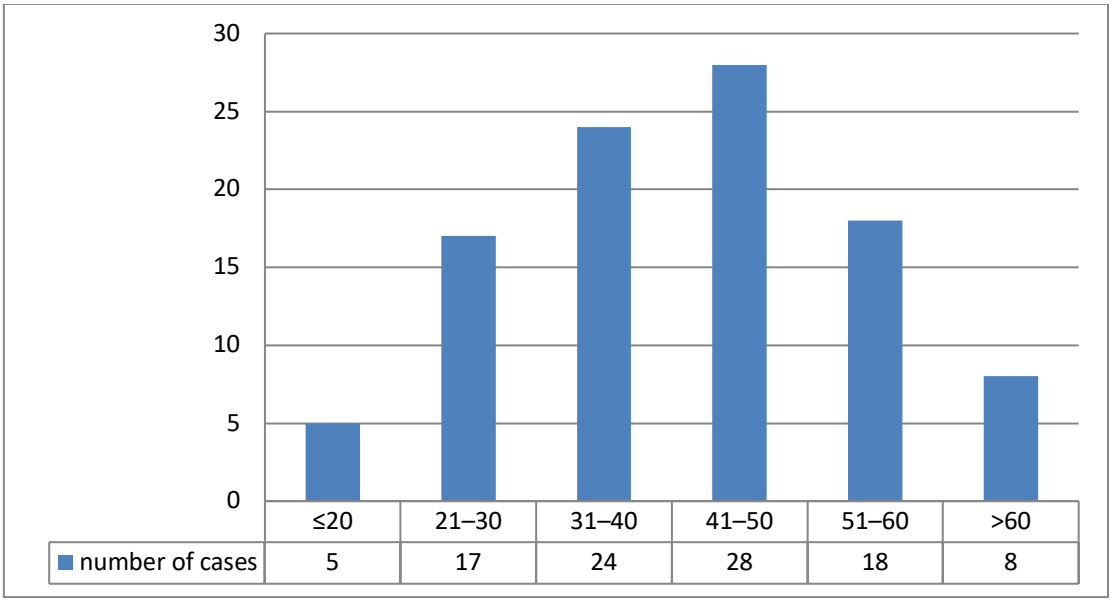


**Figure 1: Age Distribution of Study Population**

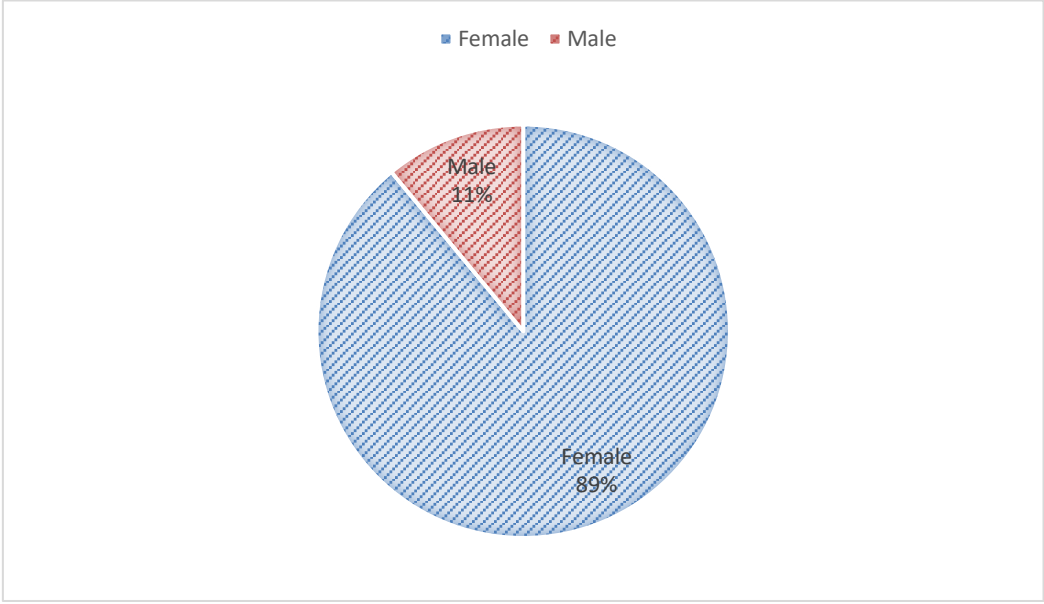


**Figure 2: Distribution of cases according to Gender**

Radiologically, the majority of thyroid nodules were classified as TIRADS 2 (63%), representing benign-appearing nodules.

TIRADS 3, denoting low-suspicion nodules, accounted for 20% of cases. Higher-risk categories were less frequent, with TIRADS 4 (intermediate suspicion) comprising 8% and TIRADS 5 (high suspicion of malignancy) comprising 4% of cases. TIRADS 1, corresponding to normal thyroid parenchyma or incidental findings, constituted 5% of the study population.

Overall, 83% of nodules fell into TIRADS 2 or 3, reflecting a predominance of radiologically low-risk lesions. [Table 1]

**Table 1: Distribution of cases according to TIRADS Categories**

| TIRADS Category | Number of Cases | Percentage |
|---|---|---|
| **TIRADS 1** | 5 | 5% |
| **TIRADS 2** | 63 | 63% |
| **TIRADS 3** | 20 | 20% |
| **TIRADS 4** | 8 | 8% |
| **TIRADS 5** | 4 | 4% |
| **Total** | **100** | **100%** |

**Table 2: Distribution of cases according to Bethesda Categories**

| Bethesda Category | Number of Cases | Percentage |
|---|---|---|
| **II** | 82 | 82% |
| **III** | 5 | 5% |
| **IV** | 3 | 3% |
| **V** | 5 | 5% |
| **VI** | 5 | 5% |
| **Total** | **100** | **100%** |

Cytologically, most nodules were benign. Bethesda II category (benign) constituted 82% of cases.

Indeterminate categories, Bethesda III (AUS/FLUS) and Bethesda IV (follicular neoplasm/suspicious for follicular neoplasm), accounted for 5% and 3% of cases respectively, together comprising 8% of the study population. Malignant and suspicious categories, Bethesda V and VI, each represented 5% of cases, yielding an overall malignant/suspicious proportion of 10%. Detailed cytological interpretation demonstrated that colloid/nodular goiter was the most common diagnosis, present in 45% of cases, followed by thyroiditis in 31%.

Benign follicular lesions constituted 6% of cases, while atypia of undetermined significance (AUS/FLUS) accounted for 5%. Follicular neoplasm was identified in 3% of cases. Categories "suspicious for malignancy" and "malignant (including papillary thyroid carcinoma and other carcinomas)" each comprised 5% of the study population. [Figure 2]

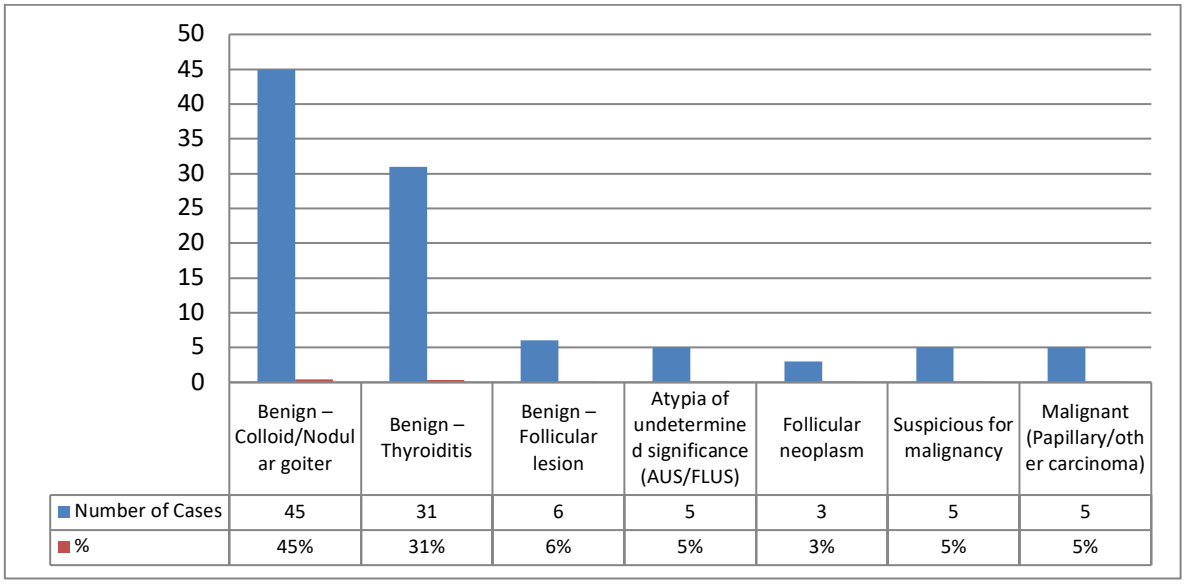


**Figure 2: Distribution of cases according to Cytological Diagnoses**

These findings indicate that benign non-neoplastic lesions predominate in thyroid cytology, with a smaller but clinically important subset of neoplastic and malignant nodules. Cross-tabulation of TIRADS and Bethesda categories revealed a clear pattern of increasing cytological atypia with higher TIRADS scores. All cases in TIRADS 1 and TIRADS 2 were Bethesda II, indicating uniformly benign cytology in radiologically low-risk nodules. In the TIRADS 3 category, 14 of 20 cases were Bethesda II, while the remaining cases were distributed between Bethesda III and IV, reflecting the heterogeneous nature of this intermediate-risk group.

**Table 3: Cross-tabulation of TIRADS and Bethesda Categories**

| TIRADS ↓ / Bethesda → | II | III | IV | V | VI | Total |
|---|---|---|---|---|---|---|
| **TIRADS 1** | 5 | 0 | 0 | 0 | 0 | 5 |
| **TIRADS 2** | 63 | 0 | 0 | 0 | 0 | 63 |
| **TIRADS 3** | 14 | 5 | 1 | 0 | 0 | 20 |
| **TIRADS 4** | 0 | 0 | 2 | 5 | 1 | 8 |
| **TIRADS 5** | 0 | 0 | 0 | 0 | 4 | 4 |
| **Total** | 82 | 5 | 3 | 5 | 5 | 100 |

| Parameter | Value |
|---|---|
| **Chi-square ($\chi^2$) value** | 183.21 |
| **Degrees of freedom (df)** | 16 |
| **P-value** | < 0.001 |
| **Statistical significance** | Highly significant |

TIRADS 4 lesions showed no benign cytology; all eight cases were classified into Bethesda IV, V, or VI categories, indicating neoplastic or malignant cytology. TIRADS 5 lesions exhibited complete agreement with malignant cytology, with all four cases categorized as Bethesda VI.

Category-wise concordance analysis demonstrated complete concordance (100%) between TIRADS and Bethesda categories in TIRADS 1, 2, 4, and 5. TIRADS 3 showed a concordance rate of 70%, with discordant cases falling into indeterminate cytological categories (Bethesda III and IV).

Application of the Chi-square test confirmed a highly significant association between TIRADS and Bethesda categories ($\chi^2 = 183.21$, df = 16, $p < 0.001$), indicating that the distribution of cytological categories varied systematically with TIRADS scores rather than occurring by chance.

When Bethesda V and VI categories were grouped as malignant for analytical purposes, the overall malignancy rate in the study was 10% (10 out of 100 cases). Malignancy rates varied markedly across TIRADS categories: no malignant cases were observed in TIRADS 1, 2, or 3; in contrast, TIRADS 4 had a malignancy rate of 75% (6 of 8 cases), and TIRADS 5 had a malignancy rate of 100% (all 4 cases).

These results demonstrate a progressive increase in malignancy risk with rising TIRADS category, with a sharp escalation at TIRADS 4 and 5.

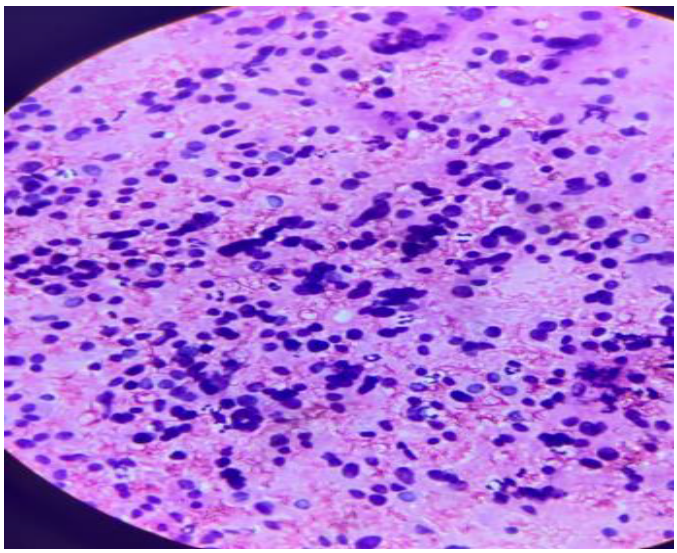

**Figure 3: Medullary Thyroid Carcinoma (40X,H&E)**

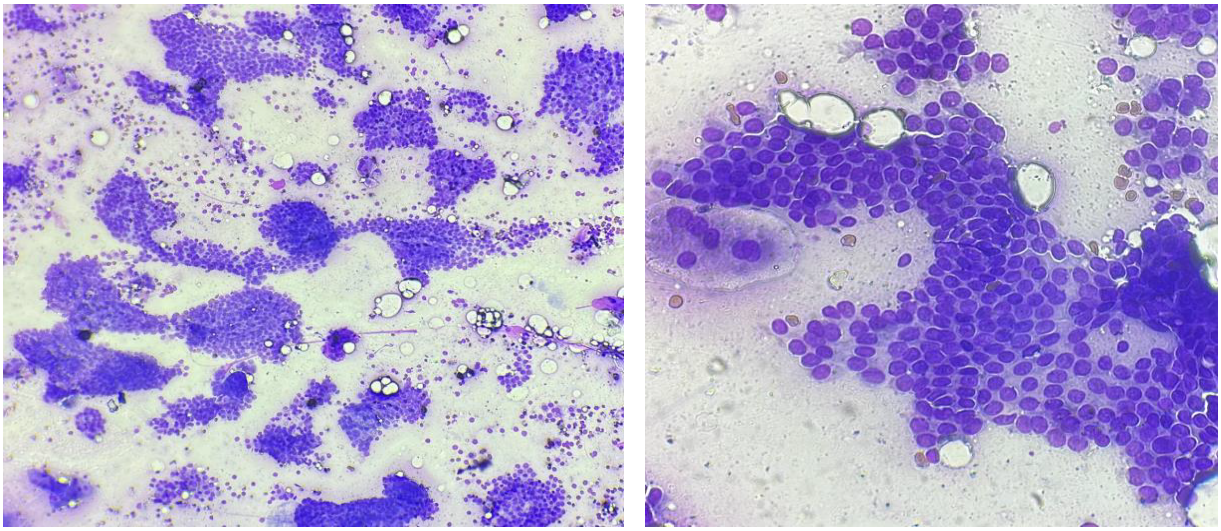

**Figure 4: Papillary Thyroid Carcinoma A - (10X,H&E), B – (40X, H&E)**

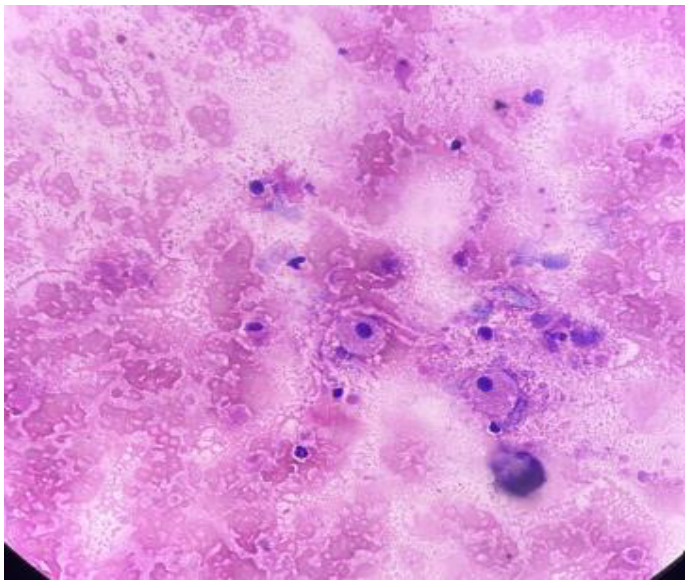

**Figure 5: Colloid Goitre-Foamy macrophage (40X, H&E)**

## Discussion

This study demonstrates a strong and statistically significant correlation between ultrasonographic TIRADS categories and Bethesda cytological categories in thyroid nodules in a tertiary care cohort from Western India. The results broadly align with published literature, particularly in showing high concordance for clearly benign and clearly malignant nodules and reduced agreement in intermediate-risk lesions.

**Demographic characteristics:** The mean age in the present study was 42.33 years, with peak incidence in the fourth and fifth decades, consistent with reports by Grandhi et al. [6] (mean age 43.8 years) and Faiz et al. [7] (45.76 years), which also describe a predominance of middle-aged patients. In contrast, Huang et al. [8] reported a higher mean age of 60 years, likely reflecting differences in demographic profile and referral patterns. The marked female predominance (89% females; female:male ratio 8:1) parallels observations by Periakaruppan et al. [9] (female:male ratio 5.5:1), Grandhi et al. [6] (22:1), Faiz et al. [7] (4.8:1), and Stephanie HG et al. [10] (14:1), reinforcing the well-established gender bias in thyroid disease.

**TIRADS and Bethesda distributions:** In this study, most nodules were radiologically benign or low suspicion (TIRADS 2: 63%; TIRADS 3: 20%), with only a small proportion in higher-risk categories (TIRADS 4: 8%; TIRADS 5: 4%). Grandhi et al. [6] reported a different pattern, with TIRADS 3 constituting the largest group (59.57%), while Faiz et al. [7] found TIRADS 4 to be most common (44.7%), reflecting a relatively higher burden of suspicious nodules in their cohorts. Periakaruppan et al. [9] similarly noted clustering of nodules in lower TIRADS categories, which, together with the present findings, supports the

clinical observation that the majority of thyroid nodules are radiologically low-risk.

Cytologically, Bethesda II (benign) predominated in this series (82%), with indeterminate categories (III and IV) comprising 8% and malignant categories (V and VI) together 10%. These figures closely match those of Grandhi et al. [6] (Bethesda II: 80.86%) and Faiz et al. [7] (78.3%), and are comparable to findings by Huang et al. [8] (Bethesda II: 78.1%), indicating a consistent predominance of benign cytology across different populations. The relatively modest but clinically important proportions of indeterminate and malignant categories are also in line with published series, underscoring the need for careful evaluation and follow-up of these subsets.

**Cytological profile:** The cytological spectrum in the present study was dominated by benign lesions, with colloid/nodular goiter (45%) and thyroiditis (31%) together accounting for the majority of cases, and neoplastic/malignant lesions forming a smaller subset. This pattern agrees with reports by Grandhi et al. [6], Faiz et al. [7], and Periakaruppan et al. [9], all of whom described colloid goiter and thyroiditis as the most frequent diagnoses, with follicular neoplasms and carcinomas comprising relatively fewer cases. Such concordance across studies reinforces the role of FNAC in distinguishing non-neoplastic from neoplastic pathology and in preventing unnecessary thyroid surgery.

**Correlation between TIRADS and Bethesda systems:** The present study showed complete concordance between TIRADS 1 and 2 and Bethesda II, indicating that low-risk TIRADS categories almost uniformly correspond to benign cytology. This is consistent with Periakaruppan et al. [9], who reported no malignancy in TIRADS 2 and excellent concordance in lower TIRADS categories, and with Stephanie HG et al. [10], who found that all lesions with TIRADS <4 were true negatives. Overall concordance in the present study is relatively high, particularly at the extremes, and compares favourably with overall concordance rates of 69.8% reported by Nebu Abraham et al. [11] and approximately 81.7% by Huang et al. [8]

TIRADS 4 and 5 categories in this series showed complete agreement with higher Bethesda categories (IV, V, VI), reflecting strong association with neoplastic and malignant cytology, in line with multiple reports that document very high correlation of TIRADS 5 with malignant histology. Nebu Abraham George et al. [11] reported malignancy rates around 97.1% in TIRADS 5 nodules, and Faiz et al. [7] found 93.1%, which are comparable to the 100% malignancy rate observed in TIRADS 5 in the present study, acknowledging that small sample size may amplify the percentage.

In contrast, Grandhi et al. [6] reported maximal concordance in TIRADS 3 with Bethesda II, suggesting that a substantial proportion of intermediate-risk nodules can still be benign, a finding echoed by the 70% benign concordance observed in TIRADS 3 in the present series.

**Malignancy risk across TIRADS categories:** The malignancy profile in this study showed a clear stepwise increase with higher TIRADS categories, from 0% in TIRADS 1–3 to 75% in TIRADS 4 and 100% in TIRADS 5. Periakaruppan et al. [9] reported a similar gradient, with malignancy rates rising from 0% in TIRADS 2 to 38.5% in TIRADS 4 and 77.8% in TIRADS 5, while Faiz et al. [7] observed malignancy rates of 2.9% in TIRADS 3, 18.2% in TIRADS 4, and 93.1% in TIRADS 5. The slightly higher malignancy rates in TIRADS 4 and 5 in the present study, particularly the 100% rate in TIRADS 5, may be attributed to smaller subgroup sizes and differences in case mix, but the overall trend is consistent with published literature.

Collectively, these findings support the robustness of TIRADS as a risk stratification tool, with low malignancy risk in TIRADS 2–3 and high risk in TIRADS 4–5, and reinforce the practice of reserving FNAC and more aggressive management for higher TIRADS categories.

**Clinical implications of the study:** From a clinical perspective, these findings suggest that:

- TIRADS 1–2 nodules with concordant benign clinical and cytological features can be safely managed with observation and periodic follow-up rather than routine FNAC or surgery.
- TIRADS 3 nodules require individualized management, with FNAC recommended in most cases to rule out indeterminate or neoplastic pathology; repeat imaging and cytology may be considered when results are inconclusive.
- TIRADS 4 and 5 nodules should be prioritized for FNAC, multidisciplinary evaluation, and definitive management, given their high likelihood of malignancy.

**Strengths and Limitations:** Strengths of the present study include standardized use of TIRADS and Bethesda in a single tertiary care centre, defined inclusion/exclusion criteria, and formal statistical evaluation ($\chi^2 = 183.21$, $p < 0.001$), all of which provide robust evidence for correlation between the two systems. Limitations include the record-based design, potential interobserver variability in ultrasound and cytology, limited histopathological confirmation for all malignant/suspicious cases, and relatively small numbers in high-risk TIRADS subgroups. Future prospective studies with uniform histological follow-up and integration of additional imaging

modalities or molecular testing could further refine malignancy risk estimates, especially in intermediate-risk nodules.

## Conclusion

This study demonstrates a statistically significant and clinically meaningful correlation between TIRADS ultrasonographic categories and Bethesda cytological categories in patients with thyroid nodules. Most nodules in the study were benign both radiologically and cytologically, with TIRADS 2 and Bethesda II predominating. Malignancy was concentrated in higher TIRADS categories, with TIRADS 4 and 5 showing very high malignancy rates and complete concordance with neoplastic and malignant Bethesda categories. TIRADS thus serves as a dependable non-invasive screening and triaging tool, enabling stratification of nodules according to malignancy risk and guiding decisions on which nodules require FNAC and closer evaluation. Bethesda cytology complements imaging by providing definitive or near-definitive diagnosis, especially in intermediate and high-risk nodules. The reduced concordance and absence of malignancy in TIRADS 3 lesions in this series highlight that this category remains diagnostically heterogeneous and mandates careful correlation with cytology and clinical context.

Overall, the combined use of TIRADS and Bethesda systems enhances diagnostic precision, supports evidence-based management pathways, and can help reduce unnecessary invasive procedures in low-risk nodules while ensuring timely identification and treatment of malignant lesions. Integration of these frameworks into routine clinical practice, with ongoing local validation, can significantly improve the quality and efficiency of thyroid nodule evaluation in tertiary care settings.

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