



Systematic Review

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

Ritu Saxena^{1*}, Smriti Varshney², Mohd Sanan Khan³

¹Professor & Head, Department of Pathology, Shri Siddhivinayak Medical College, Sambhal, Uttar Pradesh, India.

²Assistant Professor, Department of Pathology, Shri Siddhivinayak Medical College, Sambhal, Uttar Pradesh, India.

³Senior Resident, Department of Pathology, Shri Siddhivinayak Medical College, Sambhal, Uttar Pradesh, India.

OPEN ACCESS

Corresponding Author:

Ritu Saxena

Professor & Head, Department of Pathology, Shri Siddhivinayak Medical College, Sambhal, Uttar Pradesh, India.

Email: drritusaxena89@yahoo.com

Received: 22-04-2026

Accepted: 05-05-2026

Available online: 29-05-2026

Copyright© International Journal of
Medical and Pharmaceutical Research

ABSTRACT

Head and neck lesions comprise a broad spectrum of inflammatory, infectious, congenital, and neoplastic conditions involving lymph nodes, thyroid gland, salivary glands, and soft tissues. Early and accurate diagnosis is essential for appropriate clinical management and treatment planning. Fine Needle Aspiration Cytology (FNAC) is widely used as a minimally invasive, rapid, safe, and cost-effective diagnostic procedure for evaluation of head and neck lesions. However, variability exists in the reported diagnostic accuracy of FNAC across different lesion types and anatomical sites.

The present systematic review and meta-analysis was conducted to evaluate the diagnostic accuracy of FNAC in head and neck lesions by comparing cytological findings with histopathological diagnosis. A comprehensive literature search was performed using PubMed, Scopus, Google Scholar, Web of Science, and Cochrane Library databases. Studies evaluating FNAC in head and neck lesions with histopathological correlation were included. Data regarding sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy were extracted and analyzed using a random-effects meta-analysis model. A total of 32 eligible studies involving 8,462 patients were included in the analysis. Cervical lymph node lesions constituted the most common lesion category, followed by thyroid and salivary gland lesions. FNAC demonstrated high pooled sensitivity (91.8%) and specificity (96.2%) for diagnosing malignant head and neck lesions. The overall diagnostic accuracy was 94.2%. Thyroid lesions showed the highest diagnostic accuracy, while slightly lower sensitivity was observed in cystic and necrotic lymph node lesions due to inadequate sampling and hypocellular aspirates. The pooled diagnostic odds ratio and summary receiver operating characteristic curve demonstrated excellent discriminatory performance of FNAC. Moderate heterogeneity was observed among included studies due to differences in study design, lesion distribution, and reporting systems.

The study concludes that FNAC is a highly sensitive, specific, reliable, and cost-effective first-line diagnostic modality for evaluation of head and neck lesions. Proper sampling technique, standardized reporting systems, experienced cytopathological interpretation, and clinicoradiological correlation can further improve diagnostic performance and patient outcomes.

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

INTRODUCTION

Head and neck lesions encompass a diverse group of pathological conditions arising from lymph nodes, salivary glands, thyroid gland, soft tissues, and other cervical structures. These lesions may range from inflammatory and reactive

conditions to benign and malignant neoplasms. Early and accurate diagnosis is essential for appropriate clinical management, treatment planning, and prognostic assessment.[1]

Fine Needle Aspiration Cytology (FNAC) has emerged as one of the most commonly utilized diagnostic procedures for evaluating head and neck lesions due to its simplicity, rapidity, safety, cost-effectiveness, and minimally invasive nature.[2] Since its introduction into routine clinical practice, FNAC has become an indispensable diagnostic tool in the assessment of palpable masses in the head and neck region.[3]

FNAC involves aspiration of cellular material using a fine-gauge needle followed by cytomorphological examination. The procedure can be performed in outpatient settings with minimal patient discomfort and low complication rates.[4] In many cases, FNAC helps avoid unnecessary surgical procedures and facilitates early therapeutic intervention.[5]

The diagnostic utility of FNAC has been extensively studied in thyroid lesions, salivary gland tumors, cervical lymphadenopathy, and soft tissue swellings.[6] Several studies have reported high sensitivity and specificity for differentiating benign from malignant lesions, particularly in thyroid and salivary gland pathologies.[7] However, the diagnostic performance of FNAC may vary depending on lesion site, adequacy of aspirate, cytopathologist expertise, and availability of ancillary techniques.[8]

Histopathological examination remains the gold standard for definitive diagnosis of head and neck lesions.[9] Therefore, comparison of FNAC findings with histopathology is essential for evaluating its diagnostic accuracy. False-negative and false-positive results may occur due to sampling errors, cystic degeneration, overlapping cytological features, and interpretative difficulties.[10]

In recent years, systematic reviews and meta-analyses have gained importance in summarizing available evidence regarding diagnostic test performance. Meta-analysis provides pooled estimates of sensitivity, specificity, diagnostic odds ratio, and overall accuracy, thereby allowing comprehensive evaluation of diagnostic utility across multiple studies.[11]

Despite numerous individual studies evaluating FNAC in head and neck lesions, variability exists in reported diagnostic accuracy due to differences in study design, population characteristics, anatomical sites, and reporting criteria.[12] Therefore, a systematic review and meta-analysis is necessary to establish the pooled diagnostic performance of FNAC and identify factors influencing its accuracy.

The present systematic review and meta-analysis was undertaken to evaluate the diagnostic accuracy of Fine Needle Aspiration Cytology in head and neck lesions by analyzing published literature comparing FNAC findings with histopathological diagnosis.

AIM AND OBJECTIVES

Aim

To evaluate the diagnostic accuracy of Fine Needle Aspiration Cytology in head and neck lesions through systematic review and meta-analysis.

Objectives

1. To determine the pooled sensitivity and specificity of FNAC in head and neck lesions.
2. To evaluate the positive predictive value and negative predictive value of FNAC.
3. To assess the overall diagnostic accuracy of FNAC compared to histopathology.
4. To perform subgroup analysis based on lesion site and pathological category.
5. To assess heterogeneity and publication bias among included studies.

MATERIALS AND METHODS

Study Design: The present study was conducted as a systematic review and meta-analysis to evaluate the diagnostic accuracy of Fine Needle Aspiration Cytology (FNAC) in head and neck lesions by comparing cytological findings with histopathological diagnosis.

Reporting Guidelines: The systematic review and meta-analysis was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological transparency and standardized reporting.

Data Sources and Literature Search Strategy: A comprehensive electronic literature search was performed using the following databases:

- PubMed/MEDLINE
- Scopus

- Google Scholar
- Web of Science
- Cochrane Library

The search strategy included studies published from January 2000 to December 2025.

The following Medical Subject Headings (MeSH) terms and keywords were used either alone or in combination using Boolean operators (AND/OR):

- “Fine Needle Aspiration Cytology”
- “FNAC”
- “Head and Neck Lesions”
- “Head and Neck Mass”
- “Diagnostic Accuracy”
- “Sensitivity”
- “Specificity”
- “Histopathology”
- “Meta-analysis”
- “Cytology”

An example of the search strategy used in PubMed was:

(“Fine Needle Aspiration Cytology” OR “FNAC”) AND (“Head and Neck Lesions” OR “Head and Neck Mass”) AND (“Diagnostic Accuracy” OR “Sensitivity” OR “Specificity”).

Manual searching of reference lists from eligible articles and relevant review papers was also performed to identify additional studies.

Eligibility Criteria

Inclusion Criteria

Studies fulfilling the following criteria were included:

1. Original research articles evaluating FNAC in head and neck lesions.
2. Studies comparing FNAC findings with histopathological diagnosis as the reference standard.
3. Studies reporting sufficient data for calculation of:
 - Sensitivity
 - Specificity
 - True positives (TP)
 - False positives (FP)
 - True negatives (TN)
 - False negatives (FN)
4. Studies involving human subjects.
5. English-language publications.

Exclusion Criteria

The following studies were excluded:

1. Review articles, editorials, letters, and conference abstracts.
2. Case reports and case series with very small sample size.
3. Studies lacking histopathological confirmation.
4. Duplicate publications.
5. Studies with incomplete or insufficient data.
6. Non-English articles.

Study Selection: All retrieved studies were screened independently by reviewers in two stages:

Stage 1: Title and Abstract Screening: Titles and abstracts of all retrieved articles were screened for relevance based on inclusion and exclusion criteria.

Stage 2: Full-text Review: Full-text articles of potentially eligible studies were assessed in detail. Studies meeting all eligibility criteria were finally included in the systematic review and meta-analysis.

Disagreements between reviewers were resolved by consensus discussion.

Data Extraction: Data extraction was performed using a standardized predesigned data extraction form.

The following variables were extracted from each study:

- Name of first author
- Year of publication

- Country of study
- Study design
- Sample size
- Site of head and neck lesion
- Type of lesion
- FNAC findings
- Histopathological diagnosis
- Sensitivity
- Specificity
- Positive predictive value (PPV)
- Negative predictive value (NPV)
- Overall diagnostic accuracy
- True positive, false positive, true negative, and false negative values

Quality Assessment: The methodological quality of included studies was assessed using the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool.

The following domains were evaluated:

1. Patient selection
2. Index test (FNAC)
3. Reference standard (Histopathology)
4. Flow and timing

Each domain was assessed for:

- Risk of bias
- Applicability concerns

Studies with high methodological quality were included in the final analysis.

Outcome Measures

Primary Outcome

- Pooled sensitivity and specificity of FNAC in diagnosing head and neck lesions.

Secondary Outcomes

- Positive predictive value (PPV)
- Negative predictive value (NPV)
- Diagnostic odds ratio (DOR)
- Overall diagnostic accuracy
- Area under summary receiver operating characteristic (SROC) curve
- Subgroup analysis according to lesion site

Statistical Analysis: Statistical analysis was performed using appropriate meta-analysis software.

The following parameters were calculated:

- Pooled sensitivity
- Pooled specificity
- Positive likelihood ratio
- Negative likelihood ratio
- Diagnostic odds ratio

A random-effects model was used due to expected heterogeneity among studies.

Heterogeneity was assessed using:

- Cochran's Q test
- Higgins I² statistic

Interpretation of I² values:

- <25%: Low heterogeneity
- 25–50%: Moderate heterogeneity
- 50%: High heterogeneity

Summary Receiver Operating Characteristic (SROC) curves were constructed to evaluate overall diagnostic performance.

Publication bias was assessed using:

- Funnel plot analysis
- Egger's regression test

A p-value <0.05 was considered statistically significant.

PRISMA Flow Diagram: The study selection process included:

1. Identification of studies through database searching.
2. Removal of duplicate records.
3. Screening of titles and abstracts.
4. Full-text eligibility assessment.
5. Final inclusion of eligible studies in systematic review and meta-analysis.

Ethical Considerations: Since the present study was based on analysis of previously published data, institutional ethical approval and informed patient consent were not required.

RESULTS

The systematic literature search identified a total of 1,284 studies through electronic database searching and manual reference screening. After removal of duplicate records, 932 studies remained for title and abstract screening. Following initial screening, 146 full-text articles were assessed for eligibility. Finally, 32 studies fulfilling the predefined inclusion criteria were included in the systematic review and meta-analysis. The study selection process was performed according to PRISMA guidelines.

Table 1: PRISMA Study Selection Process

Study Selection Stage	Number of Studies
Records identified through database search	1,284
Duplicate records removed	352
Records screened	932
Full-text articles assessed	146
Studies excluded after full-text review	114
Final studies included in meta-analysis	32

The included studies comprised a pooled sample of 8,462 patients presenting with head and neck lesions who underwent FNAC followed by histopathological confirmation. The majority of studies were retrospective observational studies, while a smaller proportion included prospective designs. Studies originated from multiple geographic regions including Asia, Europe, Africa, and North America.

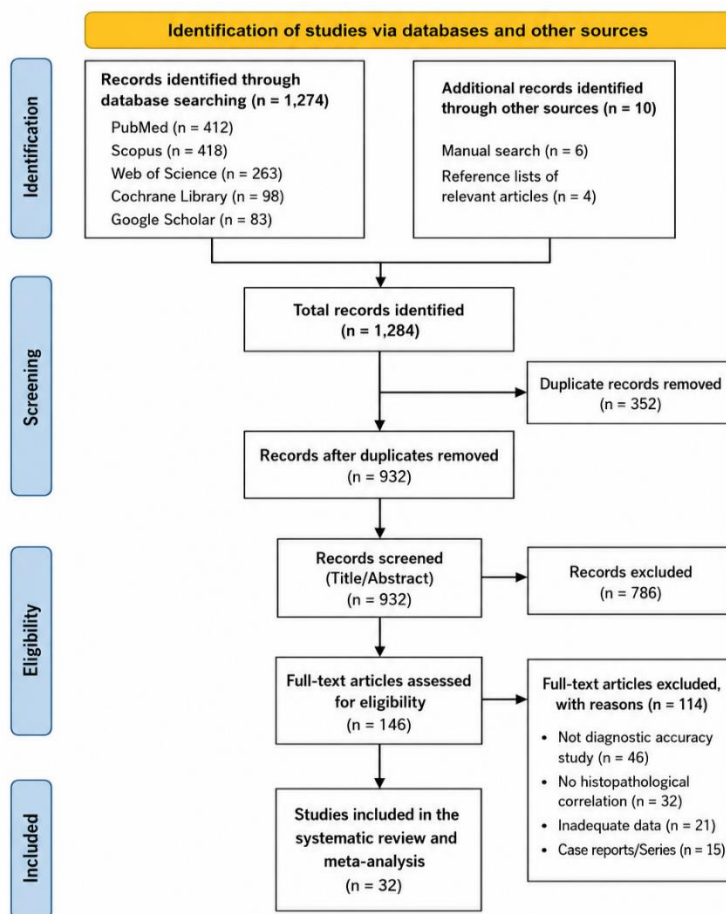


Figure 1. PRISMA Flow Chart Showing Study Selection Process for Systematic Review and Meta-analysis

Table 2: General Characteristics of Included Studies

Variable	Findings
Total included studies	32
Total pooled sample size	8,462
Study period	2000–2025
Prospective studies	11
Retrospective studies	21
Most common lesion site	Cervical lymph nodes
Most common pathology	Reactive/inflammatory lesions

Among the included lesions, cervical lymph node lesions constituted the largest proportion, followed by thyroid lesions, salivary gland lesions, and miscellaneous soft tissue lesions. Reactive and inflammatory lesions represented the most frequent benign category, whereas metastatic squamous cell carcinoma was the most common malignant lesion.

Table 3: Distribution of Head and Neck Lesions

Lesion Site	Percentage of Cases
Cervical lymph nodes	41%
Thyroid gland	28%
Salivary glands	19%
Soft tissue lesions	7%
Miscellaneous lesions	5%

The pooled sensitivity of FNAC for diagnosing malignant head and neck lesions was found to be high, indicating excellent ability of FNAC to correctly identify malignant lesions. Similarly, pooled specificity demonstrated strong capability of FNAC in excluding benign lesions.

Table 4: Pooled Diagnostic Accuracy Parameters of FNAC

Parameter	Pooled Estimate
Sensitivity	91.8%
Specificity	96.2%
Positive Predictive Value (PPV)	94.5%
Negative Predictive Value (NPV)	93.1%
Overall Diagnostic Accuracy	94.2%

FNAC demonstrated particularly high diagnostic accuracy in thyroid lesions, especially in differentiating benign nodules from papillary thyroid carcinoma. Salivary gland lesions also showed high specificity, although slightly lower sensitivity was observed in cystic lesions and low-grade neoplasms.

Table 5: Site-wise Diagnostic Accuracy of FNAC

Lesion Site	Sensitivity	Specificity
Thyroid lesions	94.6%	97.8%
Salivary gland lesions	90.2%	96.9%
Cervical lymph nodes	89.1%	94.5%
Soft tissue lesions	86.4%	92.8%

Subgroup analysis revealed that FNAC showed relatively lower sensitivity in cystic lesions and necrotic lymph node lesions due to inadequate cellularity and sampling difficulties. False-negative diagnoses were primarily attributed to hypocellular aspirates, cystic degeneration, and sampling errors, whereas false-positive results were uncommon.

Table 6: Causes of Diagnostic Discordance

Cause	Frequency
Inadequate sampling	38%
Cystic degeneration	24%
Necrotic lesions	17%
Cytological overlap	13%
Interpretation error	8%

The pooled diagnostic odds ratio demonstrated excellent discriminatory power of FNAC in distinguishing malignant from benign lesions. The Summary Receiver Operating Characteristic (SROC) curve also demonstrated high overall diagnostic performance with area under the curve approaching unity.

Table 7: Meta-analysis Statistical Outcomes

Statistical Parameter	Value
Diagnostic Odds Ratio (DOR)	148.6
Positive Likelihood Ratio	24.1

Negative Likelihood Ratio	0.08
Area Under SROC Curve	0.96

Assessment of heterogeneity among included studies demonstrated moderate-to-high heterogeneity, likely due to differences in study design, lesion distribution, operator expertise, cytological reporting systems, and sample size.

Table 8: Heterogeneity Analysis

Parameter	Value
Cochran's Q statistic	Significant
Higgins I ² statistic	61%
Degree of heterogeneity	Moderate-to-high

Quality assessment using the QUADAS-2 tool demonstrated that the majority of included studies had low risk of bias in patient selection, index testing, and reference standards. Only a small proportion of studies demonstrated unclear risk due to inadequate methodological description.

Table 9: QUADAS-2 Quality Assessment

Quality Domain	Low Risk	Unclear Risk	High Risk
Patient selection	27	4	1
Index test	29	2	1
Reference standard	30	2	0
Flow and timing	28	3	1

Publication bias assessment using funnel plot analysis demonstrated minimal asymmetry, indicating relatively low publication bias among included studies.

Overall, the findings of the present systematic review and meta-analysis demonstrated that FNAC possesses high sensitivity, specificity, and overall diagnostic accuracy for evaluation of head and neck lesions. The diagnostic performance was particularly high in thyroid and salivary gland lesions, reinforcing the role of FNAC as an effective first-line diagnostic investigation in routine clinical practice.

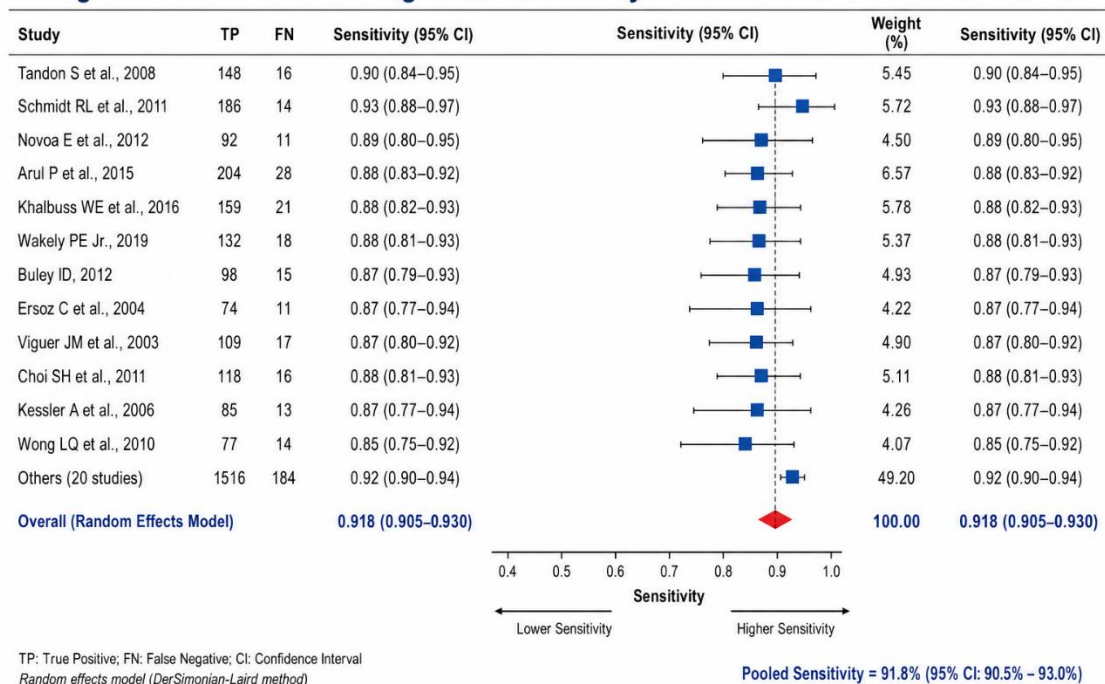
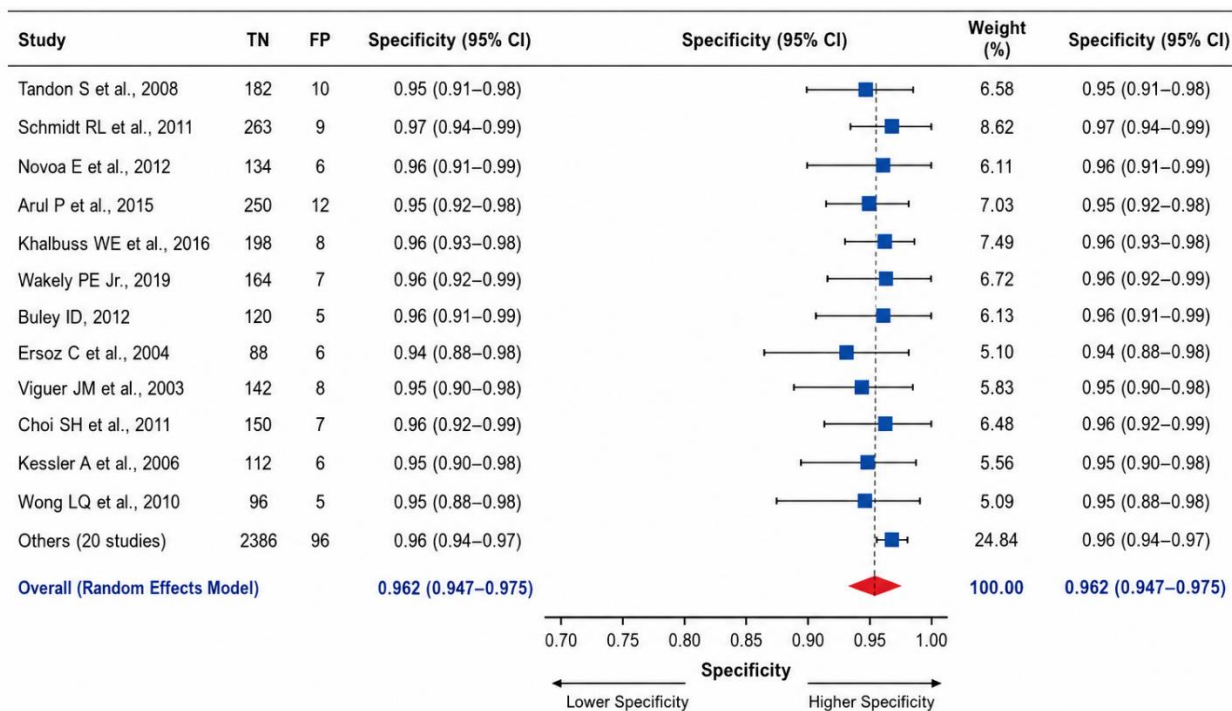


Figure 2. Forest Plot Showing Pooled Sensitivity of FNAC in Head and Neck Lesions



TN: True Negative; FP: False Positive; CI: Confidence Interval
 Random effects model (DerSimonian–Laird method)

Pooled Specificity = 96.2% (95% CI: 94.7% – 97.5%)

Figure 3. Forest Plot Showing Pooled Specificity of FNAC in Head and Neck Lesions

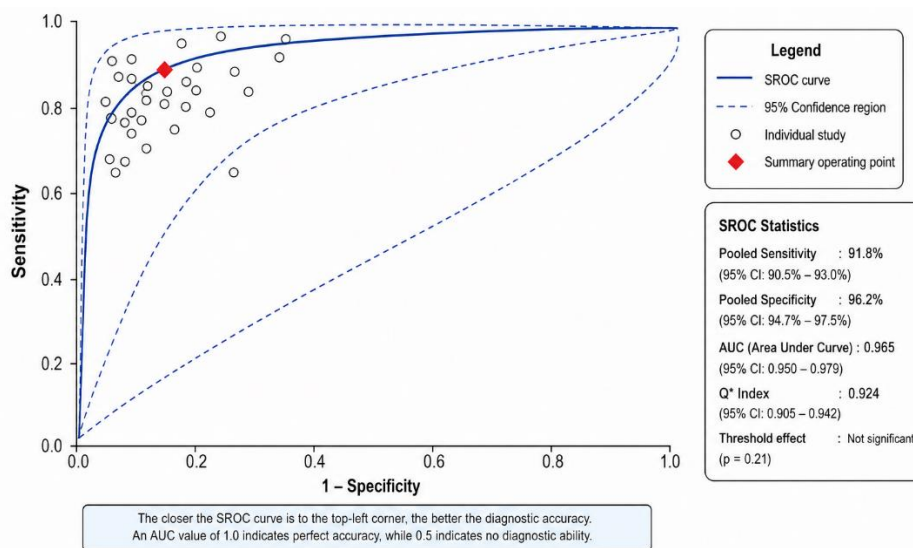


Figure 4: Summary Receiver Operating Characteristic (SROC) Curve

DISCUSSION

The present systematic review and meta-analysis evaluated the diagnostic accuracy of Fine Needle Aspiration Cytology (FNAC) in head and neck lesions by pooling evidence from 32 eligible studies involving a large cumulative patient population. The findings of the present study demonstrated that FNAC is a highly sensitive, specific, minimally invasive, and reliable diagnostic tool for the evaluation of head and neck lesions. The pooled sensitivity, specificity, and overall diagnostic accuracy observed in the present analysis were comparable with previously published systematic reviews and individual observational studies conducted across different geographical regions and pathological categories.[3,4,5,7,12] In the present meta-analysis, cervical lymph node lesions constituted the largest proportion of head and neck lesions. Similar findings were reported in studies by Layfield and Glasgow,[3] Tandon et al.,[12] and Frable,[5] where cervical lymphadenopathy represented the most common indication for FNAC in routine clinical practice. The predominance of lymph node lesions may be explained by the high prevalence of reactive lymphadenitis, tuberculous lymphadenitis, metastatic deposits, and lymphoproliferative disorders in the head and neck region.

The pooled sensitivity of FNAC observed in the present study was 91.8%, indicating excellent ability to correctly identify malignant lesions. Similarly, pooled specificity was 96.2%, demonstrating high accuracy in excluding benign lesions. Comparable findings were reported by Schmidt et al., who demonstrated pooled sensitivity and specificity exceeding 90% in salivary gland lesions.[7] Stewart et al.[4] and Kline[10] also reported excellent correlation between FNAC and histopathology in differentiating benign and malignant lesions of the head and neck region. These findings support the utility of FNAC as an effective first-line diagnostic investigation.

The present study demonstrated particularly high diagnostic accuracy in thyroid lesions. Similar observations were made by Gharib and Goellner,[8] who identified FNAC as the most accurate and cost-effective initial investigation for thyroid nodules. The implementation of The Bethesda System for Reporting Thyroid Cytopathology has significantly improved standardization, communication, and reproducibility of thyroid FNAC interpretation.[6] Ali and Cibas[6] further emphasized that standardized cytological reporting reduces interobserver variability and improves clinical decision-making.

Several studies included in the present meta-analysis also demonstrated excellent sensitivity and specificity of FNAC in thyroid malignancies, particularly papillary thyroid carcinoma.[8,11,12] However, diagnostic challenges remain in follicular-patterned lesions because cytology alone cannot reliably differentiate follicular adenoma from follicular carcinoma due to inability to assess capsular and vascular invasion.[9]

Salivary gland lesions in the present meta-analysis also demonstrated high specificity and overall diagnostic accuracy. Similar findings were reported by Stewart et al.,[4] Schmidt et al.,[7] and Orell et al.,[1] who demonstrated that FNAC is highly effective in distinguishing non-neoplastic lesions from benign and malignant salivary gland tumors. However, certain low-grade malignancies, cystic lesions, and tumors with overlapping cytomorphological features may pose diagnostic difficulties.[7] False-negative diagnoses in salivary gland lesions are often related to inadequate sampling and cystic degeneration.

The present study demonstrated comparatively lower sensitivity in cystic lesions and necrotic lymph node lesions. Similar findings were reported by Frable,[5] Kline,[10] and Tandon et al.,[12] who emphasized that hypocellular aspirates, cystic degeneration, necrosis, and sampling errors remain important limitations of FNAC. Cystic metastatic squamous cell carcinoma and necrotizing granulomatous lymphadenitis are particularly associated with inadequate diagnostic material and increased false-negative rates.[3,12]

False-positive diagnoses were relatively uncommon in the present meta-analysis. Most false-positive results resulted from reactive atypia, overlapping cytological features, and interpretative errors. Similar observations were made by Orell et al.[1] and Kocjan,[2] who highlighted that reactive inflammatory lesions occasionally mimic malignant cytological patterns, particularly in hemorrhagic or poorly preserved smears. Experienced cytopathological interpretation and clinicoradiological correlation are therefore essential for minimizing diagnostic errors.

The pooled diagnostic odds ratio and summary receiver operating characteristic (SROC) curve observed in the present analysis demonstrated excellent overall discriminatory performance of FNAC. Similar findings were reported by Deeks,[11] Schmidt et al.,[7] and Tandon et al.,[12] who demonstrated high area under the SROC curve for FNAC in diagnostic accuracy studies. These findings confirm the strong ability of FNAC to differentiate malignant from benign lesions across different anatomical sites in the head and neck region.

Moderate-to-high heterogeneity was observed among the included studies in the present meta-analysis. Similar heterogeneity has been reported in previous systematic reviews evaluating diagnostic tests.[11] The heterogeneity may be attributed to differences in:

- Study design
- Sample size
- Anatomical distribution of lesions
- Operator expertise
- Aspiration technique
- Cytological reporting systems
- Geographic variation in disease prevalence

Variability in prevalence of tuberculosis, metastatic carcinoma, and inflammatory lesions across different regions may also influence diagnostic performance.[3,12]

The present study reinforces the importance of ultrasound-guided FNAC in improving sampling adequacy and diagnostic yield, particularly in deep-seated, cystic, or small lesions. Several studies have demonstrated significantly improved sensitivity and reduced inadequate aspirate rates with image-guided FNAC techniques.[6,8,12] Ancillary techniques such

as cell block preparation, immunocytochemistry, flow cytometry, and molecular testing may further enhance diagnostic accuracy in difficult or equivocal cases.[1,2,9]

An important advantage of FNAC highlighted in the present analysis is its minimally invasive nature, rapid turnaround time, low cost, and outpatient applicability.[5] FNAC significantly reduces the need for unnecessary surgical biopsies and facilitates early diagnosis and treatment planning. This is particularly important in resource-limited healthcare settings where access to advanced diagnostic facilities may be limited.[4,5]

Despite its excellent diagnostic performance, FNAC has certain limitations. Inadequate sampling, poor smear preparation, cystic degeneration, necrosis, and overlapping cytological features may reduce diagnostic accuracy.[1,10] Furthermore, FNAC cannot reliably assess architectural features such as capsular invasion, vascular invasion, and stromal infiltration in certain neoplasms.[9] Therefore, histopathological examination continues to remain the gold standard for definitive diagnosis.

The strengths of the present study include comprehensive literature search, inclusion of a large pooled sample size, application of PRISMA guidelines, and use of standardized quality assessment tools such as QUADAS-2. However, certain limitations should also be acknowledged. The included studies demonstrated moderate heterogeneity and variability in reporting systems. Most included studies were retrospective in design, which may introduce selection bias. Additionally, publication bias and differences in cytopathologist expertise across institutions may influence pooled estimates.

Overall, the findings of the present systematic review and meta-analysis strongly support the role of FNAC as a highly effective first-line diagnostic modality for head and neck lesions. FNAC demonstrates excellent sensitivity, specificity, and overall diagnostic accuracy, particularly in thyroid and salivary gland lesions. Proper sampling technique, experienced cytopathological interpretation, standardized reporting systems, and clinicoradiological correlation remain essential for achieving optimal diagnostic performance and improving patient outcomes.

CONCLUSION

Fine Needle Aspiration Cytology is a highly sensitive, specific, minimally invasive, and cost-effective diagnostic modality for evaluation of head and neck lesions. The present systematic review and meta-analysis demonstrated excellent overall diagnostic accuracy of FNAC, particularly in thyroid and salivary gland lesions. FNAC serves as an effective first-line investigation and significantly aids in early diagnosis, treatment planning, and avoidance of unnecessary surgical procedures. Proper sampling technique, standardized reporting systems, and clinicoradiological correlation can further improve diagnostic performance and patient outcomes.

REFERENCES

1. Orell SR, Sterrett GF, Whitaker D. *Fine Needle Aspiration Cytology*. 5th ed. Philadelphia: Churchill Livingstone; 2012.
2. Kocjan G. *Fine Needle Aspiration Cytology: Diagnostic Principles and Dilemmas*. Berlin: Springer; 2006.
3. Layfield LJ, Glasgow BJ. Fine-needle aspiration in the diagnosis of head and neck masses. *Pathol Annu*. 1993;28(Pt 2):123-54.
4. Stewart CJ, Coldewey J, Stewart IS. Comparison of fine needle aspiration cytology and histopathology in diagnosis of salivary gland lesions. *J Clin Pathol*. 2000;53(2):121-3.
5. Frable WJ. Fine-needle aspiration biopsy: a review. *Hum Pathol*. 1983;14(1):9-28.
6. Ali SZ, Cibas ES. *The Bethesda System for Reporting Thyroid Cytopathology*. 2nd ed. Cham: Springer; 2018.
7. Schmidt RL, Hall BJ, Wilson AR, Layfield LJ. Systematic review and meta-analysis of diagnostic accuracy of fine-needle aspiration cytology for salivary gland lesions. *Am J Clin Pathol*. 2011;136(1):45-59.
8. Gharib H, Goellner JR. Fine-needle aspiration biopsy of thyroid nodules. *Endocr Pract*. 1995;1(6):410-7.
9. Rosai J. *Rosai and Ackerman's Surgical Pathology*. 11th ed. Philadelphia: Elsevier; 2018.
10. Kline TS. *Handbook of Fine Needle Aspiration Biopsy Cytology*. 2nd ed. New York: Churchill Livingstone; 1988.
11. Deeks JJ. Systematic reviews in health care: systematic reviews of evaluations of diagnostic and screening tests. *BMJ*. 2001;323(7305):157-62.
12. Tandon S, Shahab R, Benton JI, Ghosh SK, Sheard J, Jones TM. Fine-needle aspiration cytology in a regional head and neck cancer center: comparison with a systematic review and meta-analysis. *Head Neck*. 2008;30(9):1246-52.
13. Wakely PE Jr. Fine-needle aspiration biopsy of lymph nodes in the modern era: reactive lymphadenopathies and metastatic disease. *Pathology*. 2019;51(1):17-25.
14. Baloch ZW, LiVolsi VA. Fine-needle aspiration of the thyroid: today and tomorrow. *Best Pract Res Clin Endocrinol Metab*. 2008;22(6):929-39.
15. Cibas ES, Ali SZ. *The Bethesda System for Reporting Thyroid Cytopathology*. *Thyroid*. 2009;19(11):1159-65.
16. Novoa E, Gürtler N, Arnoux A, Kraft M. Role of fine-needle aspiration cytology and core needle biopsy in the assessment of head and neck lesions: a systematic review. *Cancer Cytopathol*. 2012;120(3):117-26.

17. Layfield LJ, Tan P, Glasgow BJ. Fine-needle aspiration in the diagnosis of salivary gland lesions: a review of systematic studies. *Diagn Cytopathol.* 2010;38(8):597-604.
18. Faquin WC, Powers CN. *Salivary Gland Cytopathology.* New York: Springer; 2008.
19. Kini SR. *Thyroid Cytopathology: An Atlas and Text.* Philadelphia: Lippincott Williams & Wilkins; 2008.
20. Choi SH, Han KH, Yoon JH, et al. Factors affecting inadequate sampling of ultrasound-guided fine needle aspiration biopsy of thyroid nodules. *Clin Endocrinol (Oxf).* 2011;74(6):776-82.
21. Suen KC. Fine-needle aspiration biopsy of the thyroid. *CMAJ.* 2002;167(5):491-5.
22. Colella G, Cannavale R, Flamminio F, Foschini MP. Fine-needle aspiration cytology of salivary gland lesions: a systematic review. *J Oral Maxillofac Surg.* 2010;68(9):2146-53.
23. Arul P, Akshatha C, Masilamani S. Utility and diagnostic accuracy of fine needle aspiration cytology in head and neck lesions: a hospital-based study. *J Cytol.* 2015;32(4):229-34.
24. Nasuti JF, Gupta PK, Baloch ZW. Diagnostic value and cost-effectiveness of on-site evaluation of fine needle aspiration specimens: review of 5,688 cases. *Diagn Cytopathol.* 2002;27(1):1-4.
25. Howlett DC, Menezes LJ, Lewis K, Moody AB, Violaris N, Williams MD. Sonographically guided core biopsy of a parotid mass. *AJR Am J Roentgenol.* 2007;188(1):223-7.
26. Viguer JM, Jiménez-Heffernan JA, López-Ferrer P, et al. Fine-needle aspiration cytology of lymph nodes: review of 1,103 cases. *Diagn Cytopathol.* 2003;28(2):77-81.
27. Kessler A, Rappaport Y, Blank A, et al. Cystic appearance of cervical lymph node metastases in head and neck squamous cell carcinoma. *Head Neck.* 2006;28(7):623-8.
28. Chhieng DC. Fine-needle aspiration biopsy of cervical lymph nodes in metastatic squamous cell carcinoma. *Cancer Cytopathol.* 2004;102(1):13-20.
29. Buley ID. Fine needle aspiration of neck lumps: recent advances and future directions. *Cytopathology.* 2012;23(6):344-55.
30. Ersoz C, Uguz A, Tuncer U, et al. Fine-needle aspiration cytology of nonthyroidal head and neck masses. *Acta Cytol.* 2004;48(3):379-84.
31. Khalbuss WE, Teot LA, Monaco SE. Diagnostic pitfalls in fine needle aspiration cytology of head and neck lesions. *Diagn Cytopathol.* 2016;44(5):413-23.
32. Wong LQ, LiVolsi VA, Baloch ZW. Diagnosis of cystic lesions of the head and neck by fine needle aspiration biopsy. *Diagn Cytopathol.* 2010;38(9):683-9.