ORIGINAL RESEARCH PAPER
Volume - 13 | Issue - 11 | November - 2024 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

UTILITY OF MULTIDETECTOR COMPUTED TOMOGRAPHY IN THE ASSESSMENT OF ORAL CARCINOMA

Radiology

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ABSTRACT

Background: Oral cavity malignancies, particularly squamous cell carcinoma, represent a significant health concern in India, with a high incidence and mortality rate. Early detection is crucial for improving patient outcomes, yet late presentation remains common. This study aimed to evaluate the diagnostic accuracy of multidetector computed tomography (MDCT) in staging oral cavity carcinoma and to compare its findings with histopathological results. **Material & Methods:** An analytical cross-sectional study was conducted at SAIMS & PG Institute, Indore, involving 40 adult patients with clinical suspicion of oral carcinomas. After obtaining ethical approval and informed consent, patients underwent contrast-enhanced CT examinations using a SIEMENS 64-slice MDCT scanner. Tumor extension, nodal metastasis, and pathological findings were assessed, and the data were analyzed statistically to determine sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy. **Results:** The mean age of participants was 52 ± 6.25 years, with a male predominance (60%). Buccal mucosa was identified as the most common subsite of malignancy, and 85% of patients reported a history of tobacco, areca nut, or betel nut chewing. The majority of participants were classified as T4a (57.5%) and N2b (45%). CT exhibited high sensitivity for detecting maxillary sinus and skin infiltrations (both 100%), while showing significant results for bone infiltration (77.78%) and muscle infiltration (60.00%). Nodal assessment revealed a sensitivity of 86.67%. Overall, the accuracy of CT imaging in staging was statistically significant ($p < 0.001$) compared to postoperative histopathology, affirming its role as a valuable non-invasive tool in the management of oral cavity squamous cell carcinoma. **Conclusion:** MDCT is a valuable non-invasive imaging modality for the T and N staging of squamous cell carcinoma of the oral cavity. Its use of contrast and the puffed cheek maneuver enhances soft tissue visualization, aiding in the accurate assessment of malignancies. The findings support CT's role in improving diagnosis and treatment planning for oral cavity carcinoma, emphasizing the need for early detection strategies.

KEYWORDS

Oral carcinoma, CT staging, malignancy, histopathological correlation

INTRODUCTION

Oral cavity malignancy is frequently encountered in clinical practice. In India, cancers of the lip and oral cavity constitute approximately 7.6% of total cancer cases and are responsible for over 7% of cancer-related deaths. Squamous cell carcinoma is the most frequent malignancy of oral cavity and oropharyngeal region, accounting for 5% of all malignant tumors worldwide. Sex-standardized data indicate a higher prevalence in males, with an incidence of 11.3% and a mortality rate of 10.2%, compared to females, who have an incidence of 4.3% and a mortality rate of 4.8%. [1,2]

In India, oral cancer represents a significant public health concern due to factors such as late diagnosis, limited access to quality healthcare, and a higher prevalence among lower socioeconomic groups, likely linked to increased exposure to risk factors. [2,3] The etiology of oral cancer is multifactorial, with lifestyle choices and environmental factors playing a significant role. [2] Smoking, chewing tobacco, betel nut consumption, and alcohol use are primary risk factors that are largely preventable. [2-4] Moreover, late presentation for diagnosis and treatment is common, with 60–80% of Indian patients presenting in advanced stages, compared to only 40% in Western populations. This delay significantly worsens prognosis and increases the burden on healthcare systems. [2]

Early detection is crucial for improving cure rates, reducing morbidity, and minimizing treatment costs. Oral cancers, including those of the lips, tongue, floor of the mouth, and other oral cavity structures, often present with nonspecific symptoms in their early stages, leading to delayed diagnosis and treatment initiation. [5] However, when detected early, the chances of successful treatment and cure are significantly higher. Thus, highlighting the importance of strategies aimed at early detection and diagnosis of these malignancies is paramount. [6] Further, tumor extension into local anatomical areas, such as the face, maxilla, and neck spaces, is critical for cancer staging, which plays a pivotal role in determining prognosis and treatment strategies while minimizing excessive morbidity. [7,8]

Although clinical evaluation of the oral cavity and oropharynx is important, cross-sectional imaging plays a crucial role in staging, assessing pathology beneath the mucosa, and determining tumor size, thickness, depth, and local invasion. Traditional clinical examination techniques may not always be sufficient to identify subtle or deep-seated lesions. Imaging modalities such as computed tomography (CT) offer a non-invasive means to visualize the internal structures of the oral cavity with high detail and accuracy. [9] Imaging features that influence staging and treatment planning, such as involvement of the retromolar trigone (RMT), muscles of the tongue, masticator space, bone, neurovascular bundles, and lymph nodal and distant metastasis, are accurately delineated by multidetector computed tomography (MDCT). Additionally, the puffed cheek CT technique is easy to perform and offers a clearer and more detailed evaluation of the buccal and gingival mucosa of the oral cavity. [10] By offering valuable insights into the extent and characteristics of lesions, imaging facilitates timely identification, staging, and formulation of appropriate treatment strategies and prognostication for oral cavity and oropharyngeal cancer. [9]

Understanding the anatomy of the oral cavity and oropharynx is crucial for comprehending the associated malignancies. The squamous epithelium lining the oropharynx originates from the endoderm and has a higher propensity for developing poorly differentiated, aggressive malignancies. In contrast, the squamous epithelium of the oral cavity, derived from the ectoderm, tends to give rise to more differentiated and less aggressive tumors. Additionally, identifying the specific subsite of tumor origin is vital, as the routes of spread, lymphatic drainage, and treatment options vary depending on the subsite. [11]

CT is a widely utilized as the primary imaging modality in the evaluation of oral cavity lesions. It utilizes X-rays to generate cross-sectional images of the body, allowing for detailed visualization of anatomical structures and pathological abnormalities. CT imaging provides detailed information regarding the size, location, morphology, and tissue characteristics of oral cavity lesions, while also helping to evaluate metastatic lymph nodes and bone involvement thus aiding clinicians in making accurate diagnoses and treatment decisions. Its ability to capture three-dimensional images and detect subtle changes makes it an invaluable tool in the comprehensive assessment of oral cavity malignancies. [8,12]

The literature regarding the validity indices of CT have provided mixed results. Moreover, as local data regarding the sensitivity and specificity are not available, our study would help us in determining the diagnostic accuracy of CT in detecting oral cavity carcinoma. To address the gap, we conducted this study to determine the diagnostic accuracy of MDCT in the assessment of Oral carcinoma, evaluate its utility in staging, and examine the association between CT findings and histopathological results in patients with oral carcinoma.

MATERIAL & METHODS

After obtaining approval from the institutional ethical committee, this analytical cross-sectional study was conducted in the Department of Radiodiagnosis at SAIMS & PG Institute, Indore, involving 40 adult patients (aged >18 years) of either sex with a clinical suspicion of oral carcinomas referred for CT examination. Eligible patients were enrolled in the study, with all participants providing written informed consent after receiving a comprehensive explanation of the study protocol.

Inclusion Criteria

- Adult Patients aged > 18 years irrespective of sex having with clinical suspicion of oral malignancies.

Exclusion Criteria

- Patients refusing consent to participate in the study;
- Pregnant females;
- Elevated serum creatinine levels >1.5mg/dl;
- Patients having commenced treatment;
- Patients who have undergone earlier radiotherapy or chemotherapy; and
- Patients who have undergone any earlier head and neck surgeries.

Methodology:

The purpose of the study was explained to the participants, including the associated risks and benefits especially the potential risks associated with contrast administration and written consent was obtained prior to imaging with contrast. Participants were required to fill out a proforma with their name, sex, age, and patient ID number. The patients with clinical suspicion of oral carcinomas were subjected to CT examination. CT images were obtained using a SIEMENS 64-slice multidetector CT scanner (Somatom Definition AS).

After the injection of non-ionic contrast media (90 ml bolus at 1.5 ml/sec) and a scan delay of 50 to 60 seconds, contiguous slices of 5 mm thickness were obtained in the axial plane, covering the area from the base of the skull to the upper chest, parallel to the infraorbital-meatal line. All patients with oral cavity tumors underwent the "puffed-cheek" technique during image acquisition. The images were retro-reconstructed with a slice thickness and interval of 1.25 mm, reformatted in sagittal and coronal planes for analysis. All images were analyzed using bone and soft tissue algorithms.

Tumor extension on CT was defined by the presence of enhancement in the soft tissue adjacent to the primary site of malignancy, while nodal metastasis was identified as lymph nodes with a maximum short axis diameter of 10 mm or greater. Bone invasion criteria on CT were defined as the absence of the cortex of bone adjacent to the malignancy. Clinical examination findings were obtained from patient records, and both CT and clinical findings were compared with postoperative histopathology. The cases were staged according to the seventh edition of the American Joint Committee on Cancer (AJCC) TNM staging system.

Statistical Analysis

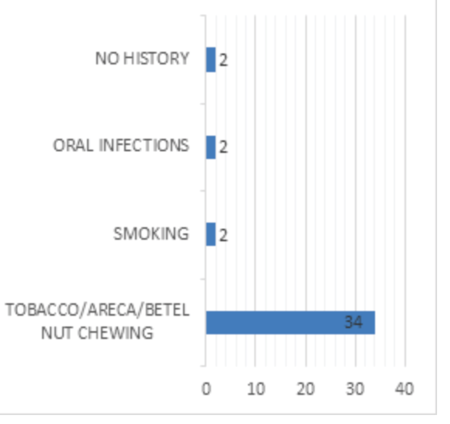
Data were collected and entered into MS Excel, where they were presented using frequency tables. Descriptive statistics were calculated, providing the mean and standard deviation (SD) for quantitative data, along with frequency and percentage for qualitative data. To visualize the qualitative data, pie and bar diagrams were utilized. The Chi-square test was applied to assess associations between two qualitative variables, while the correlation coefficient test evaluated correlations between two quantitative variables. A p-value of less than 0.05 was considered statistically significant. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for MDCT were calculated using histopathology as the gold standard.

RESULTS

A total of 40 patients were enrolled in the study. The age of the patients ranged from 19 to 75 years, with the majority of patients being in the 51-60 years age group, accounting for approximately 15 (37.5%) patients. The mean age was 52 + 6.25 years. Males showed a higher preponderance in the study, with 24 patients (60%) compared to 16 females (40%), resulting in a male-to-female ratio of 1.5:1. The most common subsite in our study was the buccal mucosa, observed in 22 (60%) patients. RMT, alveolus, and GBS were the second most common subsites (as shown in Table 1). 85% of total patients had history of tobacco/areca nut/ betel nut chewing. 5% had history of smoking and 5% had history of oral infections while 5% of patients had no history of any addictions/ risk factors. (Graph 1)

Table 1. Distribution of study participants based upon Primary oral cavity malignancy subsites

Primary Subsites	Total
BM	22 (60%)
RMT	4 (10%)
Lower lip/upper lip	3 (7.5%)
Tongue	3 (7.5%)
Upper or lower alveolus	3 (7.5%)
Hard palate	2 (5%)
FOM	2 (5%)
Lower lip/upper lip	1 (2.5%)
GBS	1 (2.5%)
Total	40 (100%)



Graph 1. Distribution of patients according to risk factors.

Tumor size was measured using calipers and staged according to the 8th edition TNM classification. T1 tumors were less than 2 cm with a depth of invasion ≤5 mm, T2 were 2-4 cm or ≤2 cm with a depth of 5-10 mm, and T3 were >4 cm with a depth ≤10 mm or any tumor with a depth ≥10 mm. T4a tumors were >4 cm with a depth >10 mm or involved adjacent structures like bone, the maxillary sinus, or skin. (Figure 1a, 2a).

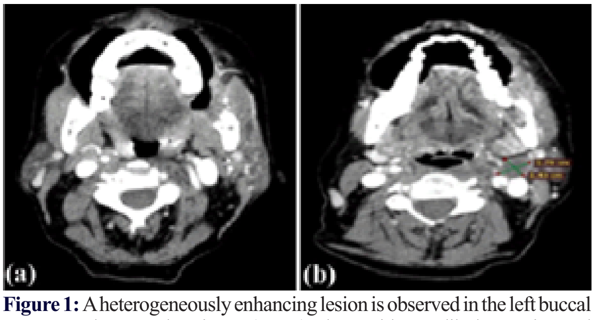


Figure 1: A heterogeneously enhancing lesion is observed in the left buccal mucosa and retromolar trigone (RMT), along with mandibular erosion and ipsilateral cervical level II lymphadenopathy, classified as T4a N1.

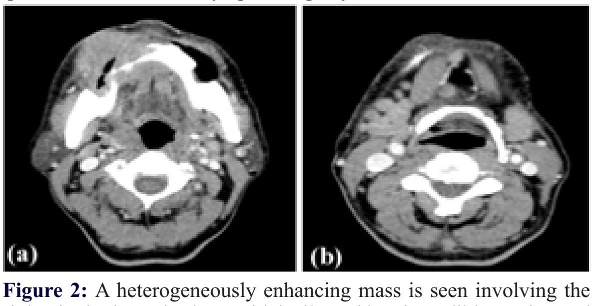


Figure 2: A heterogeneously enhancing mass is seen involving the right gingivobuccal sulcus, with ipsilateral hemimandible erosion and multiple small cervical level Ia and right level Ib lymph nodes. The lesion is classified as right inferior gingivobuccal sulcus squamous cell carcinoma (GBS SCC), staged as T4a N2b.

 PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

According to radiological staging using contrast CT, in our study, 23 out of 40 patients were classified under the T4a stage, making it the most common stage. The next most common stage was T2, with 11 out of 40 patients. The T1 stage was the least common in our study group. Most of the patients with T4a stage exhibited bone infiltration both radiologically and pathologically, with only a few cases showing maxillary sinus or skin infiltration (Table 2).

Table. 2. Distribution of study participants based upon Radiological T stage

Radiological T stage	Total
T1	2 (5%)
T2	11 (27.5%)
T3	4 (10%)
T4a	23 (57.5%)
Only Bone infiltration	7 (17.5%)
Muscle Infiltration	4 (10%)
Maxillary Sinus infiltration	2 (5%)
Skin infiltration	2 (5%)
Bone and muscle infiltration	6 (15%)
Bone, Muscle and skin infiltration	1 (2.5%)
Bone and Skin infiltration	1 (2.5%)

According to radiological TNM staging (8th edition AJCC) using contrast CT, N0 represents no regional nodal metastasis, N1 is defined as metastasis in a single ipsilateral node ≤3 cm without extranodal extension (Figure 1b), N2a refers to metastasis in a single ipsilateral node 3-6 cm without extranodal extension or in a single ipsilateral node ≤3 cm with extranodal extension (Figure 2b), N2b indicates metastasis in multiple ipsilateral nodes ≤6 cm without extranodal extension, and N2c involves metastasis in bilateral or contralateral nodes ≤6 cm without extranodal extension. N3 stage is characterized by a node >6 cm or metastasis in a single ipsilateral node >3 cm with extranodal extension, or multiple ipsilateral, contralateral, or bilateral nodes with extranodal extension, or a single contralateral node with extranodal extension.

In our study, the majority of patients fell under the N2b stage, with 18 (45%) out of 40 patients, followed by the N0 stage, with 10 (25%) out of 40 patients, and the least being the N3 stage, with 1 (2.5%) patient (Table 3).

Table. 3. Distribution of study participants based upon Radiological N stage

Radiological N stage	Total
N0	10 (25%)
N1	6 (15%)
N2a	1 (2.5%)
N2b	18 (45%)
N2c	3 (7.5%)
N3	1 (2.5%)
Total	40 (100%)

According to the pathological T stage distribution, most of the patients showed only bone infiltration. Least common T stage was T1. Out of T4a stage, most patients showed only bone infiltration (Table 4).

Table. 4. Distribution of study participants based upon Pathological T stage

Pathological T stage	Total
T1	2 (5%)
T2	12 (30%)
T3	4 (10%)
T4a	22 (55%)
Only Bone infiltration	14 (35%)
Muscle Infiltration	2 (5%)
Maxillary Sinus infiltration	1 (2.5%)
Skin infiltration	0 (0%)
Bone and muscle infiltration	3 (7.5%)
Bone, Muscle and skin infiltration	0 (0%)
Bone and Skin infiltration	2 (5%)

Pathologically, most patients fell under N2b stage 15 (37.5%) while 12 (30%) patients showed no node involvement (Table 5).

Table 5. Distribution of study participants based upon Pathological N stage

Pathological N stage	Total
N0	12 (30%)
N1	9 (22.5%)
N2a	1 (2.5%)
N2b	15 (37.5%)
N2c	2 (5%)
N3	1 (2.5%)
Total	40 (100%)

Table 6 summarizes the tumor staging observations based on a diagnostic evaluation of 40 patients according to the TNM classification. For T1 stage, all patients were correctly identified, achieving a sensitivity and specificity of 100%, indicating exceptional reliability in detection. In the T2 stage, the sensitivity was 66.67%, showing that two-thirds of true T2 cases were accurately identified, while specificity was 89.29%, reflecting a strong ability to rule out non-T2 cases. The positive predictive value (PPV) was 72.73%, suggesting that among those identified as T2, a significant portion actually had the disease, whereas the negative predictive value (NPV) of 86.21% indicated good accuracy in identifying patients without T2. For T3 stage, sensitivity stood at 75%, with high specificity at 97.22%, highlighting effective detection while minimizing false positives. The T4a stage showed sensitivity of 82.61%, capturing most cases, but with lower specificity at 70.59%, indicating some misclassification. Overall, the high sensitivity, specificity, and statistical significance ($p < 0.001$) across the stages reflect the effectiveness of the diagnostic evaluation, though improvements may be needed, particularly for T2 and T4a classifications.

Table 6. Correlation of radiological and pathological findings on tumour staging

Tumour staging	Observation					Correlation					P value
	TP	FP	FN	TN	Total	Se	Sp	PPV	NPV	Accuracy	
T1	2	0	0	38	40	100%	100%	100%	100%	100%	<0.001*
T2	8	3	4	25	40	66.67%	89.29%	72.73%	86.21%	82.50%	<0.001*
T3	3	1	1	35	40	75.00%	97.22%	75.00%	97.22%	95.00%	<0.001*
T4a	19	5	4	12	40	82.61%	70.59%	79.17%	75.00%	75.00%	<0.001*

* Statistically significant

Most patients with T4a stage exhibited bone infiltration, both radiologically and pathologically, followed by muscle infiltration. Only a few cases showed maxillary sinus infiltration and skin infiltration. Among T4a patients with bone infiltration, the majority had infiltration limited to the mandible. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy for bone infiltration, muscle infiltration, maxillary sinus infiltration, and skin infiltration are presented in Table 7.

Table. 7. Correlation of radiological and pathological findings on T4a staging

Tumour staging	Observation					Correlation					P value
	TP	FP	FN	TN	Total	Se	Sp	PPV	NPV	Accuracy	
Bone infiltration	14	2	4	20	40	77.78%	90.91%	87.50%	83.33%	85%	<0.001*
Muscle infiltration	3	10	2	25	40	60.00%	71.43%	23.08%	92.59%	70.00%	<0.001*
Maxillary sinus infiltration	2	0	0	38	40	100%	100%	100%	100%	100%	<0.001*
Skin infiltration	2	3	0	35	40	100%	92.11%	40.00%	100%	92.50%	<0.001*

* Statistically significant

Radiologically, out of 30 patients with positive nodes, 26 were correctly identified as true positives, while 4 were classified as true negatives. The sensitivity, specificity, PPV, NPV, and accuracy of CT for detecting positive nodes were 86.67%, 80.00%, 92.86%, 66.67% and 85.00%, respectively, yielding a P-value of less than 0.001, indicating a highly significant association (see Table 8). This data suggests that the CT scan is an effective tool for diagnosing positive lymph nodes, demonstrating a strong performance in accurately identifying affected patients.

Tab. 8. Correlation of radiological vs pathological for Positive node Radiological node in relation to pathological node of patients studied

Radiological Node	Pathological Node		
	Negative Nodes	Positive Nodes	Total
Negative Nodes	8 (66.7%)	2 (7.1%)	10 (25%)
Positive Nodes	4 (33.3%)	26 (92.9%)	30 (75%)
Total	12 (100%)	28 (100%)	40 (100%)
Correlation of radiological vs pathological for Positive node		**P value**	
Sensitivity %	86.67%	<0.001*	
Specificity %	80.00%	<0.001*	
PPV %	92.86%	<0.001*	
NPV %	66.67%	<0.001*	
Accuracy %	85.00%	<0.001*	

* Statistically significant

DISCUSSION

In this study, we investigated the diagnostic efficacy of CT imaging in staging oral cavity carcinoma by correlating radiological findings with postoperative histopathological results. The integration of TNM staging provided a structured framework for evaluating tumor characteristics and lymph node involvement. [13]

To the best of our knowledge, this is the first study to evaluate the diagnostic accuracy of multidetector computed tomography (MDCT) in detecting oral cavity carcinoma among patients in Central India. Our findings indicate that MDCT demonstrates a high capability to identify tumor invasion when compared to histopathology, considered the gold standard. Understanding the extent of involvement in oral cavity carcinoma is crucial for surgeons, as it significantly influences decision-making regarding surgical resection. Our findings underscore the significance of accurate staging in guiding treatment decisions and improving patient outcomes, while also highlighting the strengths and limitations of CT as a diagnostic tool in oncology.

In this analytical cross-sectional study, 40 adult patients provided written informed consent and were enrolled based on clinical suspicion of oral cavity carcinoma, leading to their referral for a CT scan. The study employed TNM staging for radiological assessment, which was then correlated with postoperative histopathological staging, recognized as the gold standard for accurate tumor classification [14].

Out of the 40 patients studied, 22 (60%) had buccal mucosa as their primary subsite, making it the most common site for oral cavity malignancies, followed by the gingivobuccal sulcus (GBS), retromolar trigone (RMT), and alveolus. The majority of patients were in the age group of 51-60 years. Regarding gender distribution, there was a higher prevalence of oral cavity malignancy in males compared to females, with a ratio of 60% to 40% (male: female ratio of 1.5:1). This finding aligns with the study conducted by Agarwal B.D. et al. [13], which also noted a male predominance in oral cavity malignancies. However, their research reported an equal distribution between genders, contrasting with the results of our study. This discrepancy highlights the need for further investigation into the demographic factors influencing oral cavity cancer presentation in different populations.

In our study, the majority of patients were classified under the T4a stage, with 23 cases identified radiologically and 22 cases confirmed pathologically. Pathologically, most patients were categorized as N2b stage. The study reported a total of 19 true positive cases across various T stages on CT: 2 in T1, 8 in T2, 3 in T3, and 19 in T4. The detection percentages for different T stages on CT demonstrated statistical significance and were consistent with findings from prospective studies by Wiener et al. [15] and Agarwal B.D. et al. [13] This correlation reinforces the reliability of CT imaging in accurately staging oral cavity carcinoma and supports its use in clinical practice for effective patient management.

The sensitivity, specificity, PPV, NPV and accuracy of CT for bone infiltration in present study was 77.78%, 90.91%, 87.50%, 83.33% and 85% respectively which was comparable to the study conducted by Agarwal B.D et al. [13], Wiener et. al. [15], Uribe et. al. [16] and Kushraj et. al. [17].

In the present study, the sensitivity of CT for detecting positive nodes was found to be 86.67%, which closely aligns with the findings of Agarwal B.D. et al. [13] (92%), Pandeshwar et al. [18] (92%), and Saafan et al. [19] (83%). The specificity reported in our study was 80%, comparable to the 75.7% observed by Wiener et al. [15] and the 68% reported by Agarwal B.D. et al. [13]. Our study recorded a positive predictive value (PPV) of 92.86%, consistent with values reported by Agarwal B.D. et al. [13] (87%), Pandeshwar et al. [18] (85%), Saafan et al. [19] (95%), and Anand et al. [20] (94.5%). The negative predictive value (NPV) in our study was 66.67%, which is similar to findings from Wiener et al. [15] (86%), Agarwal B.D. et al. [13] (79%), Saafan et al. [19] (68%), and Anand et al. [20] (71%). Lastly, the overall accuracy of 85% in our study is consistent with the results of Agarwal B.D. et al. [13], Pandeshwar et al. [18], Wiener et al. [15], Saafan et al. [19], and Anand et al. [20]. These findings highlight the reliability of CT imaging in assessing lymph node involvement in oral cavity carcinoma.

This study has several limitations that should be acknowledged. First, as our institute is a tertiary care hospital, the majority of cases referred were locally advanced malignant lesions, specifically at the T4a stage. Consequently, we were unable to conduct a comparative analysis of other T4a parameters, such as skin infiltration and maxillary sinus infiltration, due to a lack of available reference articles. Additionally, evaluating the usefulness of CT in assessing T4b stage lesions was not feasible, as most cases at this stage are managed palliatively with chemoradiation, resulting in a lack of postoperative histopathological findings for comparison. Lastly, the study did not consider M staging due to the rarity of metastatic disease, which, in turn, outweighs the radiation exposure risks associated with whole-body CT scans. These limitations highlight the need for further research in more diverse populations and stages of oral cavity malignancies.

CONCLUSION

CT serves as a valuable non-invasive cross-sectional imaging tool for T and N staging of squamous cell carcinoma across various subsites of the oral cavity. The administration of contrast, combined with the puffed cheek maneuver, enhances soft tissue delineation, allowing for a thorough evaluation of the gingivobuccal sulcus and buccal mucosa. Our study reveals that the sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy of CT in staging oral cavity squamous cell carcinoma are statistically significant when compared to the gold standard of postoperative histopathological staging.

Among the subsites of the oral cavity, the buccal mucosa emerged as the most common site of malignancy, followed by the retromolar trigone (RMT). When assessing T4a parameters, CT demonstrated the highest sensitivity in detecting skin infiltration, maxillary sinus infiltration, and bone infiltration, while showing moderate significance in identifying muscle infiltration. Notably, the most common N stage identified in our study was N2b. For nodal staging, CT exhibited significant sensitivity, specificity, positive predictive value, negative predictive value, and accuracy, further validating its role as an effective imaging modality in the management of oral cavity squamous cell carcinoma.

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