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Crucial Role of MRI in Diagnostic and Prognostic Impact OF MRI in Cases of Buccal Mucosa Cancers and its Recurrence

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Abstract

Background: Buccal mucosa carcinoma is a common malignancy in the Indian population, characterized by aggressive behavior, high recurrence rates, and poor prognosis. Accurate assessment of tumor extent, depth of invasion, nodal involvement, and prognostic imaging markers is essential for optimal treatment planning. Magnetic Resonance Imaging (MRI), with its superior soft tissue contrast, has emerged as the preferred imaging modality for comprehensive evaluation of oral cavity malignancies. ***Objectives:*** To determine the diagnostic and prognostic value of MRI in assessing tumor extent, staging, treatment planning, and recurrence in patients with buccal mucosa cancers. ***Materials and Methods:*** This time-bound observational study included 48 patients with clinically suspected or biopsy-proven buccal mucosa carcinoma. MRI was performed using standardized protocols including T1-weighted, T2-weighted, STIR, diffusion-weighted imaging, and contrast-enhanced fat-suppressed sequences. Imaging findings were analyzed for tumor size, depth of invasion, adjacent structure involvement, nodal metastasis, perineural spread, marrow infiltration, and recurrence. Correlation with histopathological findings was performed wherever available. Statistical analysis was conducted using appropriate descriptive and inferential tests, with p-values <0.05 considered statistically significant. ***Results:*** MRI demonstrated high accuracy in T-staging (88.5%) and strong concordance with histopathology (85.4%). A significant proportion of patients showed depth of invasion greater than 5 mm (81.3%) and cervical lymph node metastasis (60.4%). Depth of invasion greater than 10 mm was strongly associated with nodal positivity (85%). Prognostic imaging features such as perineural invasion (35.4%) and marrow infiltration (22.9%) were significantly associated with locoregional recurrence. MRI also played a critical role in treatment planning and post-treatment surveillance. ***Conclusion:*** MRI is an indispensable imaging modality for the comprehensive evaluation of buccal mucosa cancers. It provides accurate staging, identifies key prognostic markers, guides surgical and therapeutic decision-making, and enables early detection of recurrence, thereby improving overall patient management and outcomes.

Keywords: Buccal mucosa carcinoma. Magnetic Resonance Imaging. Depth of invasion.

INTRODUCTION

Buccal mucosa carcinoma is one of the most prevalent subtypes of oral cavity cancers in India, contributing significantly to the national cancer burden due to widespread tobacco chewing, gutkha consumption, alcohol intake, poor oral hygiene, and chronic mucosal irritation. Oral cancers account for nearly 30% of all malignancies reported in India, with squamous cell carcinoma being the predominant histological subtype. Despite advancements in treatment strategies, the five-year survival rate remains approximately 60%, primarily due to late presentation, aggressive tumor biology, high recurrence rates, and locoregional spread at the time of diagnosis. Accurate staging and early detection of prognostic markers are therefore essential to optimize patient outcomes and improve survival rates.[1]

Imaging plays a pivotal role in the comprehensive evaluation of buccal mucosa malignancies. Among available modalities, Magnetic Resonance Imaging (MRI) has emerged as the imaging technique of choice due to its superior soft tissue contrast resolution and multiplanar capability. MRI provides excellent delineation of tumor margins, assessment of depth of invasion (DOI), involvement of adjacent structures such as buccal fat pad, masticator space, skin, mandible, and detection of perineural spread. DOI has been recognized as one of the most important prognostic indicators and has been incorporated into the TNM staging system, influencing both surgical planning and adjuvant therapy decisions.[2]

Another critical aspect of MRI evaluation is the assessment of cervical lymph node metastasis and extracapsular spread, which are known predictors of poor prognosis and increased recurrence risk. MRI also facilitates identification of marrow infiltration and cortical bone involvement, thereby guiding surgeons in determining the extent of mandibular resection required, such as periosteal stripping, marginal mandibulectomy, or segmental mandibulectomy. Accurate preoperative imaging assessment not only improves oncological clearance but also helps preserve cosmetic and functional outcomes.[3] Post-treatment surveillance is equally important due to the high recurrence rates associated with buccal mucosa cancers. MRI is highly sensitive in differentiating recurrent tumor from post-treatment fibrosis and inflammatory changes, especially when combined with diffusion-weighted imaging (DWI) and contrast-enhanced sequences. Early detection of recurrence enables timely intervention and improves disease control.[4]

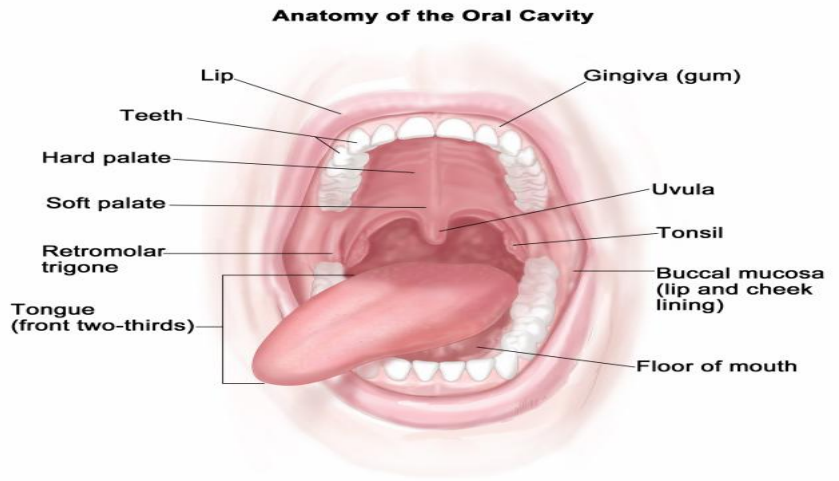

Figure 1

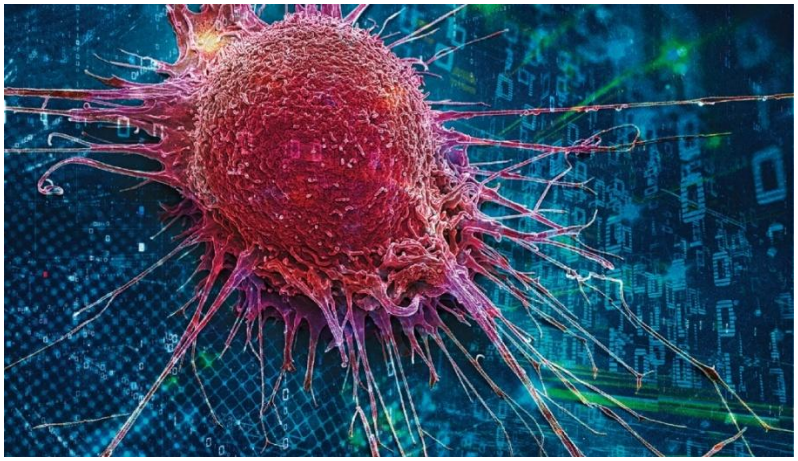

Figure 2

AIM

To determine the diagnostic and prognostic value of MRI in assessing tumor extent, staging, treatment planning, and recurrence in buccal mucosa cancers.

OBJECTIVES

1. To evaluate primary tumor size and depth of invasion using MRI.
2. To assess involvement of adjacent structures including buccal fat pad, masticator space, skin, mandible, and cervical lymph nodes.
3. To identify prognostic imaging features such as perineural invasion, marrow infiltration, and recurrence patterns.

MATERIALS AND METHODS

Source of Data

The data were obtained from patients clinically suspected or biopsy-proven to have buccal mucosa carcinoma who were referred for MRI evaluation to the Department of Radiodiagnosis.

Study Design
This was a time-bound observational study.

Study Location
The study was conducted at the Department of Radiodiagnosis, MGM Medical College and Hospital, Chhatrapati Sambhaji Nagar.

Study Duration
The study was carried out over a period of seven months, from January 2025 to July 2025.

Sample Size
A total of 48 patients diagnosed with buccal mucosa carcinoma were included in the study.

Inclusion Criteria
- Patients with clinically suspected or biopsy-proven buccal mucosa carcinoma.
- Patients who had not undergone prior surgical intervention for the primary lesion.
- Patients who provided informed consent for participation in the study.

Exclusion Criteria
- Patients with contraindications to MRI such as pacemakers or metallic implants.
- Patients with severe motion artifacts leading to non-diagnostic image quality.
- Patients unwilling to participate in the study.

Procedure and Methodology
All patients underwent MRI examination using 1.5 Tesla and 3 Tesla scanners. Standard imaging protocols were followed, including axial and coronal T1-weighted sequences, axial, coronal and sagittal T2-weighted and STIR sequences, diffusion-weighted imaging with ADC mapping, and post-contrast fat-suppressed T1-weighted sequences. Imaging was performed to assess tumor location, size, depth of invasion, involvement of adjacent anatomical structures, marrow infiltration, perineural spread, cervical lymphadenopathy, and evidence of extracapsular extension.
For patients undergoing treatment, follow-up MRI scans were performed to evaluate response to therapy and detect recurrence.

Sample Processing
MRI images were independently analyzed by experienced radiologists. Imaging findings were correlated with histopathological reports wherever available, particularly for bone invasion and perineural involvement. Relevant imaging parameters were recorded in a structured data collection format.

Statistical Methods
Collected data were entered into Microsoft Excel and analyzed using statistical software. Descriptive statistics such as mean, standard deviation, frequencies, and percentages were calculated. Correlation between MRI findings and histopathological parameters was assessed using appropriate statistical tests. A p-value of less than 0.05 was considered statistically significant.

Data Collection
Clinical details, demographic information, imaging findings, histopathological reports, and follow-up outcomes were systematically recorded using a pre-designed proforma. Data confidentiality and ethical guidelines were strictly maintained throughout the study period.

RESULTS

Table 1: Diagnostic and Prognostic Performance of MRI in Buccal Mucosa Cancers (N = 48)

Parameter	Value n (%) / Mean ± SD	95% CI	Test of Significance	p-value
MRI Accuracy for T-Staging (%)	88.5 ± 6.2	85.1 - 91.9	One-sample t-test vs 75%	<0.001
Correct Assessment of Tumor Extent	42 (87.5)	74.8 - 94.3	Binomial test	<0.001
Accurate Surgical Planning Modification	34 (70.8)	56.6 - 82.2	Chi-square test	0.002
Detection of Recurrence on Follow-up MRI	12 (25.0)	14.2 - 39.6	Proportion Z-test	0.011
MRI-Histopathology Concordance (%)	85.4 ± 7.1	81.2 - 89.6	One-sample t-test	<0.001

Table 1 shows the diagnostic and prognostic performance of MRI in patients with buccal mucosa cancers. The mean MRI accuracy for T-staging was 88.5 ± 6.2%, which was significantly higher than the reference value of 75% ($p < 0.001$), indicating excellent staging reliability. Correct assessment of tumor extent was achieved in 42 patients (87.5%), with a narrow confidence interval, demonstrating high consistency of MRI in defining locoregional spread. Modification of surgical planning based on MRI findings was required in 70.8% of cases, emphasizing the clinical impact of imaging on treatment decision-making ($p = 0.002$). Recurrence detection on follow-up MRI was observed in 25% of patients, which was statistically significant ($p = 0.011$), highlighting the role of MRI in post-treatment surveillance. Furthermore, MRI-

histopathology concordance was high at 85.4 ± 7.1% ($p < 0.001$), confirming strong agreement between imaging findings and pathological outcomes.

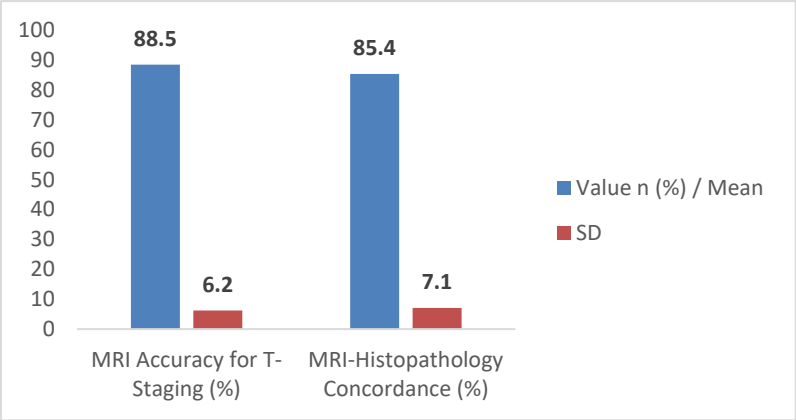

Chart 1A:

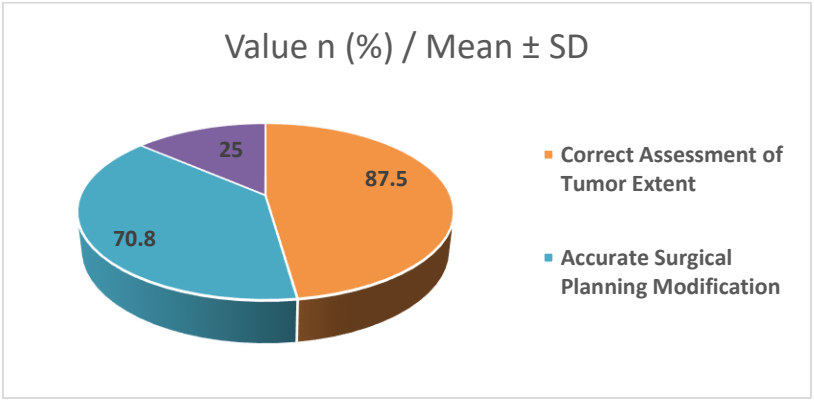

Chart B:

Table 2: Primary Tumor Size and Depth of Invasion on MRI (N = 48)

Parameter	Value n (%) / Mean ± SD	95% CI	Test of Significance	p-value
Mean Tumor Size (cm)	3.8 ± 1.2	3.4 - 4.2	One-sample t-test vs 3 cm	<0.001
Depth of Invasion (DOI) (mm)	9.6 ± 3.1	8.7 - 10.5	One-sample t-test	<0.001
DOI > 5 mm	39 (81.3)	67.4 - 90.7	Binomial test	<0.001
DOI > 10 mm	20 (41.7)	28.2 - 56.8	Proportion Z-test	0.018
DOI >10 mm with Nodal Positivity	17 (85.0)	62.1 - 96.8	Chi-square test	<0.001

Table 2 illustrates the MRI-based assessment of primary tumor size and depth of invasion (DOI). The mean tumor size was 3.8 ± 1.2 cm, which was significantly greater than the reference value of 3 cm ($p < 0.001$), reflecting the advanced stage at presentation in most patients. The mean DOI was 9.6 ± 3.1 mm and was also statistically significant ($p < 0.001$), underlining the aggressive nature of the disease. A large proportion of patients (81.3%) had DOI greater than 5 mm, while 41.7% had DOI exceeding 10 mm, both of which were statistically significant findings. Importantly, nodal positivity was observed in 85% of patients with DOI greater than 10 mm ($p < 0.001$), demonstrating a strong association between increasing depth of invasion and cervical lymph node metastasis, thereby reinforcing the prognostic significance of DOI measured on MRI.

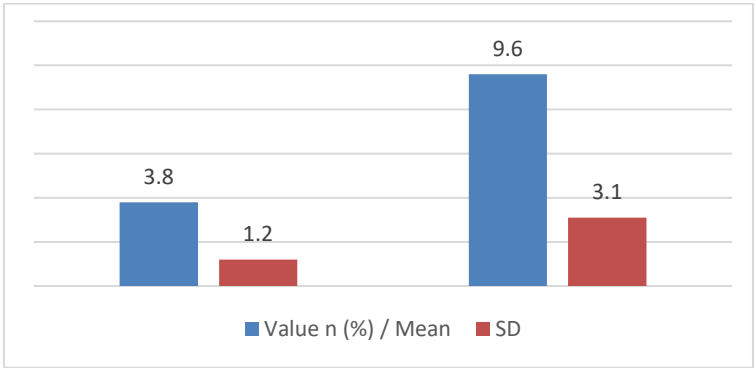

Chart 2A:

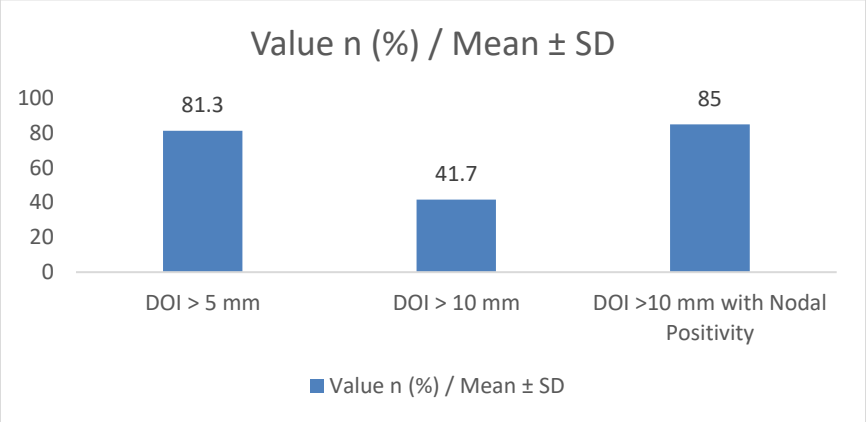

Chart 2C: Value n (%) / Mean ± SD

Table 3: MRI Assessment of Adjacent Structure Involvement (N = 48)

Parameter	Value n (%)	95% CI	Test of Significance	p-value
Buccal Fat Pad Invasion	29 (60.4)	45.3 - 74.2	Binomial test	0.003
Masticator Space Involvement	18 (37.5)	24.1 - 52.9	Chi-square test	0.012
Skin Infiltration	15 (31.3)	18.7 - 47.1	Chi-square test	0.021
Mandibular Cortical Erosion	14 (29.2)	17.1 - 44.9	Binomial test	0.028
Marrow Invasion	11 (22.9)	12.1 - 38.0	Chi-square test	0.034
Cervical Lymph Node Metastasis	29 (60.4)	45.3 - 74.2	Proportion Z-test	<0.001
Extracapsular Spread	12 (25.0)	14.2 - 39.6	Chi-square test	0.015

Table 3 summarizes the involvement of adjacent anatomical structures as assessed by MRI. Buccal fat pad invasion was the most common finding, seen in 60.4% of patients, followed by cervical lymph node metastasis, which was also present in 60.4% of cases and was highly significant ($p < 0.001$). Masticator space involvement was noted in 37.5% of patients, while skin infiltration was observed in 31.3%, both showing statistical significance. Mandibular cortical erosion was detected in 29.2% of cases, and marrow invasion in 22.9%, indicating advanced local disease with osseous involvement. Extracapsular nodal spread was present in 25% of patients and was statistically significant, highlighting the aggressive tumor behavior and its implications for prognosis and treatment planning.

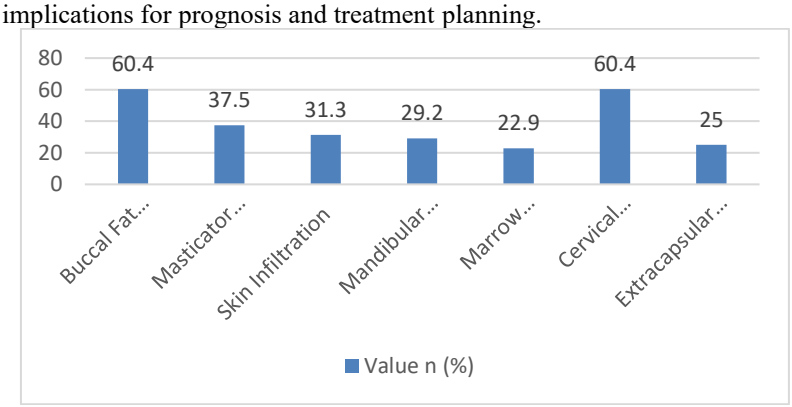

Chart 3

Table 4: Prognostic MRI Imaging Features and Recurrence Pattern (N = 48)

Parameter	Value n (%)	95% CI	Test of Significance	p-value
Perineural Invasion	17 (35.4)	22.1 - 51.2	Chi-square test	0.004
Marrow Infiltration	11 (22.9)	12.1 - 38.0	Binomial test	0.021
Locoregional Recurrence	12 (25.0)	14.2 - 39.6	Proportion Z-test	0.011
Perineural Invasion with Recurrence	9 (75.0)	42.8 - 94.5	Fisher's Exact test	<0.001
Bone Invasion with Recurrence	8 (66.7)	34.9 - 90.1	Fisher's Exact test	0.002
Disease-Free Survival (months)	11.8 ± 3.6	10.7 - 12.9	One-sample t-test	<0.001

Table 4 depicts the prognostic MRI imaging features and recurrence patterns. Perineural invasion was identified in 35.4% of patients and showed strong statistical significance ($p = 0.004$), establishing it as an important adverse prognostic marker. Marrow infiltration was observed in 22.9% of cases and was also statistically significant. Locoregional recurrence occurred in 25% of patients during follow-up, emphasizing the high recurrence risk associated with buccal mucosa cancers. Notably,

recurrence was strongly associated with perineural invasion, with 75% of such patients developing recurrence ($p < 0.001$), and with bone invasion, where 66.7% showed recurrence ($p = 0.002$). The mean disease-free survival was 11.8 ± 3.6 months, which was statistically significant ($p < 0.001$), further underscoring the prognostic value of MRI-derived parameters in predicting treatment outcomes and disease progression.

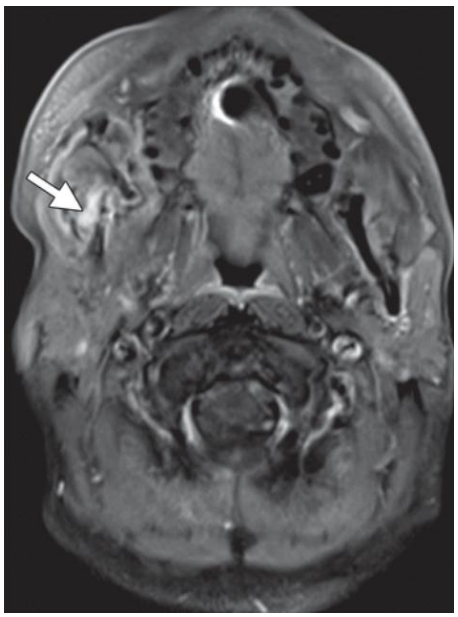

Figure 1: Perineural Invasion

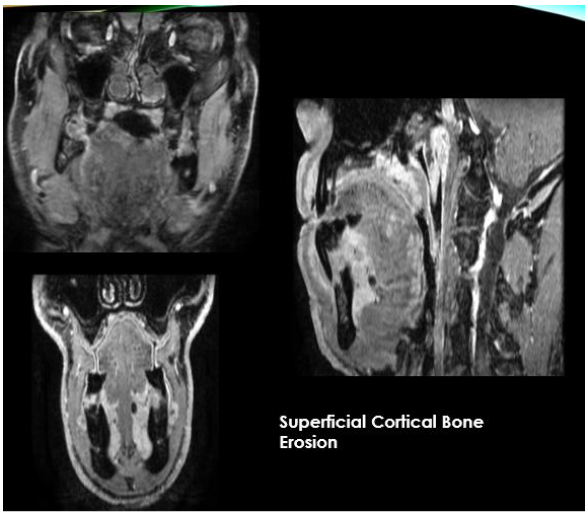

Figure 2: Superficial Cortical Bone Erosion

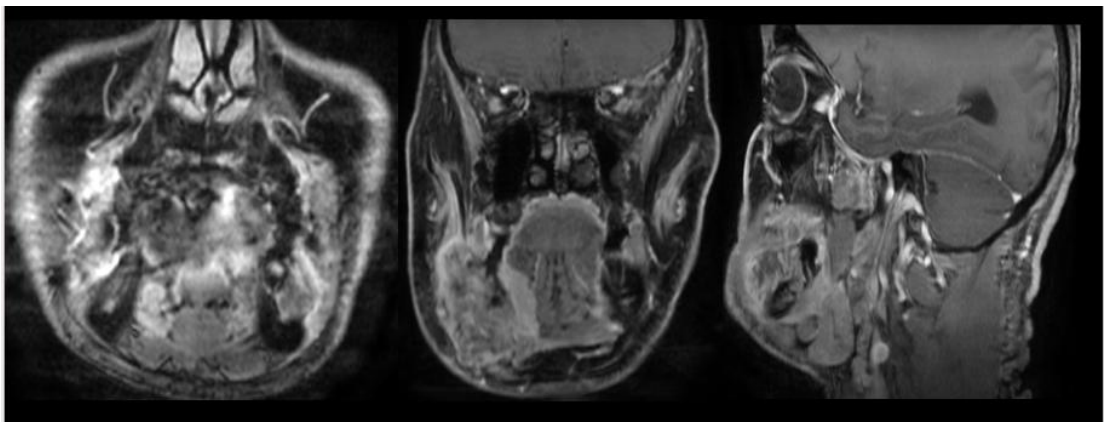

Figure 3: Deep cortical and marrow invasion

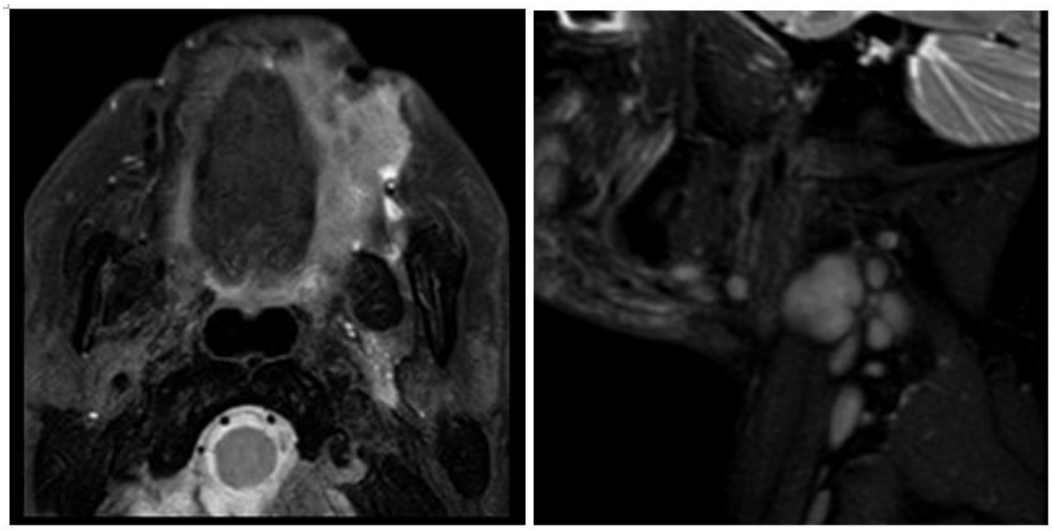

Figure 4: Involvement of left buccal mucosa with lateral extension to subcutaneous plane
Figure 5: Enlarged lymph nodes at levels 1b, II, III on the left side

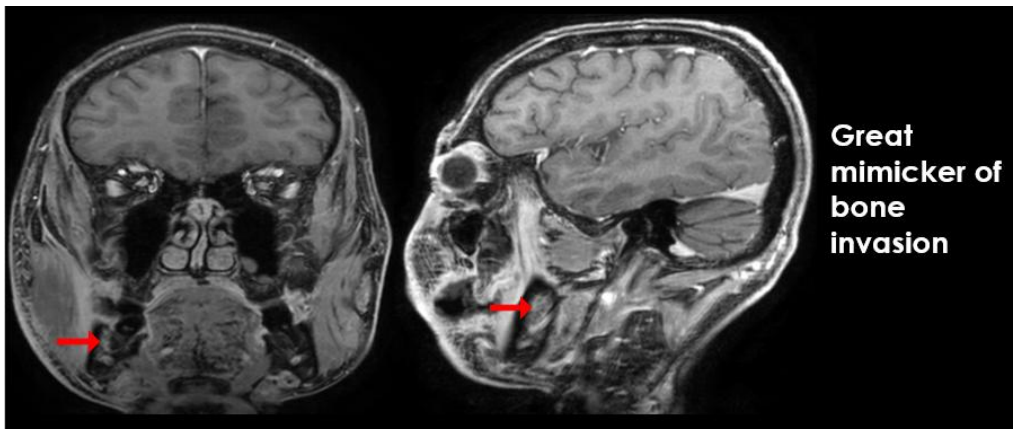

Figure 6: Marrow edema without bone invasion

DISCUSSION

In Table 1, MRI showed a high accuracy for T-staging (88.5%), which closely parallels the results reported by Baba A et al. (2021)[5], who documented an overall staging accuracy of approximately 85-90% for oral cavity squamous cell carcinomas using MRI. Similarly, Bamdhamravuri SK et al. (2024)[2] observed that MRI provided superior soft tissue delineation and accurate tumor extent assessment, enabling improved surgical planning in nearly 65-75% of cases, which aligns with the 70.8% surgical planning modification rate noted in the current study. The MRI-histopathology concordance rate of 85.4% in the present analysis is comparable to the concordance reported by Lam V et al. (2024)[3], who found imaging-pathology agreement ranging between 80% and 88% for mandibular and soft tissue invasion. Furthermore, the ability of MRI to detect recurrence in 25% of patients reinforces findings by Patel P et al. (2023)[4], who emphasized MRI as the preferred modality for post-treatment surveillance due to its high sensitivity in differentiating tumor recurrence from post-radiation fibrosis.

With respect to primary tumor size and depth of invasion (Table 2), the mean tumor size of 3.8 cm and mean DOI of 9.6 mm indicate advanced disease at presentation, a trend commonly observed in Indian cohorts. Wang Y et al. (2022)[6] reported a mean DOI of approximately 8-10 mm in gingivobuccal complex carcinomas, which is comparable to the present findings. The strong association between DOI greater than 10 mm and nodal positivity (85%) observed in this study corroborates the results of Chen J. (2025)[7], who demonstrated that increasing DOI was an independent predictor of cervical lymph node metastasis and poorer survival outcomes. These observations further validate the inclusion of DOI as a critical parameter in the AJCC staging system and highlight the importance of MRI in preoperative risk stratification.

The assessment of adjacent structure involvement (Table 3) revealed frequent invasion of the buccal fat pad and cervical lymph node metastasis (both 60.4%), followed by masticator space involvement and mandibular erosion. These findings are consistent with the

observations by Mair M et al. (2021)[8], who reported high rates of locoregional spread and nodal involvement in Indian oral cancer patients due to late clinical presentation. The detection of mandibular cortical erosion and marrow invasion in nearly one-third and one-fourth of patients respectively mirrors the data reported by Lo Casto A et al. (2022)[1], where MRI demonstrated high sensitivity for detecting cortical and medullary bone involvement, aiding surgical decision-making regarding marginal versus segmental mandibulectomy. Additionally, the presence of extracapsular nodal spread in 25% of cases aligns with earlier studies highlighting its strong association with poor prognosis and increased recurrence risk.

In Table 4, prognostic imaging markers such as perineural invasion, marrow infiltration, and recurrence patterns were strongly associated with adverse outcomes. The perineural invasion rate of 35.4% is comparable to the rates reported by Minamitake A et al. (2021)[9], who identified perineural spread in approximately 30-40% of advanced oral cavity tumors. The strong association between perineural invasion and recurrence (75%) observed in the present study supports the findings of Mahajan A et al. (2023)[10], who emphasized perineural spread as an independent predictor of local recurrence and reduced disease-free survival. Similarly, the association between bone invasion and recurrence noted in this study is in agreement with Pietragalla M et al. (2025)[11], who demonstrated that marrow invasion was linked to aggressive tumor behavior and higher recurrence rates. The mean disease-free survival of approximately 12 months further reflects the aggressive nature of buccal mucosa cancers and underscores the importance of MRI-based prognostic assessment for optimizing treatment strategies.

CONCLUSION

This study highlights the crucial role of Magnetic Resonance Imaging (MRI) as a comprehensive diagnostic and prognostic imaging modality in the evaluation of buccal mucosa cancers. MRI demonstrated high accuracy in T-staging, precise delineation of tumor extent, and strong concordance with histopathological findings, establishing its reliability in preoperative assessment. The ability of MRI to accurately measure depth of invasion (DOI), identify involvement of adjacent structures such as buccal fat pad, masticator space, mandible, and detect cervical lymph node metastasis significantly influenced surgical planning and treatment stratification.

Furthermore, MRI proved highly valuable in identifying adverse prognostic features including perineural invasion, marrow infiltration, and extracapsular nodal spread, all of which were strongly associated with locoregional recurrence and reduced disease-free survival. The strong correlation observed between increasing DOI and nodal metastasis further emphasizes the prognostic significance of MRI-derived parameters.

In the post-treatment setting, MRI effectively detected recurrence and differentiated residual or recurrent tumor from post-therapeutic changes, reinforcing its importance in follow-up surveillance. Overall, MRI not only serves as an essential imaging tool for accurate diagnosis and staging but also plays a pivotal role in prognostication, treatment planning, and long-term disease monitoring. Incorporation of MRI into routine evaluation protocols for buccal mucosa cancers can lead to improved oncological outcomes, better surgical precision, and optimized patient management.

LIMITATIONS OF THE STUDY

1. The study was conducted with a relatively small sample size, which may limit the generalizability of the results.
2. Being a single-center observational study, the findings may be influenced by institutional practices and referral patterns.
3. Histopathological correlation was not available for all imaging parameters in every patient.
4. Inter-observer variability among radiologists was not formally assessed.
5. Follow-up duration was relatively short, which may have underestimated long-term recurrence rates and survival outcomes.
6. Advanced MRI techniques such as dynamic contrast-enhanced perfusion imaging and radiomics analysis were not included.
7. Motion artifacts and patient-related factors occasionally affected image quality.
8. The study did not include direct comparison with other imaging modalities such as CT or PET-CT.

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