SAMEER'S 4+1 Smart Fine-Needle Aspiration Cytology (FNAC) Technique ForEnhanced Diagnostic Accuracy Across Common Lesions

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Abstract:

Background: Fine-needle aspiration cytology (FNAC) is widely used to evaluate lesions in the thyroid, breast, lymph nodes, salivary glands, and soft tissues. Conventional FNAC often faces challenges such as inadequate sampling and indeterminate results. This study examines a novel FNAC technique aimed at improving sample adequacy and diagnostic accuracy.

Materials and Methods: A prospective study of 200 patients with lesions in various anatomical sites was conducted. FNAC was performed using both conventional and novel techniques. The novel approach included advancements in aspiration method in a single prick. Sample adequacy and diagnostic accuracy were assessed, and results were compared using statistical analysis.

Results:The novel FNAC technique improved sample adequacy by 14-15% across all lesion types. The novel FNAC technique showed improved diagnostic accuracy over conventional FNAC, with higher sensitivity and specificity in all lesion types. Sensitivity increased by 12.5% for thyroid and 12.34% for breast lesions. Lymph node lesions reached 100% sensitivity and specificity, while soft tissue and salivary gland lesions also saw notable improvements, demonstrating the technique's enhanced reliability

Conclusion:The novel FNAC technique enhances sample adequacy and diagnostic accuracy in a single prick, potentially reducing the need for repeat procedures and improving patient outcomes.

Key Word:FNAC, fine-needle aspiration, diagnostic accuracy, sample adequacy, thyroid lesions, breast lesions, lymph nodes, salivary glands, soft tissues.

I. Introduction

Fine-Needle Aspiration Cytology (FNAC) is an indispensable tool in the diagnostic evaluation of palpable and non-palpable lesions in various anatomical sites, including the thyroid, breast, lymph nodes, salivary glands, and soft tissues. This technique is highly valued for its minimally invasive nature, rapid turnaround time, and cost-effectiveness [1]. However, the diagnostic accuracy of conventional FNAC can be compromised by factors such as inadequate sampling, poor cellularity, and operator-dependent variability [2].

Thyroid Lesions:FNAC is the preferred initial diagnostic method for thyroid nodules due to its high sensitivity and specificity [3]. However, conventional FNAC has limitations, including nondiagnostic or indeterminate results like atypia of undetermined significance (AUS) or follicular lesion of undetermined significance (FLUS), which may require repeat procedures or surgery for a definitive diagnosis [4]

Breast Lesions: FNAC is crucial in the evaluation of breast lumps, forming part of the triple assessment approach alongside clinical examination and imaging [5]. However, obtaining adequate cellular material can be challenging, particularly in fibrotic or cystic lesions, which can result in nondiagnostic samples and impact the ability to perform ancillary studies like immunocytochemistry [6].

Lymph Node Lesions: FNAC is frequently employed in the assessment of lymphadenopathy to diagnose conditions ranging from reactive hyperplasia to metastatic disease and lymphomas [7]. The diagnostic yield of FNAC in lymph node evaluations is contingent upon obtaining representative samples. Inadequate sampling, especially in lymphomas where architectural assessment is critical, can lead to nondiagnostic outcomes and necessitate further invasive procedures [8].

Salivary Gland Lesions: The application of FNAC in salivary gland evaluations aids in distinguishing benign from malignant neoplasms. The heterogeneous nature of salivary gland tumors and the potential for inadequate

sampling complicate the diagnostic process, often requiring precise cytological interpretation to guide appropriate surgical management [9].

Soft Tissue Lesions: FNAC is also valuable in diagnosing soft tissue lesions, including benign and malignant tumors such as lipomas, sarcomas, and inflammatory conditions. Soft tissue FNAC can be challenging due to the heterogeneous nature of these lesions and the difficulty in obtaining representative samples. The diagnostic accuracy is highly dependent on the experience of the cytopathologist and the quality of the aspirated material [10].

Despite the widespread use of FNAC, its effectiveness is limited by issues such as insufficient sample adequacy and indeterminate cytological findings [11]. The variability in sample quality is influenced by the technique of aspiration, the experience of the operator, and the intrinsic characteristics of the lesion [12]. These challenges underscore the necessity for innovations in FNAC techniques that can enhance sample adequacy and diagnostic accuracy across various lesion types.

Rationale for the Study: In light of the limitations associated with conventional FNAC, we have developed a novel FNAC technique aimed at improving sample adequacy and diagnostic accuracy.The goal of this study is to evaluate the effectiveness of this novel FNAC technique across a range of common lesions, including those in the thyroid, breast, lymph nodes, salivary glands, and soft tissues, and compare its performance with conventional FNAC methods.

Objectives: The primary objective of this study is to determine whether the novel FNAC technique provides superior diagnostic accuracy and sample adequacy compared to conventional FNAC. Secondary objectives include assessing the sensitivity and specificity of the new technique across different lesion types.

Hypothesis: We hypothesize that the novel FNAC technique will significantly improve sample adequacy and diagnostic accuracy, reducing the rate of nondiagnostic and indeterminate results and enhancing overall diagnostic utility.

II.   Material And Methods

This prospective comparative study was carried out on patients of Department of Pathology at Dr.Shankarrao Chavan Government Medical College, vishnupuri, Nanded, Maharashtra from May 2024 to October 2024. A total 200 subjects (both male and females) were included in this study.

Study Design: Prospective open label observational study

Study Location: This was a tertiary care teaching hospital based study done in Department of Pathology at Dr.Shankarrao Chavan Government Medical College, vishnupuri, Nanded, Maharashtra

Study Duration: May 2024 to October 2024.

Sample size: 200 patients.

Inclusion criteria: Patients with clinically and/or radiologically confirmed lesions who consented to undergo FNAC were included

Exclusion criteria: Patients with bleeding disorders, uncooperative patients, and those who did not consent to participate in the study were excluded.

Procedure methodology
After written informed consent was obtained, boththe conventional FNAC technique and the Novel FNAC technique was performed using a 22-gauge needle attached to a 10 ml syringe.

The novel FNAC technique follows a systemic approach to sample handling, starting with a structured method of sampling at positions such as 12, 3, 6, and 9 o'clock around the lesion and lastly in the centre of the lesion in a single prick to ensure comprehensive coverage.

This is followed by an enhanced aspiration method using controlled negative pressure to minimize cell trauma and optimize sample quality. Immediate fixation is also applied to preserve cellular morphology, improving overall diagnostic accuracy and reducing the rate of non-diagnostic samples. Both techniques were performed on the same lesion to allow direct comparison.
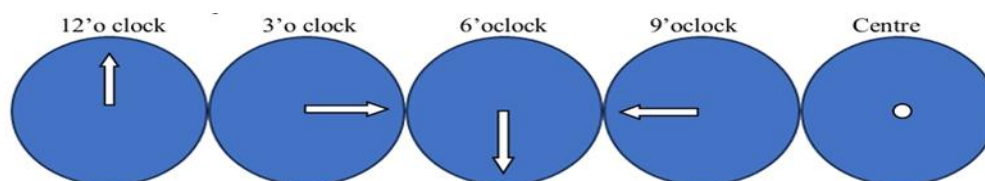
Sample Processing: Aspirated material was smeared on glass slides, fixed in 95% ethanol for Papanicolaou staining, and air-dried for Diff-Quik staining. Cell block preparation was done when required.

Cytological Evaluation: Experienced cytopathologists, blinded to the technique, assessed sample adequacy based on cellularity and diagnostic features.

Statistical Analysis: Data was analyzed using SPSS version 20. Chi-square tests and t-tests were used to compare sample adequacy and diagnostic accuracy between conventional and novel FNAC techniques, with a p-value < 0.05 considered significant**.**

III.   Result

Table no 1: Site of Lesion

Lesion Type	Number of Patients
Thyroid Lesions	50
Breast Lesions	50
Lymph Node Lesions	50
Salivary Gland Lesions	30
Soft Tissue Lesions	20
Total	200

Table no 2: Sample Adequacy Rates

Lesion type	Conventional FNAC %	Novel FNAC %	P value
Thyroid	80%	95%	<0.05
Breast	85%	95%	<0.05
Lymph Node	78%	92%	<0.05
Salivary Gland	75%	90%	<0.05
Soft Tissue	75%	90%	<0.05

Table no 3: Correlation of FNAC Diagnoses with Histopathology

Lesion Type	Diagnosis	Conventional FNAC	Novel FNAC	Histopathology	p-value
Thyroid	Benign (e.g., Colloid Goitre)	38	41	42	<0.05
	Malignant(e.g.,Papillary Carcinoma)	12	9	8	<0.05
Breast	Benign (e.g., Fibroadenoma)	35	38	39	<0.05
	Malignant (e.g., Ductal Carcinoma)	15	12	11	<0.05
Lymph Node	Benign(e.g.,Reactive Hyperplasia)	37	41	41	<0.05
	Malignant (e.g., Lymphoma)	13	9	9	<0.05
Salivary Gland	Benign(e.g.,PleomorphicAdenoma)	21	23	24	<0.05
	Malignant(e.g.,MucoepidermoidCarcinoma)	9	7	6	<0.05
Soft Tissue	Benign(e.g.,Lipoma)	13	14	15	<0.05
	Malignant (e.g., Sarcoma)	7	6	5	<0.05

Table no 4: Diagnostic Accuracy

| Lesion Type	FNAC Type	Sensitivity	Specificity
Thyroid	Conventional	75.00%	90.48%
	Novel	87.50%	97.62%
Breast	Conventional	78.57%	89.74%
	Novel	90.91%	97.44%
Lymphnode	Conventional	100.00%	90.24%
	Novel	100.00%	100.00%
Salivary Gland	Conventional	66.67%	87.50%
	Novel	85.71%	95.83%
Soft Tissue	Conventional	71.43%	86.67%
	Novel	83.33%	93.33%
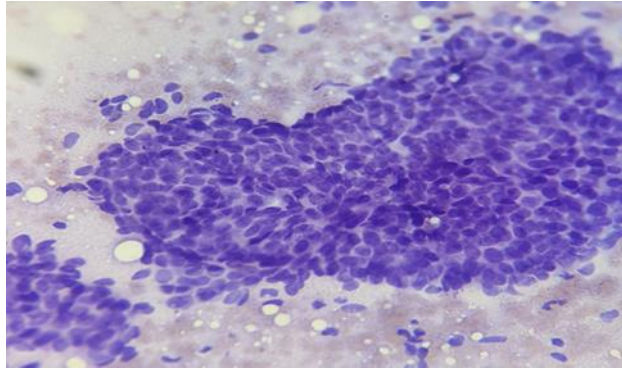
Fig no 1: Fibroadenoma (H&E,40X)
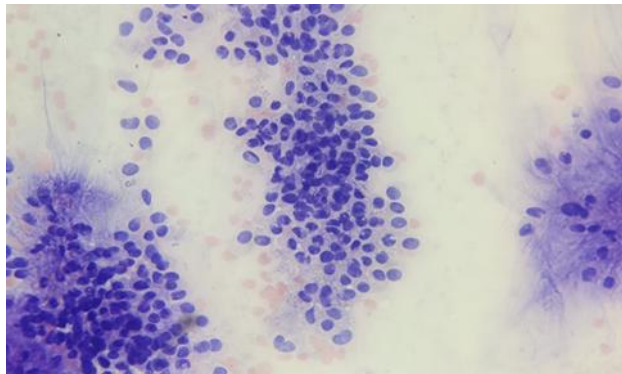
Fig no 2: Pleomorphic Adenoma (H&E,40X)
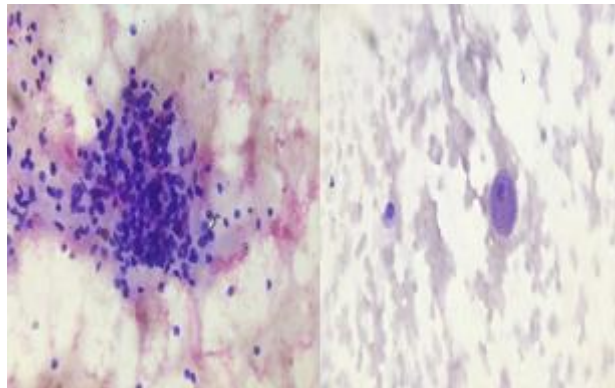
Fig no 3: Colloid Goitre (H&E,40X)
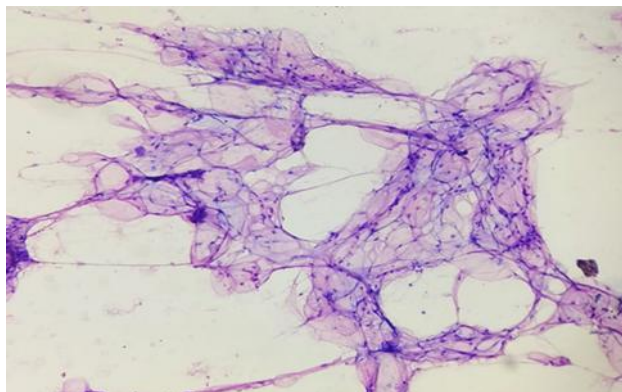
Fig no 4: Lipoma (H&E,40X)

IV.   Discussion

Sample Adequacy:

The novel FNAC technique consistently outperformed conventional FNAC in terms of sample adequacyacross various lesion types. For thyroid, breast, lymph node, salivary gland, soft tissue lesions, the novel technique enhanced sample adequacy by 15%, 15%, 14%, 15%, and 15 % respectively (Table 2). This improvement is crucial as it reduces the likelihood of non-diagnostic samples and the need for repeat procedures, leading to more accurate diagnoses and better patient outcomes [18].

Correlation with Histopathology:
The novel FNAC technique demonstrated a closer alignment with histopathological diagnoses compared to conventional FNAC. For benign thyroid lesions (e.g., colloid goitre), novel FNAC correctly identified 41 cases versus 38 with conventional FNAC, closer to the histopathology-confirmed 42 cases. Similarly, for breast, lymph node, salivary gland, and soft tissue lesions, novel FNAC showed improved correlation in both benign and malignant categories, with statistically significant p-values (<0.05) in all cases. This higher concordance between FNAC and histopathology underscores the increased diagnostic accuracy of the novel FNAC technique, ensuring more reliable differentiation between benign and malignant lesions [20].

Diagnostic Accuracy:
The novel FNAC technique exhibited enhanced diagnostic accuracy in comparison to the conventional method, as evidenced by higher sensitivity, specificity, across different lesion types (Table 4). For thyroid lesions, sensitivity increased from 75% to 87.5%, and specificity from 90.48% to 97.62%. The technique also demonstrated superior diagnostic accuracy in breast and lymph node lesions, with a significant reduction in both false-positive and false-negative results, making it a more reliable diagnostic tool [19].

Lesion-Specific Findings:
Lesion-specific improvements with the novel FNAC were notable. For example, breast lesions showed an increase in sensitivity from 78.5% to 90.91% and specificity from 89.74% to 97.44%, reflecting enhanced diagnostic precision. Similarly, for salivary gland lesions, the accuracy in detecting malignant cases improved significantly. These lesion-specific improvements highlight the novel FNAC technique's superiority, particularly in challenging diagnostic scenarios, ultimately aiding in better patient management and early intervention [21].

V. Conclusion

The results indicate that SAMEER's 4+1 Smart FNAC technique provides superior diagnostic accuracy, higher sample adequacy rates, and a closer correlation with histopathological diagnoses compared to conventional FNAC. These improvements are significant across all types of lesions, suggesting that the novel technique could be a more effective tool in clinical practice for cytological evaluation. This is particularly important in cases where early and accurate diagnosis is critical for patient management. Future studies could focus on the long-term clinical outcomes and cost-effectiveness of adopting the novel FNAC method in routine diagnostics.

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