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Correlation of Radiological Findings with Histopathology in Precancerous and Cancerous Oral Mucosal Lesions

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ABSTRACT

Oral precancerous and cancerous lesions present diagnostic challenges due to variable clinical appearances and progression patterns. This study aimed to evaluate the correlation between radiological findings, specifically using contrast-enhanced magnetic resonance imaging (MRI) and computed tomography (CT), with histopathologic grading of oral mucosal lesions. A prospective observational study was conducted at three tertiary care centers in Pakistan, enrolling 284 patients with clinically diagnosed oral leukoplakia, erythroplakia, or squamous cell carcinoma. All patients underwent detailed clinical examination, MRI, and CT imaging, followed by incisional or excisional biopsy for histopathologic confirmation. Radiological parameters including lesion thickness, enhancement patterns, and bone involvement were recorded. Statistical analyses employed Pearson correlation coefficients, chi-square tests, and multivariate regression, with significance set at $p < 0.05$. Radiological measurements of lesion thickness correlated strongly with histopathologic grade ($r = 0.78$, $p < 0.001$). Contrast enhancement intensity showed moderate correlation with dysplasia severity ($r = 0.63$, $p = 0.002$). Bone invasion detected radiologically corresponded with histologically confirmed cortical involvement in 42 of 48 cases (87.5%). Multivariate regression identified lesion thickness >5 mm and heterogeneous enhancement as independent predictors of high-grade dysplasia or invasive carcinoma (OR 4.21, 95% CI 2.13–8.31, $p < 0.001$). These findings demonstrate that radiological imaging, particularly MRI, provides reliable non-invasive assessment correlating with histopathology in oral mucosal lesions, facilitating early diagnosis and management planning. The study emphasizes integrated radiologic-pathologic evaluation to enhance diagnostic accuracy and optimize therapeutic strategies.

Keywords: *oral mucosal lesions, radiology, MRI, CT, histopathology, precancerous lesions*

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INTRODUCTION

Oral cancer is among the most prevalent malignancies worldwide, with significant morbidity and mortality, particularly in South and Southeast Asia [1]. The majority of oral cancers arise from precancerous lesions such as leukoplakia and erythroplakia, which demonstrate variable risks of malignant transformation [2]. Early detection and accurate characterization of these lesions are essential to reduce morbidity and improve prognosis [3]. Histopathology remains the gold standard for diagnosis; however, limitations such as sampling error, invasiveness, and patient discomfort necessitate complementary non-invasive diagnostic modalities [4].

Radiological imaging has emerged as an essential adjunct in the evaluation of oral mucosal lesions. High-resolution imaging modalities such as magnetic resonance imaging (MRI) and computed tomography (CT) provide detailed visualization of lesion morphology, depth of invasion, and bone involvement [5]. MRI offers superior soft tissue contrast, enabling assessment of submucosal extension and perineural invasion, while CT is particularly useful for evaluating cortical bone integrity and detecting early osteolytic changes [6]. The integration of imaging findings with histopathologic grading has potential to improve preoperative risk stratification and guide surgical planning [7].

Despite these advantages, there remains a paucity of comprehensive studies systematically correlating radiologic features with histopathologic severity in oral mucosal lesions. Most prior research is limited by small sample sizes, retrospective design, or focus on advanced carcinoma rather than precancerous lesions

[8,9]. As a result, clinicians often rely solely on biopsy for prognostication, missing opportunities for early non-invasive assessment and monitoring.

Additionally, the clinical presentation of precancerous oral lesions is highly heterogeneous. Leukoplakia may present as thin, homogenous white plaques, while erythroplakia is frequently red, atrophic, and associated with higher dysplastic potential [10]. Morphologic features such as lesion thickness, surface keratinization, and submucosal infiltration are critical determinants of malignant transformation risk [11]. Radiologic assessment provides objective measurement of these features, offering quantifiable parameters that can complement clinical evaluation [12].

Emerging evidence suggests that radiologic markers such as lesion thickness, contrast enhancement pattern, and signal heterogeneity correlate with histopathologic grade in oral lesions. For instance, studies have shown that lesions with heterogeneous enhancement and greater thickness are more likely to harbor severe dysplasia or invasive carcinoma [13,14]. However, these correlations have not been validated extensively in South Asian populations, where etiologic factors such as betel nut chewing, tobacco use, and dietary habits influence lesion biology and progression [15].

Furthermore, radiology can aid in identifying subclinical bone invasion, which is critical for surgical planning. Involvement of the mandibular cortex or maxillary alveolus significantly alters reconstructive strategy and prognosis [16]. Histopathology alone may underestimate the extent of bone invasion due to sampling limitations, emphasizing the value of combined radiologic-pathologic evaluation [17].

Given the clinical and public health implications, this study was designed to systematically evaluate the correlation between radiological findings and histopathologic grading in precancerous and cancerous oral mucosal lesions in Pakistan. The objectives included quantifying the relationship between lesion thickness, contrast enhancement, and bone involvement on imaging with histopathologic severity, assessing the predictive value of radiologic parameters for high-grade dysplasia or invasive carcinoma, and generating evidence to support integrated diagnostic approaches [1–15]. By addressing these gaps, the study aims to enhance early diagnosis, risk stratification, and treatment planning, ultimately improving patient outcomes in a region with high oral cancer prevalence.

MATERIAL AND METHODS

Study Design and Setting

This prospective observational study was conducted from January 2022 to July 2023 at University of Lahore. Ethical approval was obtained from the Pakistan Medical Research Council Ethics Committee (Ethical Approval No. PMRC/ORAL/2022/1123).

Sample

A total of 284 patients aged 18–70 years presenting with clinically suspicious oral mucosal lesions were included. Sample size was calculated based on an estimated correlation coefficient of 0.6 between radiological and histopathological findings, 95% confidence interval, and 80% power.

Inclusion/Exclusion Criteria

Inclusion Criteria:

- Clinically diagnosed leukoplakia, erythroplakia, or oral squamous cell carcinoma
- Patients able to undergo MRI and CT imaging
- Willingness to provide informed consent

Exclusion Criteria:

- Prior surgical or radiotherapy intervention at lesion site
- Contraindications to MRI (e.g., pacemaker, metallic implants)
- Severe systemic illness precluding imaging

Radiological Assessment

All patients underwent MRI (1.5 Tesla) and contrast-enhanced CT of the oral cavity. MRI sequences included T1-weighted, T2-weighted, and contrast-enhanced T1-weighted images. Parameters recorded included:

- Lesion thickness (mm)
- Signal intensity patterns (homogeneous vs heterogeneous)
- Contrast enhancement pattern (mild, moderate, intense)
- Bone involvement (cortical erosion, medullary infiltration)

CT imaging was used to corroborate bone involvement. Radiologic assessments were performed by two independent radiologists blinded to histopathologic findings.

Histopathologic Evaluation

Incisional or excisional biopsies were performed for all lesions. Specimens were processed with hematoxylin and eosin staining. Histopathologic grading included:

- Mild dysplasia
- Moderate dysplasia
- Severe dysplasia
- Invasive carcinoma

Two experienced oral pathologists independently reviewed all samples. Discordant cases were adjudicated through consensus.

Data Collection

Demographic variables, clinical lesion characteristics, risk factors (tobacco, betel nut, alcohol), and radiologic parameters were documented.

Statistical Analysis

Statistical analyses were conducted using SPSS version 27. Continuous variables were reported as mean ± SD; categorical variables as frequencies and percentages. Pearson correlation assessed relationships between radiologic parameters and histopathologic grade. Chi-square tested associations between categorical variables. Multivariate logistic regression identified independent radiologic predictors of high-grade dysplasia or carcinoma. Statistical significance was defined as $p < 0.05$.

RESULTS

Table 1: Demographic and Clinical Characteristics (n=284)

Parameter	Value
Mean Age (years)	45.2 ± 12.6
Gender (M/F)	168/116
Tobacco Use	172 (60.6%)
Betel Nut Use	81 (28.5%)
Lesion Type	Leukoplakia: 142 (50%) Erythroplakia: 61 (21.5%) SCC: 81 (28.5%)

Table 2: Radiologic Findings

Parameter	Mean / Frequency
Lesion Thickness (mm)	5.8 ± 2.1
Heterogeneous Enhancement	114 (40.1%)
Intense Contrast Enhancement	97 (34.2%)
Bone Involvement Detected	48 (16.9%)

Table 3: Correlation of Radiologic Parameters with Histopathologic Grade

Radiologic Parameter	r / OR	95% CI	p-value
Lesion Thickness vs Grade	0.78	–	<0.001
Enhancement Intensity vs Grade	0.63	–	0.002
Bone Involvement vs Histology	–	–	0.001
Thickness >5 mm & Heterogeneous	4.21	2.13–8.31	<0.001

Explanation of Tables:

Table 1 shows the demographic profile, with a predominance of males (59%) and significant exposure to tobacco. Leukoplakia was the most frequent lesion, followed by SCC.

Table 2 demonstrates that lesion thickness and heterogeneous enhancement were common radiologic findings, with bone involvement identified in 16.9% of patients.

Table 3 highlights strong correlation between lesion thickness and histopathologic grade ($r = 0.78$, $p < 0.001$). Intense or heterogeneous contrast enhancement also correlated with higher-grade lesions. Lesion thickness >5 mm and heterogeneous enhancement were independent predictors of severe dysplasia or carcinoma (OR 4.21, 95% CI 2.13–8.31).

DISCUSSION

The study demonstrates a significant correlation between radiologic findings and histopathologic severity in oral mucosal lesions. Lesion thickness measured on MRI correlated strongly with histopathologic grade, corroborating prior evidence that deeper and thicker lesions are more likely to harbor high-grade dysplasia or invasive carcinoma [15,16]. This supports the utility of MRI as a non-invasive diagnostic tool for early risk stratification.

Heterogeneous and intense contrast enhancement was associated with higher-grade lesions, likely reflecting increased angiogenesis and altered tissue architecture within dysplastic or neoplastic epithelium [17,18]. This finding aligns with previous studies in Indian and European cohorts, reinforcing the predictive value of imaging biomarkers [19].

Bone involvement identified radiologically corresponded with histopathologic confirmation in 87.5% of cases. Accurate assessment of cortical and medullary invasion is critical for surgical planning, particularly in mandibulectomy or maxillectomy procedures. Radiologic-pathologic correlation allows preoperative identification of high-risk lesions, reducing intraoperative uncertainty [20,21].

Novelty of this research lies in the comprehensive evaluation of both precancerous and cancerous lesions in a Pakistani population, incorporating both MRI and CT modalities. Unlike prior studies that primarily focused on carcinoma, this study emphasizes early-stage lesions where radiologic assessment can guide surveillance and intervention [22–24]. Multivariate analysis confirms lesion thickness >5 mm and heterogeneous enhancement as independent predictors of malignancy, offering actionable metrics for clinicians.

Comparative analysis with global literature indicates similar trends in correlation but highlights regional differences in etiologic exposure. High prevalence of tobacco and betel nut use in the cohort likely influenced lesion biology, underscoring the need for population-specific diagnostic strategies [25,26]. Integration of radiologic and histopathologic evaluation improves diagnostic accuracy, facilitates personalized management, and may reduce morbidity by enabling earlier, targeted interventions.

CONCLUSION

Radiologic findings, particularly lesion thickness and contrast enhancement patterns on MRI and CT, correlate strongly with histopathologic grade in precancerous and cancerous oral mucosal lesions. These parameters provide non-invasive predictive metrics, facilitating early diagnosis, risk stratification, and optimized surgical planning. The study highlights the importance of integrated radiologic-pathologic assessment in improving diagnostic accuracy and patient outcomes.

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ETHICS STATEMENT

Ethical approval was obtained from the Pakistan Medical Research Council Ethics Committee (Ethical Approval No. PMRC/ORAL/2022/1123).

INFORMED CONSENT

Written informed consent was obtained from all participants.

COMPETING INTERESTS

The authors declare no competing interests.

FINANCIAL DISCLOSURE

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