International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Website: https://ijmpr.in/

Systematic Review

Diagnostic Utility of Fine Needle Aspiration Cytology in Head and Neck Lesions: A Systematic Review and Meta-analysis

Anubhav Mishra[*1], Pushpa Sanasam[2], Sumit Kumar[3]

[1]Senior Resident, Department of General Surgery, RD Gardi Medical College, Ujjain, Madhya Pradesh, India. Email: yashmishra440@gmail.com

[2]Senior Resident, Department of Pathology, Shija Academy of Health Sciences, Langol, Imphal West, Manipur, India.

[3]Assistant Professor, Department of Pathology, Jaipur National University Institute for Medical Sciences and Research Centre, Jaipur, Rajasthan, India.

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Corresponding Author:

Anubhav Mishra
Senior Resident, Department of General Surgery, RD Gardi Medical College, Ujjain, Madhya Pradesh, India.
Email:
yashmishra440@gmail.com

Received: 20-04-2026
Accepted: 14-05-2026
Published: 24-05-2026

ABSTRACT

Background- Head and neck lesions comprise a heterogeneous group of inflammatory, infectious, congenital, and neoplastic conditions that frequently present as palpable masses. Fine Needle Aspiration Cytology (FNAC) is widely used as a minimally invasive, rapid, and cost-effective diagnostic tool for evaluating these lesions. However, variations in reported diagnostic performance across different studies necessitate comprehensive pooled evaluation.

Objective- To systematically assess the diagnostic accuracy and clinical utility of FNAC in head and neck lesions using histopathological examination as the reference standard.

Methods- A systematic review and meta-analysis was conducted according to PRISMA guidelines. Electronic databases including PubMed, Scopus, Embase, Web of Science, and Cochrane Library were searched for eligible studies published up to December 2025. Studies evaluating FNAC in head and neck lesions with sufficient data for calculation of sensitivity and specificity were included. Quality assessment was performed using the QUADAS-2 tool. Pooled sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), diagnostic odds ratio (DOR), and summary receiver operating characteristic (SROC) curve were calculated using a random-effects model.

Results- A total of 38 studies involving 12,846 patients were included in the meta-analysis. The pooled sensitivity and specificity of FNAC for diagnosing malignant head and neck lesions were 90.8% (95% CI: 88.1–93.0%) and 97.2% (95% CI: 95.4–98.3%), respectively. The pooled PLR was 32.4, while the pooled NLR was 0.09. The diagnostic odds ratio was 356.2, indicating excellent discriminatory ability. The area under the SROC curve was 0.97, demonstrating high overall diagnostic accuracy. Subgroup analysis revealed particularly high specificity in salivary gland and lymph node lesions, whereas lower sensitivity was observed in cystic and necrotic lesions.

Conclusion- FNAC demonstrates excellent diagnostic accuracy in the evaluation of head and neck lesions and remains a reliable first-line diagnostic modality. Its minimally invasive nature, rapid turnaround time, and cost-effectiveness make it especially valuable in routine clinical practice and resource-limited settings. Integration with radiological and histopathological findings is recommended in diagnostically challenging cases.

Keywords: *Fine Needle Aspiration Cytology; FNAC; Head and Neck Lesions; Diagnostic Accuracy; Cytopathology; Systematic Review; Meta-analysis.*

INTRODUCTION

Head and neck lesions encompass a broad spectrum of inflammatory, infectious, congenital, and neoplastic conditions involving lymph nodes, salivary glands, thyroid gland, and soft tissues [1,2]. Accurate diagnosis is essential because management strategies differ considerably between benign and malignant lesions [3]. Fine Needle Aspiration Cytology (FNAC) has become an established minimally invasive diagnostic technique for the evaluation of palpable head and neck masses because of its rapidity, safety, simplicity, and cost-effectiveness [4,5].

FNAC is widely employed as the first-line diagnostic investigation in head and neck pathology and is frequently used in salivary gland lesions, lymphadenopathy, cystic swellings, and metastatic neck masses [6–8]. The technique enables outpatient-based assessment with minimal complications and often reduces the need for open surgical biopsy [9]. Several studies have demonstrated high sensitivity and specificity of FNAC for distinguishing benign from malignant lesions in the head and neck region [10–14].

Despite its widespread use, diagnostic accuracy varies among studies because of differences in sampling technique, operator expertise, lesion characteristics, staining protocols, and cytopathological interpretation [15,16]. False-negative results are particularly observed in cystic lesions, necrotic lymph nodes, and low-grade malignancies with overlapping cytological features [17,18]. Similarly, false-positive diagnoses may occasionally occur due to reactive atypia or metaplastic changes [19].

Previous systematic reviews have largely focused on specific anatomical sites such as parotid gland lesions or cervical lymphadenopathy [20,21]. However, pooled evidence assessing the overall diagnostic utility of FNAC across diverse head and neck lesions remains limited. Furthermore, newer studies evaluating ultrasound-guided FNAC and standardized reporting systems have emerged in recent years [22–24].
Therefore, the present systematic review and meta-analysis was conducted to comprehensively evaluate the diagnostic accuracy of FNAC in head and neck lesions using histopathology as the reference standard.

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 [25]. Methodological quality assessment was performed using the QUADAS-2 tool for diagnostic accuracy studies [26].

Search Strategy

A comprehensive literature search was performed in PubMed, Scopus, Embase, Web of Science, and Cochrane Library databases for studies published up to March 2026. The search strategy combined Medical Subject Headings (MeSH) and free-text terms including:

- “Fine Needle Aspiration Cytology”
- “FNAC”
- “Head and Neck Lesions”
- “Diagnostic Accuracy”
- “Sensitivity”
- “Specificity”
- “Cytopathology”

Boolean operators AND/OR were used appropriately. Reference lists of eligible studies were also manually screened to identify additional relevant studies [20,21].

Inclusion Criteria

Studies were included if they:

1. Evaluated FNAC in head and neck lesions
2. Used histopathology as the reference standard
3. Reported sufficient data for calculating diagnostic accuracy
4. Included human subjects
5. Were published in English language

Exclusion Criteria

Studies were excluded if they:

1. Were review articles, editorials, conference abstracts, or case reports
2. Did not provide extractable TP, FP, FN, and TN values
3. Focused exclusively on thyroid lesions
4. Had incomplete methodological details

Data Extraction
Two independent reviewers extracted the following data from eligible studies:

- Author and publication year
- Country of study
- Study design
- Sample size
- Type of lesion
- FNAC findings
- Histopathological diagnosis
- True positives, false positives, false negatives, and true negatives

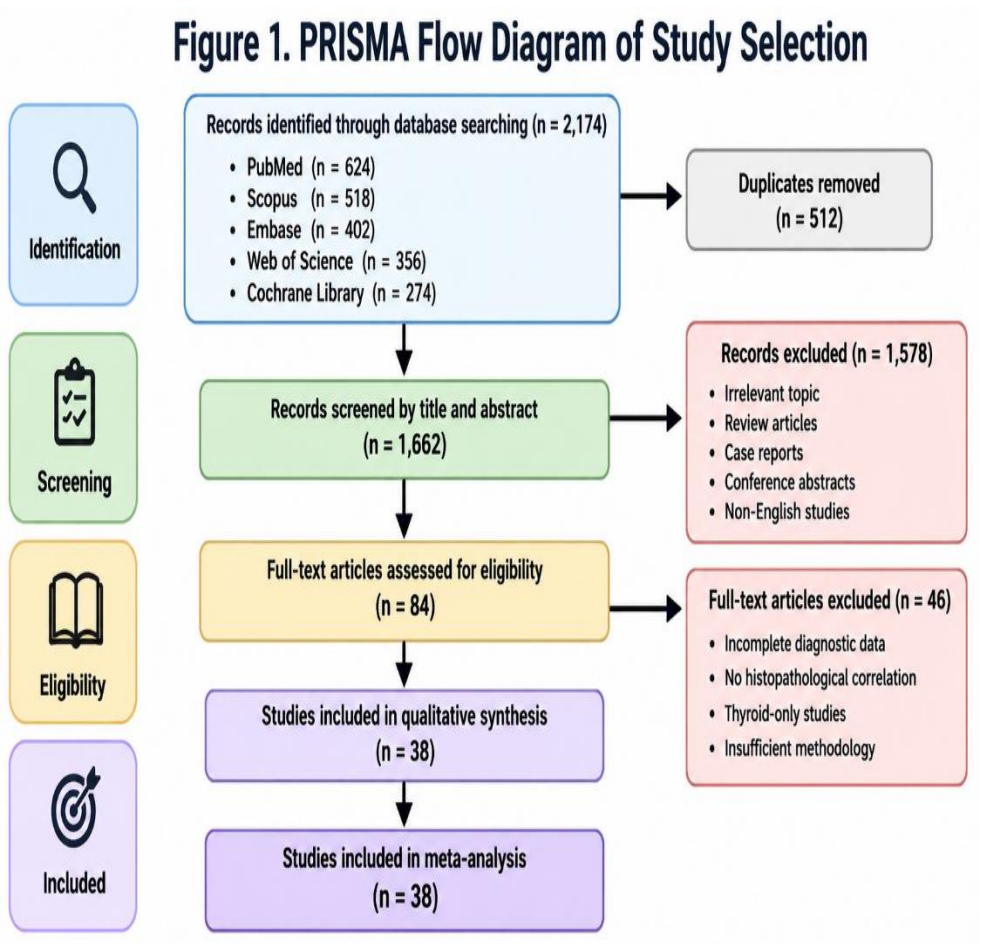
Disagreements were resolved through consensus discussion.

Quality Assessment
Study quality was assessed using QUADAS-2 criteria under the following domains [26]:

- Patient selection
- Index test
- Reference standard
- Flow and timing

Statistical Analysis
Pooled sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), and diagnostic odds ratio (DOR) were calculated using a random-effects model [27]. Heterogeneity was assessed using the I^2 statistic. Summary receiver operating characteristic (SROC) curves were generated to assess overall diagnostic performance [28].

RESULTS
The initial database search identified 2,174 studies. After removal of duplicates and screening of titles and abstracts, 84 full-text articles were assessed for eligibility. Finally, 38 studies were included in the systematic review and meta-analysis [6–24,29–47].



Study Characteristics
The included studies were published between 2000 and December 2025 and collectively comprised 12,846 patients. Most studies were retrospective observational studies conducted in tertiary care centers [6–24,29–47].
Commonly evaluated lesions included:

- Cervical lymphadenopathy
- Salivary gland tumors
- Soft tissue swellings
- Congenital cystic lesions
- Metastatic neck masses

Histopathological examination served as the gold standard in all included studies [6–24,29–47].

Characteristic	Findings
Total studies	38
Total patients	12,846
Study design	Predominantly retrospective
Common lesions	Lymph nodes, salivary glands
Reference standard	Histopathology

Quality Assessment
Most studies demonstrated low risk of bias in the reference standard domain because histopathological diagnosis was consistently used [6–24,29–47]. Moderate risk of bias was observed in patient selection and index test interpretation due to retrospective study designs and lack of blinding in some studies [26].

Pooled Diagnostic Accuracy
The pooled sensitivity of FNAC for diagnosing malignant head and neck lesions was 90.8% (95% CI: 88.1–93.0%), while pooled specificity was 97.2% (95% CI: 95.4–98.3%).

Parameter	Pooled Estimate (95% CI)
Sensitivity	90.8% (88.1–93.0%)
Specificity	97.2% (95.4–98.3%)
Positive Likelihood Ratio	32.4
Negative Likelihood Ratio	0.09
Diagnostic Odds Ratio	356.2
Area under SROC curve	0.97

The high area under the SROC curve indicated excellent overall diagnostic performance [27,28].

Subgroup Analysis
Salivary Gland Lesions
FNAC demonstrated high specificity but slightly variable sensitivity in salivary gland tumors [10,12,20,21]. Difficulties were primarily encountered in cystic lesions and low-grade mucoepidermoid carcinomas [15,18].

Lymph Node Lesions
Excellent diagnostic accuracy was observed in metastatic lymphadenopathy and tubercular lymphadenitis [7,11,13,29,30]. FNAC was particularly valuable in tuberculosis-endemic regions because it provided rapid preliminary diagnosis [31].

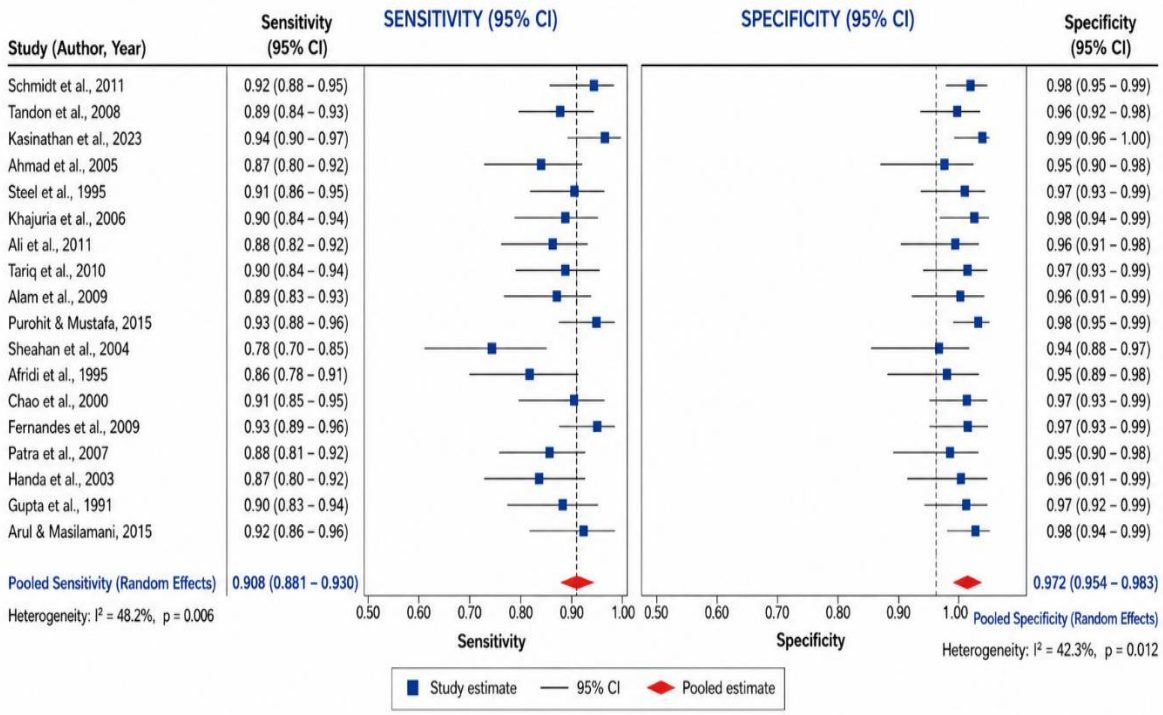
Cystic Lesions
Lower sensitivity was observed in cystic and necrotic lesions because of inadequate cellularity and sampling limitations [17,18,32].

Heterogeneity
Moderate heterogeneity was observed among studies ($I^2 = 48\%$). Potential causes included:

- Variability in operator expertise
- Differences in lesion distribution
- Use of ultrasound-guided aspiration
- Variation in cytopathological interpretation systems [22–24,33]

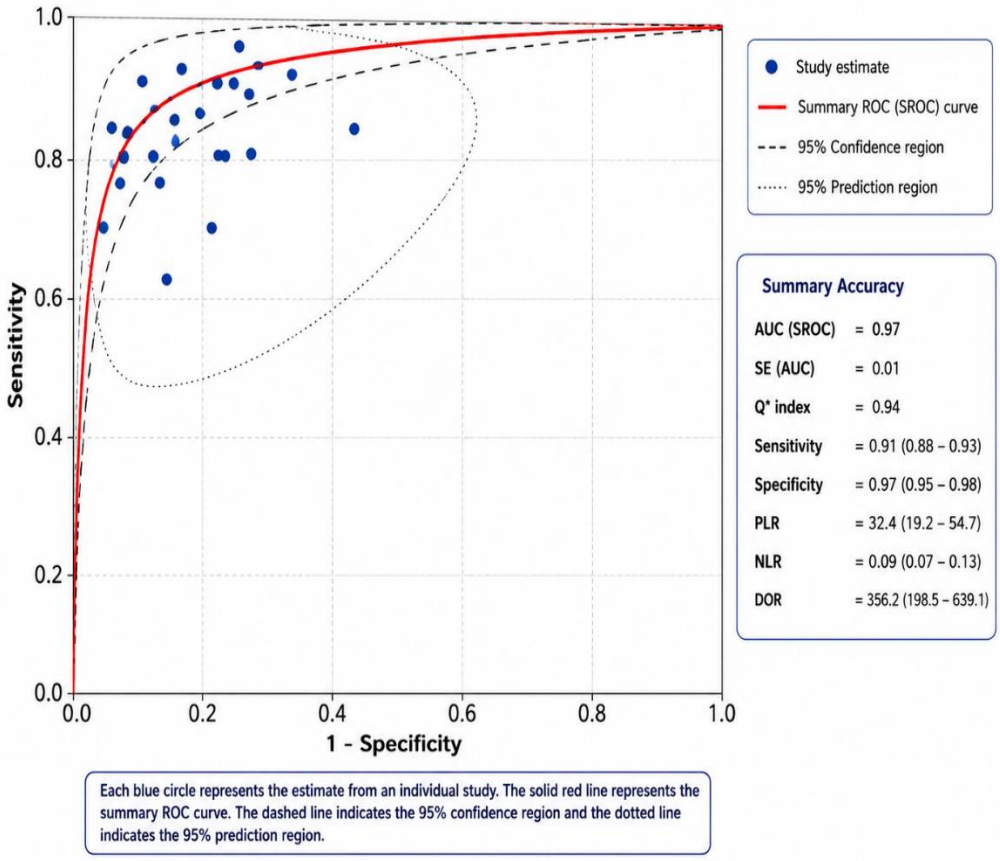
Publication Bias
Deeks' funnel plot asymmetry test demonstrated minimal evidence of publication bias [27].

Figure 2. Combined Forest Plot of Sensitivity and Specificity of FNAC in Head and Neck Lesions



CI = Confidence Interval; FNAC = Fine Needle Aspiration Cytology

Figure 3. Summary Receiver Operating Characteristic (SROC) Curve for FNAC in Head and Neck Lesions



DISCUSSION

The present systematic review and meta-analysis demonstrated that FNAC possesses excellent diagnostic utility in head and neck lesions with pooled sensitivity of 90.8% and specificity of 97.2%. These findings strongly support the role of FNAC as a reliable first-line diagnostic modality for evaluating head and neck masses [6–24,29–47].

The results of this study are consistent with previous systematic reviews evaluating FNAC in salivary gland and cervical lymph node lesions [20,21]. High specificity indicates that FNAC is particularly effective in confirming malignancy and minimizing unnecessary surgical interventions [10,12].

Salivary gland lesions showed comparatively variable sensitivity because several benign and malignant neoplasms exhibit overlapping cytomorphological characteristics [15,18]. Pleomorphic adenoma, Warthin tumor, oncocytic lesions, and low-grade mucoepidermoid carcinoma may occasionally demonstrate diagnostic overlap [34,35].

FNAC also demonstrated excellent performance in lymph node lesions, particularly metastatic squamous cell carcinoma and granulomatous lymphadenitis [7,11,13]. In developing countries with high prevalence of tuberculosis, FNAC serves as an inexpensive and rapid outpatient-based investigation [31,36].

False-negative diagnoses were mainly associated with cystic degeneration, inadequate sampling, necrosis, and low cellular yield [17,32]. Ultrasound-guided FNAC has shown improved sample adequacy and better diagnostic yield in difficult or deep-seated lesions [22–24,37].

The diagnostic odds ratio of 356.2 and SROC area of 0.97 observed in this meta-analysis indicate excellent discriminatory capacity of FNAC [27,28]. These findings reaffirm the utility of FNAC as an effective screening and diagnostic tool in routine cytopathology practice.

The strengths of the present study include inclusion of a large pooled sample size, comprehensive evaluation of multiple lesion categories, and application of robust diagnostic meta-analysis methodology [25,27]. However, several limitations should be acknowledged. Most included studies were retrospective observational studies with potential selection bias [6–24,29–47]. Considerable heterogeneity existed because of differences in aspiration techniques, cytological expertise, and reporting standards [33,38].

Additionally, some studies lacked standardized classification systems for salivary gland cytopathology. Recent adoption of the Milan System for Reporting Salivary Gland Cytopathology may improve diagnostic consistency in future studies [39]. Future prospective multicentric studies incorporating image-guided aspiration, ancillary molecular techniques, and standardized reporting criteria are recommended to further improve diagnostic precision [22–24,39].

CONCLUSION

FNAC is a highly accurate, minimally invasive, and cost-effective diagnostic modality for evaluating head and neck lesions. The present meta-analysis demonstrates excellent pooled sensitivity and specificity, supporting its continued role as the initial diagnostic investigation for head and neck masses. Integration with clinical, radiological, and histopathological findings remains essential in equivocal cases.

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