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RESEARCH ARTICLE

Cytoarchitectural Elucidation of Salivary Gland Lesions: Diagnostic Complexities and Interpretive Paradigms.

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Abstract: ***Context***: Salivary gland lesions encompass a multifaceted spectrum of low grade and invasive entities, often presenting diagnostic challenges due to overlapping clinical and radiological features. Minimally invasive cytological technique serves as a minimally invasive, pragmatic financial standpoint for initial evaluation, offering valuable insights into lesion characterization. ***Aim***: To assess the analytical accuracy of cytomorphological evaluation in glandular lesions of oral cavity and correlate cytological findings with histopathological outcomes where available. ***Study Protocol:*** A retrospective record based analysis was conducted on cases who had presented with salivary gland swellings over last 1 year (2023-2024) at our centre. FNAC smears were examined for cellularity, architectural patterns, nuclear features, and background elements. Cases with subsequent histopathological examination were included for correlation. Diagnostic accuracy, sensitivity, specificity, and concordance rates were calculated. ***Results:*** This cytomorphological study of 120 salivary gland lesions highlights pleomorphic adenoma as the predominant neoplasm, with a notable age distribution skewed toward individuals over 60 years (30%) and those aged 31–45 years (29.2%). Fine-needle aspiration cytology (FNAC) demonstrated robust diagnostic performance, yielding an overall accuracy of 89.2%. For malignant lesions, FNAC showed sensitivity of 85.7%, specificity of 89.9%, PPV of 64.3%, and NPV of 96.7%. In non-malignant cases, sensitivity index was 89.9%, selectivity index 85.7%, PPV 96.7%, and NPV 35.7%. These findings reinforce FNAC's reliability as a robust tool. ***Conclusion***: Cytomorphological evaluation remains a reliable frontline diagnostic modality for salivary gland lesions, particularly in distinguishing benign from malignant processes. When integrated with clinical and radiological data, FNAC enhances diagnostic precision and guides appropriate management. Histopathological correlation reinforces its role in definitive diagnosis and underscores areas for refinement in cytological interpretation.

Keywords: Salivary gland pathology, Cytomorphology, Fine-needle aspiration cytology (FNAC), Histopathological correlation, clinical concordance.

INTRODUCTION

Salivary gland lesions (SGT) constitute a diagnostically diverse group, encompassing a wide spectrum ranging from inflammatory and reactive conditions to benign and malignant neoplasms [1]. SGTs are age inclusive, but the incidence climax is observed in the 3rd and 4th decade for low grade and 4th and 5th decade for invasive tumors [2]. The parotid is the commonest site and constitutes 80% of all SGTs followed by submandibular gland, which accounts for 10-15% [3] [4]. Less frequently, SGTs stem from sublingual and minor salivary glands, which are located throughout the submucosa of the mouth and upper aerodigestive tract [5]. SGTs, as such, are rare in occurrence and account for about 3% of head and neck neoplasms [5] [6].

Accurate preoperative differentiation is critical, not only for guiding clinical management but also for determining the extent of surgical intervention and prognostic evaluation. Among various diagnostic modalities, fine needle aspiration cytology (FNAC) has emerged as a quintessential tool in the initial assessment [7].

FNAC enables cytomorphological evaluation of lesions, facilitating classification into non-neoplastic, benign neoplastic, and malignant categories. Despite its advantages, FNAC remains subject to interpretational challenges arising from overlapping cytological features—particularly in cystic, low-grade, and hybrid lesions [8] [9]. Due to this impending issues, tissue architecture analysis remains the standard for definitive diagnosis, providing architectural context and immunohistochemical validation when required. A symbiotic association between both the investigations have paved the way to increased accuracy and credibility of investigations and procedure.

This investigation aims to advocate integrated diagnostic strategies that enhance preoperative evaluation and clinical outcomes.

Study Protocol

A retrospective record based study was conducted at a tertiary care academic and research hospital from January 2023 to December 2024. Patients who had presented with salivary gland lesions underwent tissue biopsy followed by surgical excision and histopathological evaluation were considered.

Patients with clinically evident salivary gland lesions, availability of both FNAC smears and histopathological specimens, age 18-70 years were included. Cases having inadequate or non-diagnostic FNAC smears, Lack of

histopathological follow-up and Patients with recurrent or previously treated salivary gland tumors were excluded from the study.

Demographic details, clinical presentation, anatomical site of lesion, and radiological findings were documented. FNAC reports were reviewed for smear adequacy, cellularity, architectural patterns, cytoplasmic and nuclear features, and background elements. Histopathological reports of excised specimens were examined for definitive diagnosis, tissue architecture, cellular morphology, and presence of malignancy.

sample size calculated using the formula,

$$\mathbf{n = [(Z\alpha/2 + Z\beta)^2 \times (p_1 \times (1 - p_1) + p_2 \times (1 - p_2))] \div (p_1 - p_2)^2}$$

- $\mathbf{p_1}$ = 0.62 (proportion of benign tumors) [10]
- $\mathbf{p_2}$ = 0.38 (proportion of malignant tumors) [10]
- $\mathbf{Z\alpha/2}$ = 1.645 (for 90% confidence level)
- $\mathbf{Z\beta}$ = 0.84 (for 80% power)

$n = [6.1752 \times (0.2356+0.2356)] \div (0.62-0.38)^2$

$n \approx$ **51 (each arm)**

Statistical Analysis:

Data collected and analyzed using SPSS ver 20 and appropriate inferential and descriptive statistics were applied. Diagnostic performance metrics were calculated. Concordance between FNAC and histopathology was assessed using the Chi-square test.

RESULTS

Table 1 : Population Characteristics and Metrics (n=120)

Age Category (Years)	**Number of Cases (n-120)**	**Percentage (%)**	
18–30	18	15	**X^2 = 6.86**
31–45	35	29.2	**P= 0.076**
46–60	31	25.8	
>60	36	30	
Lesion Localization by Salivary Gland Region			
Gland Involved	**Number of Caseload**	**Percentage (%)**	
Parotid	90	75	**X^2 = 95.50**
Submandibular	19	15.8	**P<0.0001**
Minor Salivary Glands	11	9.2	
Cytological Assessment Tiers			
Cytological Category	**Number of Cases**	**Percentage (%)**	
Non-neoplastic	75	62.5	**X^2 = 47.50**
Benign neoplastic	28	23.3	**P<0.0001**
Malignant neoplastic	17	14.2	

Among the 120 participants evaluated for salivary gland lesions, the most represented age group was individuals over 60 years (30%), followed closely by those aged 31–45 years (29.2%). In contrast, the anatomical distribution revealed a highly significant predominance of parotid gland involvement (75%), with markedly fewer cases in the submandibular (15.8%) and minor salivary glands (9.2%) ($\chi^2 = 95.50$, $p < 0.0001$), indicating a strong anatomical predilection for parotid lesions.

Cytological categorization demonstrated a statistically significant skew towards Hyperplastic changes (62.5%), followed by low grade neoplasms (23.3%) and High grade neoplasms (14.2%) ($\chi^2 = 47.50$, $p < 0.0001$). These findings underscore the predominance of non-neoplastic pathology in salivary gland cytology, with pleomorphic adenoma emerging as the most frequent neoplastic diagnosis.

Table 2: Histopathological Confirmation of Cytological Diagnoses

Final Histopathological Diagnosis	***Cytology Concordant***	***Cytology Discordant***	***Total***
Pleomorphic Adenoma	42	3	45
Mucoepidermoid Carcinoma	7	2	9
Warthin's Tumor	15	2	17
Adenoid Cystic Tumor	11	1	12
Chronic Sialadenitis	20	5	25
Cystic Lesions	12	8	12

Histopathological confirmation revealed a high overall concordance between cytological and final diagnoses, with 99 out of 120 cases (82.5%) showing agreement. Pleomorphic adenoma demonstrated the highest concordance rate, with 42 of 45 cases (93.3%) accurately identified cytologically. Similarly, Warthin's tumor and adenoid cystic carcinoma showed strong concordance rates of 88.2% and 91.7%, respectively. In contrast, cystic lesions exhibited the lowest concordance, with only 4 of 12 cases (33.3%) correctly diagnosed on cytology and a discordance rate of 66.7%, highlighting the diagnostic challenges posed by cystic morphology. Chronic sialadenitis also showed a notable discordance, with 5 of 25 cases (20%) misclassified.

Table 3: Concordance Between Cytology and Histopathology

Diagnosis	**Concordant**	**Discordant**	χ^2
Pleomorphic Adenoma	42	3	3.13
Mucoepidermoid Carcinoma	7	2	0.13
Warthin's Tumor	15	2	0.33
Adenoid Cystic Carcinoma	11	1	0.67
Chronic Sialadenitis	20	5	0.10
Cystic Lesions	4	8	14.27
Total	**99**	**21**	**$\chi^2 = 18.63$**
			$p \approx 0.0023$

The statistically significant association between histopathological category and cytological concordance ($\chi^2 = 18.63$, $p \approx 0.0023$) underscores the variability in diagnostic reliability across lesion types, particularly emphasizing the need for cautious interpretation in cystic and inflammatory lesions

Table 4: Overall Diagnostic Performance Metrics

LESION TYPE	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
MALIGNANT	85.7%	89.9%	64.3%	96.7%	89.2%
NON-MALIGNANT	89.9%	85.7%	96.7%	35.7%	89.2%

Cytology showed strong diagnostic performance for salivary gland lesions, with an overall accuracy of **89.2%** for both malignant and non-malignant categories. For malignant lesions, sensitivity was **85.7%**, specificity **89.9%**, PPV **64.3%**, and NPV **96.7%**. Non-malignant lesions had slightly higher sensitivity (**89.9%**) and PPV (**96.7%**), but lower NPV (**35.7%**) and specificity (**85.7%**). These metrics highlight cytology's reliability in ruling out malignancy and confirming benign diagnoses, though caution is warranted in interpreting negative results for non-malignant lesions.

Table 5: Tumor-wise Diagnostic Metrics

Tumor Type	***Concordant***	***Discordant***	***Sensitivity (%)***	***Accuracy (%)***
Pleomorphic Adenoma	42	3	93.3%	93.3%
Mucoepidermoid Carcinoma	7	2	77.8%	77.8%
Warthin's Tumor	15	2	88.2%	88.2%
Adenoid Cystic Carcinoma	11	1	91.7%	91.7%
Chronic Sialadenitis	20	5	80.0%	80.0%
Cystic Lesions	4	8	33.3%	33.3%

Tumor-wise diagnostic metrics revealed consistently high sensitivity and accuracy for most lesions, with pleomorphic adenoma leading at 93.3%, followed by adenoid cystic carcinoma (91.7%) and Warthin's tumor (88.2%). Mucoepidermoid carcinoma and chronic sialadenitis showed moderate performance, with sensitivities of 77.8% and 80.0%, respectively. In contrast, cystic lesions demonstrated markedly lower diagnostic reliability, with both sensitivity and accuracy at 33.3%, indicating substantial cytological discordance and underscoring the diagnostic limitations in cystic presentations.

DISCUSSION

The study investigated 120 cases of salivary gland lesions, revealing key insights into their characteristics and the diagnostic performance of FNAC. Salivary gland lesions were the highest in **individuals over 60 years (30%)**, followed closely by those aged 31–45 years (29.2%). **Kamal Malukani et al** [11] reported that the highest incidence for malignant SGTs were more prevalent in the 4th and 5th decades, with a mean age of 43 years. Similarly, Narala Srivani et al [13] found that neoplastic lesions were more common in the 6th decade, noting a mean age of 45 years for overall SGTs. Anita Omhare et al [14] also indicated that the commonest age group for malignant tumors was 60 to 69 years, with an overall mean age of 40 years. In contrast, Anuj Poudel et al [15] identified the 21–30 years age group as the most

common overall, with malignant lesions observed in patients older than 50 years. Arjun Namdeo Narote et al [16]reported a mean age for malignant tumors of 53.58 years, with the many malignant cases (25%) occurring in 61-70 years age group. Soma Negi et al [16] similarly noted that neoplastic lesions were observed in patients older than 50 years.

Our study revealed a highly significant predominance of parotid gland involvement (75%), with markedly fewer cases in the submandibular (15.8%) and minor salivary glands (9.2%). This strong anatomical predilection for the parotid gland is widely consistent across the sources. Kamal Malukani et al [11] and Amin NS et al [12] stated that the parotid gland is the commonest site, constituting 80% of all SGTs. Anuj Poudel et al [15] also reported the parotid gland as the most common site (66.5%), followed by the submandibular gland (33.5%). Utpaul Kumar Sarkar et al [18] found the parotid gland affected in 78% , and the submandibular gland in 22%. Ritu Jain et al [19] reported that the majority (67.5%) of cases involved the parotid gland, 30% involved the submandibular gland. Our study demonstrated a statistically significant skew toward **non-neoplastic lesions (62.5%)**. Anita Omhare et al [14] found non-neoplastic lesions accounted for 53.22%, with benign tumors at 31.45% and malignant tumors at 15.32%. Utpaul Kumar Sarkar et al [18] categorized 22% as non-neoplastic and 78% as neoplastic (54% benign, 24% malignant).

PA was the most frequent neoplastic diagnosis here. Kamal Malukani et al [11] found PA to be the commonest benign tumor (86.8%). Anuj Poudel et al [15], Utpaul Kumar Sarkar et al [18] and Ritu Jain et al [19] found same findings.

Also this study showed strong diagnostic performance for salivary gland lesions, with an overall accuracy of 89.2% for both malignant and non-malignant categories. For malignant lesions, sensitivity was 85.7%. Soma Negi et al [17] reported overall sensitivity, specificity, and diagnostic accuracy of 95.98%, 99.20%, and 98.09%, respectively. Arjun Namdeo Narote et al [16] reported an overall accuracy of 92.21%, with sensitivity of 89.36% and specificity of 96.67%. For malignant lesions, their sensitivity was 68.75% and specificity 100%.

CONCLUSION

Cytomorphological evaluation serves as an indispensable frontline tool by systematically analyzing cellular morphology, architectural patterns, and stromal context, this approach facilitates nuanced differentiation between low grade and high grade tumors—guiding clinical management with greater precision. Hallmark features such as cohesive epithelial clusters, extracellular matrix variations, and nuclear atypia provide critical diagnostic clues, particularly in distinguishing pleomorphic adenomas from neoplastic lesions like mucoepidermoid or adenoid cystic carcinomas. Integration of ancillary modalities including immunocytochemistry, coupled with an emphasis on interobserver reproducibility, underscores the evolving sophistication of cytological interpretation.

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