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Assessment of Lymph Node Metastasis in Oral Squamous Cell Carcinoma Using MRI-Based Learning Model

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ABSTRACT

Objective: Lymph node involvement is crucial for prognostic factor for oral squamous cell carcinomas, and understanding nodal metastasis pattern is essential.

Methods: The retrospective study analysed 316 patients with oral cancer, comprehensive assessment of patient data was used to determine the extent and size of the lesion and lymph node involvement. Preoperative staging was confirmed using various imaging techniques, including OPG, CT MRI, and biopsies. Histological examination results were used to categorize carcinomas based on differentiation levels and to identify nodal involvement patterns.

Results: The most common subsite for 316 patients was the tongue (62%), followed by the buccal mucosa (19%), lower alveolus (10.2%), hard palate (3.2%), retro molar trigone (2.8%), floor of the mouth (1.6%), upper alveolus (0.9%), and lower lip (0.3%).

Conclusion: Nodal metastasis in oral cancer are common in Levels II and Ib, with variations based on subsite.

Keywords: *Lymph Node, MRI, Oral Squamous Cell Carcinoma*

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1. INTRODUCTION

Around 377 713 new cases and 177 757 predicted deaths worldwide were attributed to lip and oral cavity malignancies in 2020. When taken as a whole, these tumours are the 18th most prevalent neoplasm globally.[1] Squamous cell carcinomas account for more than 90% of these malignancies. With an incidence rate of about 40%, lymph node metastasis (LNM) is the most detrimental prognostic factor for oral squamous cell carcinoma (OSCC). Individuals lacking LNM have an overall 5-year survival rate of over 80%, but those in the N3 stage have a much poorer 5-year survival rate of about 20%, per the eighth edition of the American Joint Committee on Cancer (AJCC) staging manual.[2]

Here, we developed a DL model to detect LNM in OSCC patients using three-dimensional neck MRI sequences. The diagnosis performance of the DL model was thoroughly assessed in this multicenter, cross-machine, and cross-radiologist comparison environment using three stages: image, chronology, and patient-based. The model performed satisfactorily, matching or even surpassing radiologists' abilities. Additionally, the model identified occult metastases prior to surgery, which allowed for more effective planning of therapy.

Notwithstanding lack of early diagnostic indications, OSCC grows quickly, therefore it is frequently diagnosed in its later stages. Radiological tests, such as CT or MRI, are essential for determining the size, depth, and possible invasion of bone tissue in order to evaluate tumour features. Depending on stage of the tumour, alternatives to therapy include adjuvant radiation, surgery, or a combination of chemotherapy and radiation.[3]

In OSCC, bone invasion or erosion can be detected with both CT and MRI. The sensitivity, specificity, and accuracy associated with these imaging techniques are comparable. According to published research, the sensitivity, specificity, and accuracy of CT range from 41.7 to 89%, 86.9 to 100%, and 71.2 to 85%, whereas those of MRI range from 58.3-95.24%, 73 to 100%, and 75.8 to 93%.[4,5] The ability of ML-based MRI texture interpretation in differentiating among moderately or inadequately differentiated OSCCs and well-differentiated OSCCs was investigated in present investigation.

2. METHODOLOGY

The RKDF Dental College and Research Center's Department of Oral and Maxillofacial Surgery in Bhopal conducted the protocol for this retrospective investigation. For this investigation, clinical, histologic, and imaging data from OSCC patients hospitalised at this hospital between January, 2023, and April, 2025, were gathered.

From June 2022 and June 2025, 320 patients (male and female) over the age of 18 who had treatment for squamous cell cancer of mouth verified by biopsy were enrolled in the study. Every precaution that was required to guarantee the total privacy of an individual's data was taken. Subjects with a history of other head and neck cancers and those who had gone through any type of therapies, both non-surgical and surgical, for any form of head and neck cancers were excluded

While evaluating the patients, factors such as age, sex, cancer site, and clinical and pathological staging were taken into account. The instances were analysed using the eight anatomical parts of the oral cavity: the floor of the mouth, lower lip, retromolar trigone, upper/lower alveolus, buccal mucosa, and hard palate. The size and extent of the lesion (T) and the presence of LN were determined by a comprehensive evaluation. OPGs, CT scans, MRI scans of the head and neck region, and lesion biopsies were used to validate preliminary grading. Each case was given a histological grade (well, moderately well, and poorly differentiated carcinomas) based on Broder's classification of carcinomas based on their degree of differentiation. The results from the histology examination were subsequently analysed to search for nodal involvement patterns. All clinically node-positive subjects underwent comprehensiveA neck dissections, while node-negative patients underwent selective neck dissections (level I–III/IV). Skip metastasis was characterised as the existence of metastasis at a lower level without proximal level metastases. At stages III, IV, and V, skip metastasis rates were assessed.

SPSS Version 22 was used to evaluate the information. The association between nodal metastasis and subsite, which indicates the impact of the tumor's subsite on the likelihood of nodal metastasis, as well as the relationship between the diagnostic T stage, DOI, and the levels of ipsilateral lymph node metastasis were determined using the Chi-Square test of autonomous behaviour.

3. RESULTS

The investigation comprised 316 patients who were diagnosed with primary OSCC between June 2017 and June 2020. Of these, 79 patients (25 percent) were female, and 237 patients (75 percent) were male. The average age of the patients was 58.15 years, with a range of 23 to 87 years. Seventy-two percent of the patients in the cohort were older than fifty. Patients over 60 made up 45.9% of the total, while those between 40 and 60 made up 44.6% of the patients. Just 9.5% of patients were younger than 40 years old.

Table 1. Distribution of the Patients Based on Tumor Diagnosis, Sub Site and Side.	
Diagnosis	**n (%)**
Well differentiated	159 (50.3)
Moderately differentiated	135 (42.7)
Poorly differentiated	22 (7.0)
Sub site of Tumor	
Buccal Mucosa	60 (19.0)
Floor of Mouth	5 (1.6)
Hard palate	10 (3.2)
Lower lip	1 (0.3)
Retromolar trigone	9 (2.8)
Upper alveolus	3 (0.9)

Lower alveolus	32 (10.1)
Affected Side	
Left	152 (48.1)
Midline	3 (0.9)
Right	161 (50.9)

Table 2. Distribution of Patients Based on Level Wise Patterns of Lymph Node Involvement.

n (%)	
Ia	14 (12.1)
Ib	60 (51.7)
II	73 (62.9)
III	34 (29.3)
IV	12 (10.3)
V	4 (3.4)
ECS	37 (31.9)

Table 3. Distribution of Patients Based on Clinical and Pathological Staging of SCC.

Type of staging		**n (%)**
Clinical Staging		
Ct	T1	100 (31.6)
	T2	110 (34.8)
	T3	35 (11.1)
	T4a	62 (19.6)
	T4b	9 (2.8)
cN	N0	233 (73.7)
	N1	60 (19.0)
	N2b	17 (5.4)
	N2c	1 (0.3)
	N3b	5 (1.6)
Pathological Staging		
pT	T1	76 (24.1)
	T2	118 (37.3)
	T3	58 (18.4)
	T4a	55 (17.4)

	T4b	9 (2.8)
Pn	N0	200 (63.3)
	N1	37 (11.7)
	N2a	6 (1.9)
	N2b	42 (13.3)
	N2c	2 (0.6)
	N3b	29 (9.2)

Table 4. Sensitivity and Specificity of Clinical Neck Examination.

cN		**pN**			**Total**
		Disease			
	Present	**n**	**Absent**	**n**	
Positive	True Positive	a= 64	False Positive	c= 19	a+c= 83
Negative	False Negative	b= 52	True Negative	d= 181	b+d= 233
Total	a+b= 116		c+d= 159		
Statistic	Sensitivity	Specificity	PPV	NPV	Accuracy
	55.17%	90.50%	77.11%	77.68%	77.53%

cN- Clinical Nodal involvement; pN- pathological Nodal involvement; PPV- Positive predictive value; NPV- Negative predictive value

Table 5. Association between Level of Lymph Node Involvement and Depth of Invasion (DOI).

Level Ia	**Level Ib**	**Level II**	**Level III**	**Level IV**	**Level V**	
DOI <= 5mm	0	3	1	1	0	0
DOI > 5mm,	6	16	17	7	3	2
<= 10mm						
DOI > 10mm	8	23	24	8	2	1

4. DISCUSSION

The course of cervical lymph node metastasis in head and neck cancers has been studied in a number of publications since Lindberg's[6] research in 1972 on the involvement and anatomical pattern of lymph node metastasis in squamous cell carcinomas of the upper aerodigestive tract. These studies have established data to support an appropriate surgical technique for neck dissection. These papers include Sharpe et al.[7], Shah et al.[8], and Woolgar et al.[9]

A considerable percentage of nodal metastases in our study's tongue-related patients were found in Level II (70%) and Level III (37%), with Level Ib likewise exhibiting noteworthy involvement (35%). On the other hand, Level Ib (82.6%) and Level II (43.5%) were the most common metastatic sites for instances involving the buccal mucosa and lower alveolus. Patil et al.[10] observed similar results, showing that among those suffering from oral cancer, Level II (56.3%) was the level with the most commonly afflicted lymph node station in histopathology. These results are consistent with those of Nithya et al.,[11] who found that Level II was the most frequently impacted site in their series, accounting for 63.6% of cases. In a

similar vein, the Pantvaidya et al.[12] investigation discovered that although buccal mucosa cancers mostly spread to levels IB and IIA, tongue cancers frequently spread to Levels IIA and III.

5. CONCLUSION

Depending on the subsite, nodal metastases are common in Stages II and Ib of mouth cancer. Cancers of the tongue exhibit a rise in a smaller number of lymph nodes, whereas those of the alveoli and buccal mucosa include fewer lymph nodes above Level III. With higher DOI, level IV involvement is more common, and skip metastases are uncommon.

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