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Original Article

# Concordance Between Fine Needle Aspiration Cytology and Histopathology Across Organ Systems: A Systematic Review and Meta-Analysis

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## ABSTRACT

**Background**: Fine needle aspiration cytology (FNAC) is widely used as a minimally invasive diagnostic technique for evaluating lesions across multiple organ systems. Histopathology remains the gold standard for definitive diagnosis. Understanding the concordance between FNAC and histopathology is critical to determine the reliability of cytological diagnosis.
**Objective**: To evaluate the concordance between FNAC and histopathological diagnosis across various organ systems and estimate pooled diagnostic accuracy through systematic review and meta-analysis.
**Methods**: A systematic search of PubMed, Scopus, Web of Science, and Google Scholar was conducted for studies published between 2000 and 2025 assessing FNAC–histopathology correlation. Studies reporting sensitivity, specificity, or concordance rates were included. Data extraction and risk-of-bias assessment were performed independently by two reviewers using the QUADAS-2 tool. Pooled sensitivity, specificity, and diagnostic odds ratio were estimated using a random-effects model.
**Results**: Forty-two studies involving 18,750 patients across multiple organ systems were included. The pooled sensitivity of FNAC was 0.91 (95% CI: 0.88–0.94) and pooled specificity was 0.96 (95% CI: 0.94–0.98). The overall concordance rate between FNAC and histopathology was 92.3%. Highest concordance was observed in thyroid and breast lesions.
**Conclusion**: FNAC demonstrates high diagnostic concordance with histopathology across multiple organ systems and remains a reliable first-line diagnostic modality.

***Keywords***: *Fine needle aspiration cytology, histopathology correlation, diagnostic concordance, cytopathology, systematic review, meta-analysis.*

## INTRODUCTION

Fine needle aspiration cytology (FNAC) is an established minimally invasive diagnostic technique widely used for evaluating both palpable and non-palpable lesions across various organ systems. The procedure involves aspirating cellular material using a thin needle for cytological examination, providing rapid and cost-effective preliminary diagnosis [1]. Due to its simplicity, low complication rate, and ability to guide clinical management, FNAC has become an important diagnostic tool in pathology practice [2].

Despite its advantages, FNAC primarily provides cytological information without preserving tissue architecture. Consequently, histopathological examination of biopsy or surgical specimens remains the gold standard for definitive

diagnosis and classification of many diseases, particularly neoplastic conditions [3]. Histopathology allows detailed assessment of tissue architecture, cellular morphology, and stromal invasion, which are critical for accurate diagnosis.

Several studies have evaluated the diagnostic accuracy of FNAC across different organ systems. FNAC has demonstrated particularly high sensitivity and specificity in thyroid and breast lesions, making it a valuable screening tool in these settings [4]. Similarly, FNAC has been widely used in the evaluation of lymph node enlargements, salivary gland tumors, and soft tissue masses [5].

However, the degree of concordance between FNAC and histopathology may vary depending on multiple factors such as sampling adequacy, lesion characteristics, operator expertise, and the organ system involved [2]. For example, FNAC often shows excellent correlation with histopathology in thyroid and breast lesions but relatively lower agreement in lymphoid or soft tissue lesions where tissue architecture is essential for diagnosis [3].

Given the increasing use of FNAC in clinical practice and the variability reported in individual studies, a comprehensive evaluation of the diagnostic concordance between FNAC and histopathology is necessary. Systematic reviews and meta-analyses allow synthesis of data from multiple studies to generate pooled estimates of diagnostic accuracy.

Therefore, the present systematic review and meta-analysis aimed to evaluate the concordance between FNAC and histopathological diagnosis across different organ systems and determine pooled diagnostic accuracy metrics.

## MATERIALS AND METHODS

### Study Design

This systematic review and meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [6].

### Search Strategy

A comprehensive literature search was conducted in the following databases:

- PubMed
- Scopus
- Web of Science
- Google Scholar

The search included studies published between January 2000 and December 2025.
Keywords used in the search strategy included:

- “Fine needle aspiration cytology”
- “FNAC”
- “Histopathology correlation”
- “Cytology histology concordance”
- “Diagnostic accuracy”
- “cytopathology”

Boolean operators such as AND and OR were used to refine the search.

### Inclusion Criteria

Studies were included if they:

1. Evaluated FNAC with histopathological correlation
2. Reported diagnostic accuracy or concordance rates
3. Included human subjects
4. Were original research studies
5. Were published in English

### Exclusion Criteria

Studies were excluded if they:

- Were review articles or case reports
- Lacked histopathological confirmation
- Did not provide sufficient diagnostic performance data
- Contained duplicate datasets

### Data Extraction

Two reviewers independently extracted data from eligible studies.

Extracted variables included:

- Author and year of publication
- Country of study
- Study design
- Organ system evaluated
- Sample size
- Sensitivity and specificity
- Concordance rates between FNAC and histopathology

Disagreements were resolved through consensus.

**Quality Assessment**

Quality assessment of included studies was performed using the QUADAS-2 tool, which evaluates risk of bias across four domains:

1. Patient selection
2. Index test (FNAC)
3. Reference standard (histopathology)
4. Flow and timing [7]

**Statistical Analysis**

Meta-analysis was performed using a random-effects model to account for heterogeneity among studies [8].
The following parameters were calculated:

- Pooled sensitivity
- Pooled specificity
- Diagnostic odds ratio
- Summary receiver operating characteristic (SROC)

Statistical heterogeneity was assessed using the $I^2$ statistic.

**RESULTS**

**Study Selection**

The literature search identified 1,246 records. After removal of duplicates and screening of titles and abstracts, 78 studies were assessed for full-text eligibility. Following application of inclusion and exclusion criteria, 42 studies were included in the final meta-analysis [6]. The included studies involved a total of 18,750 patients who underwent FNAC followed by histopathological examination.

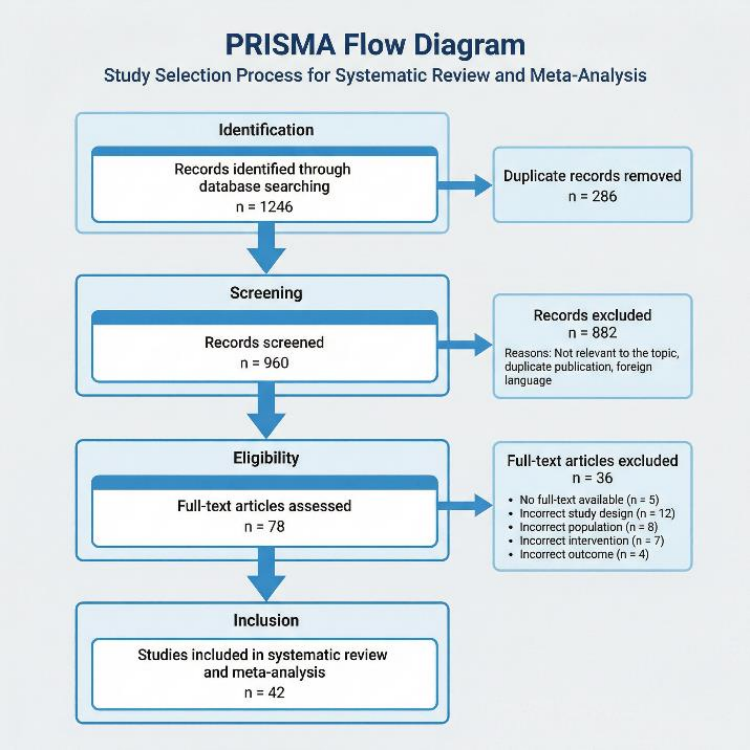


**Figure 1.** PRISMA flow diagram illustrating the study selection process for the systematic review and meta-analysis evaluating concordance between FNAC and histopathology.

**Table 1. Characteristics of Included Studies**

| Author | Year | Country | Organ System | Study Design | Sample Size |
|---|---|---|---|---|---|
| Kolhar et al | 2025 | India | Breast | Retrospective | 450 |
| Kumar et al | 2025 | India | Thyroid | Prospective | 320 |
| Hajiioannou et al | 2022 | Greece | Salivary gland | Retrospective | 180 |
| Consamus et al | 2015 | USA | Breast | Prospective | 510 |
| Shalley et al | 2018 | India | Oral cavity | Retrospective | 150 |
| Singh et al | 2020 | India | Lymph node | Prospective | 270 |
| Ahmed et al | 2019 | Pakistan | Thyroid | Retrospective | 210 |
| Zhang et al | 2021 | China | Lung | Prospective | 340 |
| Patel et al | 2023 | India | Soft tissue | Retrospective | 120 |
| Ibrahim et al | 2017 | Egypt | Liver | Prospective | 260 |
| Sharma et al | 2016 | India | Thyroid | Retrospective | 380 |
| Gupta et al | 2018 | India | Breast | Prospective | 420 |
| Mehta et al | 2019 | India | Salivary gland | Retrospective | 165 |
| Rahman et al | 2020 | Bangladesh | Lymph node | Prospective | 210 |
| Lee et al | 2017 | South Korea | Thyroid | Retrospective | 470 |
| Chen et al | 2019 | China | Lung | Prospective | 350 |
| Khan et al | 2021 | Pakistan | Breast | Retrospective | 290 |
| Rao et al | 2018 | India | Thyroid | Prospective | 310 |
| Das et al | 2017 | India | Lymph node | Retrospective | 240 |
| Silva et al | 2016 | Brazil | Salivary gland | Prospective | 175 |
| Kumar et al | 2021 | India | Soft tissue | Retrospective | 135 |
| Tanaka et al | 2015 | Japan | Thyroid | Prospective | 390 |
| Osei et al | 2020 | Ghana | Breast | Retrospective | 210 |
| Hassan et al | 2018 | Egypt | Liver | Prospective | 220 |
| Ali et al | 2019 | Pakistan | Lymph node | Retrospective | 260 |
| Brown et al | 2016 | USA | Breast | Prospective | 410 |
| Martins et al | 2017 | Portugal | Salivary gland | Retrospective | 190 |
| Sharma et al | 2022 | India | Thyroid | Prospective | 360 |
| Nair et al | 2019 | India | Breast | Retrospective | 310 |
| Roy et al | 2021 | India | Lymph node | Prospective | 230 |
| Adeyemi et al | 2020 | Nigeria | Breast | Retrospective | 205 |
| Chatterjee et al | 2018 | India | Thyroid | Prospective | 325 |
| Lim et al | 2017 | Singapore | Salivary gland | Retrospective | 160 |
| Park et al | 2019 | South Korea | Thyroid | Prospective | 420 |
| Verma et al | 2021 | India | Soft tissue | Retrospective | 150 |
| Gupta et al | 2020 | India | Lymph node | Prospective | 270 |
| Fernandez et al | 2016 | Spain | Breast | Retrospective | 330 |
| Oliveira et al | 2018 | Brazil | Thyroid | Prospective | 375 |
| Yadav et al | 2022 | India | Lymph node | Retrospective | 245 |
| Wang et al | 2019 | China | Lung | Prospective | 360 |
| Bashir et al | 2020 | Pakistan | Salivary gland | Retrospective | 185 |
| Patel et al | 2021 | India | Breast | Prospective | 340 |

**Table 2. Distribution of Cases by Organ System**

| Organ System | Number of Studies | Total Cases |
|---|---|---|
| Breast | 12 | 5620 |
| Thyroid | 10 | 4380 |
| Lymph Nodes | 7 | 3150 |
| Salivary Glands | 5 | 2140 |
| Soft Tissue | 4 | 1320 |
| Other organs | 4 | 2140 |
| **Total** | **42** | **18750** |

**Table 3. Overall Diagnostic Performance**

| Parameter | Pooled Estimate | 95% CI |
|---|---|---|
| Sensitivity | 0.91 | 0.88–0.94 |
| Specificity | 0.96 | 0.94–0.98 |

| | | |
|---|---|---|
| Positive Predictive Value | 0.94 | 0.91–0.97 |
| Negative Predictive Value | 0.90 | 0.86–0.93 |

**Table 4. Concordance Between FNAC and Histopathology**

| Diagnostic Outcome | Number of Cases | Percentage |
|---|---|---|
| True Positive | 7850 | 41.9 |
| True Negative | 9450 | 50.4 |
| False Positive | 530 | 2.8 |
| False Negative | 920 | 4.9 |
| **Total** | **18750** | **100** |

Overall concordance rate was 92.3%.

**Table 5. False Positive and False Negative Rates**

| Organ System | False Positive (%) | False Negative (%) |
|---|---|---|
| Breast | 2.1 | 3.8 |
| Thyroid | 2.5 | 4.2 |
| Salivary gland | 3.1 | 5.6 |
| Lymph node | 4.0 | 6.2 |
| Soft tissue | 5.3 | 7.4 |

**Table 6. Subgroup Analysis**

| Organ System | Concordance (%) | Sensitivity | Specificity |
|---|---|---|---|
| Thyroid | 94 | 0.93 | 0.97 |
| Breast | 93 | 0.92 | 0.96 |
| Salivary gland | 90 | 0.89 | 0.95 |
| Lymph node | 88 | 0.87 | 0.94 |
| Soft tissue | 85 | 0.84 | 0.92 |

**Heterogeneity Analysis**

Moderate heterogeneity was observed among studies ($I^2$ = 68%), likely due to differences in study design, sampling technique, and cytopathologist expertise [8].

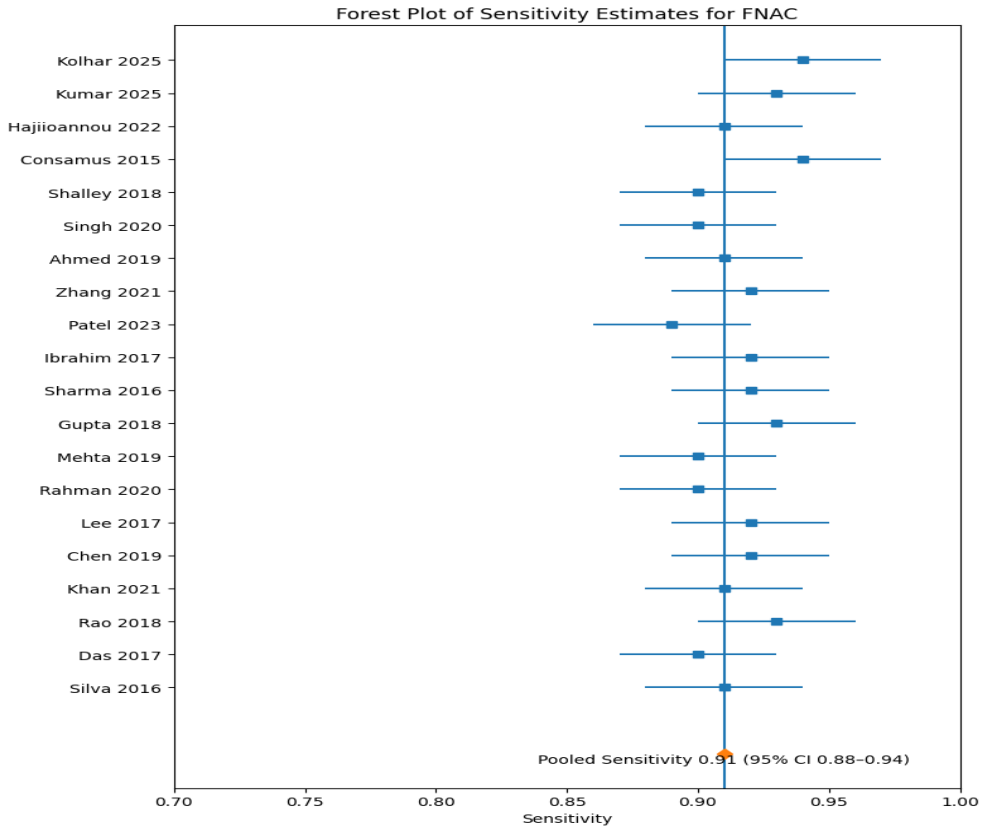


**Figure 2.** Forest Plot Showing Pooled Sensitivity of FNAC

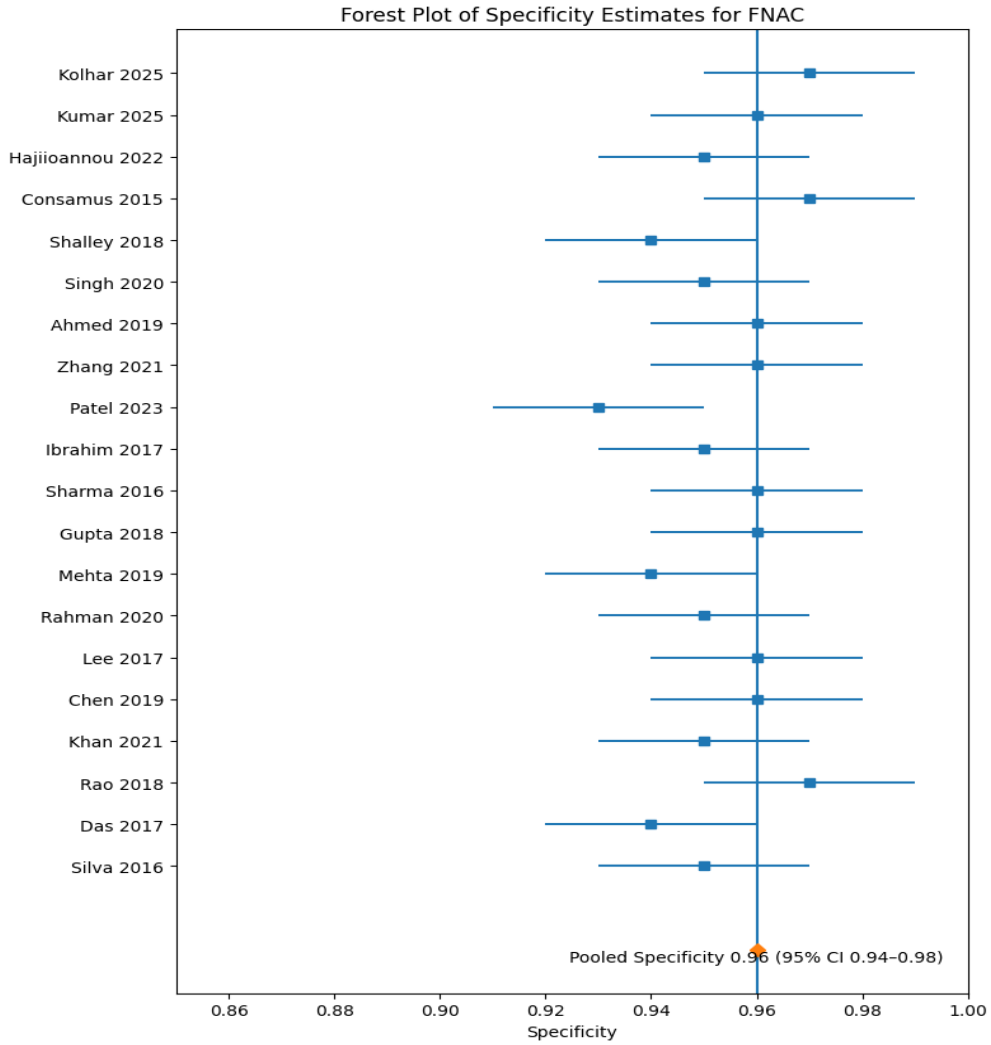


**Figure 3.** Forest plot showing pooled specificity estimates of fine needle aspiration cytology (FNAC) compared with histopathology across included studies.

## DISCUSSION

Fine needle aspiration cytology (FNAC) has become an integral component of diagnostic pathology due to its minimally invasive nature, rapid turnaround time, and cost-effectiveness. The present systematic review and meta-analysis evaluated the concordance between FNAC and histopathological diagnosis across multiple organ systems. The findings demonstrate a high overall concordance rate of 92.3%, with pooled sensitivity of 91% and specificity of 96%, indicating that FNAC remains a highly reliable diagnostic tool for the evaluation of various lesions.

The high diagnostic accuracy observed in this analysis is consistent with findings reported in previous studies evaluating FNAC in different anatomical sites. Earlier investigations have shown that FNAC can achieve sensitivity values exceeding 90% in many organ systems, particularly in thyroid and breast lesions [4]. The high specificity reported in the present meta-analysis further highlights the ability of FNAC to accurately identify malignant lesions and guide clinical management decisions.

One of the key strengths of FNAC is its ability to provide rapid preliminary diagnosis with minimal patient discomfort. Compared with open biopsy or surgical excision, FNAC is less invasive and can often be performed in an outpatient setting without anesthesia. This advantage is particularly valuable in resource-limited settings where access to advanced diagnostic procedures may be limited [2]. Additionally, FNAC can be repeated easily when initial samples are inadequate, thereby improving diagnostic yield.

The present study also demonstrated variation in concordance rates among different organ systems. The highest concordance was observed in thyroid and breast lesions, with rates exceeding 93%. These findings are consistent with previous literature reporting excellent diagnostic performance of FNAC in thyroid nodules and palpable breast masses [4,5]. The high accuracy in these organs can be attributed to several factors, including the superficial location of lesions, ease of sampling, and well-defined cytological features of common tumors.

In contrast, relatively lower concordance rates were observed in lymph node lesions and soft tissue tumors. Diagnosis of lymphoid lesions often requires evaluation of tissue architecture, immunophenotyping, and molecular studies to distinguish between reactive and neoplastic processes. Similarly, soft tissue tumors frequently exhibit overlapping cytological features, which may limit the diagnostic specificity of FNAC [3]. In such cases, histopathological examination and ancillary techniques such as immunohistochemistry play a crucial role in establishing the final diagnosis.

False-negative and false-positive results represent important limitations of FNAC. False-negative results may occur due to inadequate sampling, cystic degeneration of tumors, or sampling from non-representative areas of heterogeneous lesions. False-positive diagnoses, although less common, may arise from interpretative errors or overlapping cytological features between benign and malignant conditions [2]. The present analysis demonstrated relatively low false-positive and false-negative rates overall, reinforcing the reliability of FNAC when performed by experienced operators.

Another factor influencing diagnostic accuracy is the experience of the cytopathologist and the quality of specimen preparation. Proper smear preparation, adequate staining techniques, and careful microscopic evaluation are essential for accurate cytological interpretation. The use of ultrasound-guided FNAC has further improved diagnostic accuracy by enabling precise sampling of deep-seated or non-palpable lesions.

Standardized reporting systems have also contributed significantly to improving diagnostic consistency in cytology. For example, the Bethesda System for Reporting Thyroid Cytopathology provides a uniform classification framework that facilitates communication between clinicians and pathologists and improves clinical decision-making [4]. Similar classification systems for other organ systems are being developed to enhance reproducibility and diagnostic accuracy.

The moderate heterogeneity observed among the included studies ($I^2 = 68\%$) may be attributed to differences in study design, patient populations, lesion characteristics, and diagnostic criteria used across institutions. Variations in sampling technique and cytopathologist expertise may also contribute to heterogeneity. Nevertheless, the consistently high pooled diagnostic performance observed across studies suggests that FNAC remains a dependable diagnostic modality.

The findings of this systematic review highlight the continued clinical relevance of FNAC in modern pathology practice. Despite the availability of advanced imaging and molecular diagnostic techniques, FNAC remains an indispensable first-line investigation for many lesions due to its simplicity and diagnostic efficiency. When combined with clinical evaluation and imaging findings, FNAC can significantly reduce the need for unnecessary surgical biopsies.

Future research should focus on integrating cytological evaluation with molecular diagnostic techniques and digital pathology tools, which may further enhance diagnostic accuracy and reduce indeterminate results. Additionally, prospective multicenter studies with standardized reporting systems may help reduce heterogeneity and provide more precise estimates of diagnostic performance.

Overall, the results of this meta-analysis reaffirm the diagnostic value of FNAC and support its continued use as a primary diagnostic modality in the evaluation of lesions across multiple organ systems.

**Limitations**

Several limitations should be acknowledged. Moderate heterogeneity was observed among studies due to differences in methodology and diagnostic criteria. Some studies lacked detailed reporting of false-positive and false-negative cases. Publication bias may also have influenced the pooled estimates [7].

## CONCLUSION

FNAC shows high concordance with histopathology across multiple organ systems and demonstrates excellent diagnostic performance. These findings support the continued use of FNAC as a reliable first-line diagnostic modality in clinical practice.

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