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Clinical and Radiological Evaluation of Regional Lymph Node Metastasis in Patients of Oral Cavity Cancer

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ABSTRACT

Aim: Tostudy the pattern of regional lymph node metastasis in oral cavity cancer

Materials and Methods: This observational cross-sectional study was conducted over two years from march 2023 to February 2025, in the Department of Radiation Oncology at DVVP PRH, PIMS-DU, Loni. It includes 63 newly diagnosed, non-metastatic cases of squamous cell carcinoma of the oral cavity. Patients of all ages and genders providing informed consent were enrolled. Clinical and radiological evaluations (USG, CT, MRI, PET-CT) was used to assess lymph node involvement. Statistical analysis, including chi-square tests, was used to identify significant associations between tumour stage and lymph node metastasis.

Results: A total of 63 patients were included in the study, with a median age of 55 years (range: 30–85). Most patients (68.25%) were male, resulting in a male-to-female ratio of 2.15:1. A significant proportion (98.4%) of cases were from rural areas, the most common age group was 51-60 years (28.57%), followed by 41-50 years (23.81%), with only one patient in the 21-30 years age group (1.59%), Among the study population, 77.78% patients were literate, while 22.22% were illiterate. Regarding occupation, the majority were labourers (33.33%) and farmers (31.75%), followed by homemakers (14.29%), watchmen (7.94%), and drivers (6.35%). A small percentage (1.59%) worked in administration or business.

The most affected tumoursubsites were the buccal mucosa (28.57%) and tongue (26.98%), followed by the gingivobuccal sulcus (19.05%), lower alveolus (14.29%), and retromolar trigone (11.11%). The right side was more frequently involved (65.08%) than the left side (34.92%). Histopathological evaluation revealed that 50.79% of cases were moderately differentiated squamous cell carcinoma (MDSCC), while 31.75% were well-differentiated (WDSCC) and 17.46% were poorly differentiated (PDSCC).

In view of addiction and comorbidities, tobacco and alcohol consumption were prevalent among the study population. The most common addiction pattern was a combination of smokeless tobacco and alcohol (34.92%), followed by a mix of smoking tobacco, alcohol, and smokeless tobacco (28.57%). Smokeless tobacco alone was used by 20.63% of patients, while smoking tobacco alone was the least common (3.17%). Among the study population, 17.5% had comorbidities, with hypertension and diabetes mellitus being the most frequently observed conditions.

Fortumour staging and nodal involvement, study found that most of the patients presented with advanced-stage disease. T3 tumours were seen in 33.33% of cases, while T4a tumours accounted for 31.75%. T2 tumours made up 30.16%, with early-stage tumours (T1) being rare at 3.17%. Nodal staging revealed that 33.33% of patients had N0 nodal disease, while 66.67% had nodal metastasis. The most common nodal stage was N3b (26.98%), followed by N1 (20.63%), N2b (11.11%), and N2c (7.94%).

With regards to lymph Node level involvement and upstaging the most frequently involved lymph node level was Level II (15.87%), followed by multi-level involvement in Levels II, III, and IV (11.11%). The study observed that 5 out of 63 patients (7.94%) had their nodal staging upstaged following radiological assessment.In Stage II, no lymph node involvement was recorded, In Stage III, lymph node involvement was more dispersed, with the highest proportion (45%) had no lymph nodal involvement, followed by level II (18%) and level IV (14%). Stage IVA exhibited more widespread lymphatic involvement, with the

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majority (31%) in levels II and III combined, and 25% in level II alone. In Stage IVB, lymphatic spread was even more extensive, with 39% of cases showing involvement across levels II, III, and IV, and 28% in levels III and IV.

Conclusion: This study highlights the significant burden of oral cavity cancer, particularly in rural populations with limited healthcare access. The findings indicate that advanced tumour stages are prevalent at diagnosis, emphasizing the need for early detection and intervention. Nodal involvement strongly correlates with tumour stage, and radiological assessments, particularly PET-CT and MRI/CT, play a critical role in identifying occult metastases. The study underscores the importance of comprehensive staging to optimize treatment planning and improve patient outcomes. Strengthening screening programs, increasing awareness, and integrating advanced imaging techniques into routine clinical practice can contribute to better management and survival rates in OCC patients.

I. INTRODUCTION

Oral cavity cancer (OCC) significantly impacts speech, swallowing, and appearance, affecting patients' quality of life. The oral cavity—comprising the lips, buccal mucosa, alveolar ridge, retromolar trigone, hard palate, floor of the mouth, and anterior two-thirds of the tongue—is highly susceptible to malignancies due to environmental and mechanical factors [**1,2**].

Globally, OCC ranks as the 18th most common cancer, with 377,713 new cases and 177,757 deaths annually. India accounts for nearly one-third of this burden, largely due to tobacco use, betel quid chewing, and poor oral hygiene [**3,4**]. Head and neck cancers constitute 30% of all malignancies in Indian males and 11%–16% in females, with most OCC cases diagnosed at advanced stages (III or IV), leading to aggressive treatment, increased morbidity, and poor survival rates [**3,5**].

Lymph node metastasis is the most critical prognostic factor in OCC, significantly affecting staging and treatment outcomes **[6]**. Patients with nodal involvement face lower survival rates, underscoring the need for accurate detection. However, occult metastases in clinically negative necks (cN0) remain a challenge [5]. Advanced imaging modalities—ultrasound (USG), computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography-computed tomography (PET-CT)—enhance diagnostic accuracy and guide therapeutic decisions [**6**].

This study aims to analyse lymph node metastasis patterns and evaluate the role of radiological imaging in nodal staging. By correlating clinical, radiological, and pathological findings, the study seeks to refine staging protocols, optimize treatment approaches, and improve survival outcomes for OCC patients.

II. MATERIALS AND METHODS

Ethical consideration

After obtaining clearance from ethical committee all patients fulfilling inclusion and exclusion criteria were enrolled in the study. Informed written consent in a vernacular language was obtained from all the study participants.

Patient selection

This study was conducted in the Department of Radiation Oncology, Pravara Institute of Medical Sciences, after obtaining ethical clearance. Patients meeting the inclusion criteria—newly diagnosed, histopathologically confirmed squamous cell carcinoma of the oral cavity, and without distant metastasis—were enrolled after providing informed written consent in a vernacular language. Exclusion criteria included prior head and neck malignancies and recurrent or metastatic disease, previous treatment for oral cancer, severe comorbid conditions limiting treatment options, or unwillingness to participate.

Assessment

Patient evaluation included a detailed history covering presenting complaints, family history, and personal habits such as tobacco, alcohol, or substance use, along with dietary habits. A thorough clinical assessment was conducted, including a general physical examination for pallor, icterus, clubbing, cyanosis, pedal edema, and generalized lymphadenopathy, followed by a systemic examination. Laboratory investigations included a complete blood count (CBC), liver and renal function tests (LFT, RFT) and viral markers. A biopsy report was obtained for histopathological confirmation. Radiological assessment included a chest X-ray (PA view), contrast-enhanced CT of the face and neck, and PET-CT imaging when indicated to evaluate disease extent and lymph node involvement.

Statistical analysis

All the data collected was compiled and was subjected to statistical analysis to derive a conclusion.Patients' characteristics were assessed by simple statistical techniques using mean,

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standard deviation, median, range, proportion/percentage, etc.

Statistical analysis was done by applying an appropriate test as per the nature and distribution of variable (Chi-square test at 5% level of significance and cross-tab method).

III. RESULTS

A total of 63 patients were included in the study, with a median age of 55 years (range: 30–85). Most patients (68.25%) were male, resulting in a male-to-female ratio of 2.15:1. A significant proportion (98.4%) of cases were from rural areas, the most common age group was 51-60 years (28.57%), followed by 41-50 years (23.81%), with only one patient in the 21-30 years age group (1.59%), Among the study population, 77.78% patients were literate, while 22.22% were illiterate. Regarding occupation, the majority were labourers (33.33%) and farmers (31.75%), followed by homemakers (14.29%), watchmen (7.94%), and drivers (6.35%). A small percentage (1.59%) worked in administration or business.

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In view of addiction and comorbidities, tobacco and alcohol consumption were prevalent among the study population. The most common addiction pattern was a combination of smokeless tobacco and alcohol (34.92%), followed by a mix of smoking tobacco, alcohol, and smokeless tobacco (28.57%). Smokeless tobacco alone was used by 20.63% of patients, while smoking tobacco alone was the least common (3.17%). Among the study population, 17.5% had comorbidities, with hypertension and diabetes mellitus being the most frequently observed conditions.

Table no 1– Patient and tumour characteristic

Patient Characteristics	**Frequency (n=63)**	**Percentage (%)**	**Comorbidities**	**Frequency (n=63)**	**Percentage (%)**
Age Group (years)			None	52	82.5
21-30	1	1.6	Present	11	17.5
31-40	11	17.5	**Type of Comorbidities**		
41-50	15	23.8	Hypertension	5	45.45
51-60	18	28.6	Diabetes Mellitus	5	45.45
61-70	7	11.1	Hypertension + Diabetes	1	9.10
>70	11	17.5	**Addiction Pattern**		
Gender			Smoking Tobacco (ST)	2	3.2
Male	43	68.25	Smokeless Tobacco (SLT)	12	19.0
Female	20	31.75	Alcohol + SLT	22	34.9
Residential Status			SLT + ST	5	7.9
Rural	62	98.4	ST + AL + SLT	18	28.6
Urban	1	1.6	None	4	6.3
Occupation			**Tumour Subsite Distribution**		
Labourer	21	33.3	Buccal Mucosa	18	28.57

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Farmer	20	31.75	Tongue	17	26.98
Homemaker	9	14.3	Gingivobuccal Sulcus	12	19.05
Watchman	5	7.9	Lower Alveolus	9	14.29
Driver	4	6.35	Retromolar Trigone	7	11.11
Others (Admin, Business, Painter, Policeman)	4	6.35			
Education Level					
Illiterate	14	22.2			
Primary	28	44.4			
Secondary	20	31.7			
Postgraduate	1	1.6			

Stage-Wise Distribution	Frequency(n=63)	Percentage (%)	**Stage Grouping**	Frequency(n=63)	Percentage (%)
T1	2	3.17	Stage I	2	3.17
T2	19	30.16	Stage II	19	30.16
T3	21	33.33	Stage III	21	33.33
T4a	20	31.75	Stage IV	21	33.33
Nodal Involvement					
N0	21	33.33			
N1	13	20.63			
N2b	7	11.11			
N2c	5	7.94			
N3b	17	26.98			

Table no 2 – Lymph node level involvement

lymph node level involved	**Stage II (n=7)**		**Stage III (n=22)**		**Stage IVA (n=16)**		**Stage IVB (n=18)**		**Chi value**	**p value**
	Number	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**		
Ib	0	0	1	5	0	0	0	0		
II	0	0	4	18	4	25	2	11		
I,II	0	0	0	0	1	6	0	0		
III	0	0	2	9	1	6	3	17		
II,III	0	0	1	5	5	31	1	6	63.069	<0.001
IV	0	0	3	14	0	0	0	0		
II,III,IV	0	0	0	0	0	0	7	39		
III,IV	0	0	1	5	1	6	5	28		
N0	7	100	10	45	4	25	0	0		

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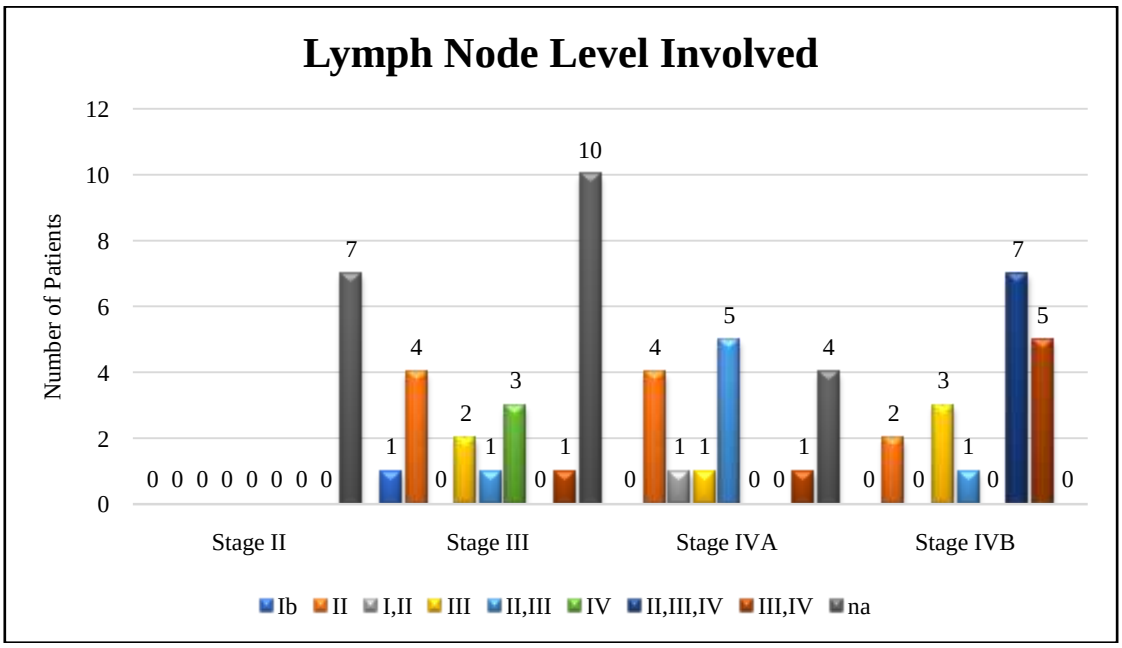

Graph no – 1Lymph Node Level Involved

The T Staging Distribution of patients is as follows: Most patients were classified as T3, accounting for 21 patients (33.33%). This was followed closely by T4a, with 20 patients (31.75%). T2 staging was observed in 19 patients (30.16%), while T1 was much less common, with only 2 patients (3.17%). The least frequent category was T4b, with just 1 patient (1.59%)

For the N Staging Distribution (Final Staging), the most common nodal stage was N0, found in 21 patients (33.33%). N3b followed, with 17 patients (26.98%), while N1 was seen in 13 patients (20.63%). The N2b category included 7 patients (11.11%), and N2c was the least common, occurring in 5 patients (7.94%).

Final nodal staging and compares clinical staging with radiological staging of lymph node involvement in 63 patients, highlighting variations between the two methods. In clinical staging, 23 patients (36.5%) were classified as N0, whereas radiological staging identified 21 patients (33.3%) in this category. Similarly, 16 patients (25.39%) were staged as N1 clinically, while radiological staging identified 13 patients (20.6%). The N2b and N3b categories remained identical in both methods, with 7 patients (11.1%) and 17 patients (27%), respectively. However, radiological staging detected 5 additional N2c cases (7.9%), which were not identified in clinical staging, where no patients were classified under this category.

Table no - 3 Site wise lymph node metastasis

Subsite	**N0 (%)**	**N1 (%)**	**N2b (%)**	**N2c (%)**	**N3b (%)**	**Total Patients**
Buccal mucosa	9 (50.0%)	5 (27.8%)	2 (11.1%)	1 (5.6%)	1 (5.6%)	18(100%)
GBS	3 (25.0%)	2 (16.7%)	1 (8.3%)	3 (25.0%)	3 (25.0%)	12(100%)
Lower Alveolus	2 (22.2%)	2 (22.2%)	0 (0.0%)	1 (11.1%)	4 (44.4%)	9(100%)
RMT	2 (28.6%)	1 (14.3%)	2 (28.6%)	0 (0.0%)	2 (28.6%)	7(100%)
Tongue	5 (29.4%)	3 (17.6%)	2 (11.8%)	0 (0.0%)	7 (41.2%)	17(100%)
Total	21(33.33%)	13(20.63%)	7(11.66%)	5(7.93%)	17(26.98%)	63(100%)

The analysis of nodal staging in 63 patients shows significant variation among different subsites. In Buccal mucosa out of 18 patients, 9 (50.0%) had N0, followed by 5 (27.8%) with N1, while N2b 2 patients (11.1%), N2c 1 patient (5.6%), and N3b 1 patient (5.6%) had lower

occurrences. Among GBS cases out of 12 patients, 3 (25.0%) were N0, while 2 (16.7%) had N1, 1 (8.3%) had N2b, and both N2c and N3b were seen in 3 patients each (25.0%).

For Lower Alveolus out of 9 patients, 2 (22.2%) had N0, 2 (22.2%) had N1, and no cases were observed in N2b, while 1 (11.1%) was classified as N2c and 4 (44.4%), had N3b, indicating significant nodal involvement. In RMT out of 7 patients, 2 (28.6%) each were in N0, N2b, and N3b, while 1 (14.3%) had N1, and no cases were found in N2c.

For Tongue (17 patients), 5 (29.4%) were N0, followed by 3 (17.6%) in N1, 2 (11.8%) in N2b, and no cases in N2c, whereas 7 (41.2%) were classified as N3b, highlighting a high rate of advanced nodal involvement.

IV. DISCUSSION

This study comprehensively analyzed 63 patients diagnosed with head and neck squamous cell carcinoma (HNSCC), highlighting significant variations in nodal staging**,** disease distribution, and patient demographics. Most patients were male (43 patients, 68.25%)**,** with amedian age of 55 yearsand anage range of 30 to 85 years. Most patients **(**98.41%**)** resided in rural areas, indicating potential disparities in access to early diagnosis and treatment.

Regarding subsite distribution, the most affected regions were buccal mucosa (18 patients, 28.57%), followed by the tongue (17 patients, 26.98%), gingivobuccal sulcus (GBS)(12 patients, 19.05%)**,** lower alveolus (9 patients, 14.29%), and retromolar trigone (RMT) (7 patients, 11.11%). The right side was more frequently involved **(**41 patients, 65.08%)**,** compared to the left side (22 patients, 34.92%)**.**

Additionally, the study analyzed risk factors, revealing a high prevalence of tobacco and alcohol consumption**,** with34.92% of patients using smokeless tobacco and alcohol**,** and 28.57% using a combination of smoking, alcohol, and smokeless tobacco. Comorbidities were present in 11 patients (17.5%)**,** withhypertension (45.45%) and diabetes (45.45%) being the most common.

The distribution of T staging revealed that most patients presented with T3 21 (33.33%) and T4a 20 (31.75%) disease, with T2 19 (30.16%) following closely. Early-stage tumours (T1) were seen in only in 2 cases (3.17%) of cases, and T4b, representing the most advanced local disease, was observed in 1(1.59%) of patients. This predominance of locally advanced tumours (T3-T4a) suggests delayed diagnosis, which is a well-known issue in head and neck cancer, particularly in low-resource settings where access to healthcare is limited.

These findings are consistent with Sharma et al., who reported that most of the oral squamous cell carcinoma patients present with T3 or higher disease, often due to a lack of awareness, financial constraints, and late medical consultation. Additionally, Gupta et al. (2014) **(8)** highlighted that tumour size and extent of invasion significantly impact prognosis, with T3 and T4a tumours having lower survival rates compared to T1-T2 tumoursGupta et al., 2014]**(8)**

The clinical significance of these findings lies in the aggressive nature of advanced T-stage tumours, which require multimodal treatment approaches including surgery, radiation therapy, and chemotherapy. Studies have shown that patients with T3-T4 tumours have a higher risk of local recurrence and poorer survival outcomes compared to early-stage tumours【Patel et al., 2019]**(7)** The high percentage of T3-T4a cases in this study further underscores the need for improved screening programs and early intervention strategies to reduce the burden of late-stage presentations.

The most common nodal stage was N0 (33.33%), indicating no lymph node involvement. The second most common stage was N3b (26.98%), followed by N1 (20.63%), N2b (11.11%), and N2c (7.94%). The increasing frequency of advanced nodal stages suggests disease progression and poorer prognosis.

Among patients with lymph node metastasis, the most involved level was Level II (15.87%), followed by Levels II and III combined (11.11%), Levels II, III, and IV (11.11%), and Levels III and IV (11.11%). Level III alone was involved in 9.52%, while Level IV alone accounted for 4.76%. The least frequent involvement was at Level Ib (1.59%). The spread of lymph node involvement was significantly correlated with disease stage ($p < 0.001$).

These findings are in alignment with previous literature, which suggests that Level II is the most involved nodal station in head and neck malignancies, given its anatomical proximity to primary tumour drainage pathways. Patel et al. (2019) found that Level II involvement is a critical prognostic marker, with patients showing higher rates of regional recurrence if Level II nodes are positive【Patel et al., 2019]**(10)**

Additionally, multi-level nodal involvement, particularly Levels II, III, and IV, indicates more aggressive disease with higher chances of extracapsular spread (ECS). This has significant treatment implications, as patients with

multi-level nodal involvement often require more aggressive adjuvant therapy, including radiation with concurrent chemotherapy to achieve better disease control【Sharma et al., 2021] **(9)**

In this study, nodal staging was determined based on both clinical examination and radiological imaging. **5 cases were observed where the clinical nodal status was upgraded following radiological assessment**. The most significant changes occurred in Stage III and Stage IVA patients, where radiological investigations revealed additional lymph node involvement not detected during clinical examination

These findings emphasize the limitations of clinical nodal assessment and the necessity of imaging modalities such as contrast-enhanced CT (CECT), MRI, and PET-CT for accurate staging.

Radiological investigations play a crucial role in precise tumour staging, treatment planning, and prognosis prediction in OSCC. While physical examination and palpation provide an initial assessment, radiological imaging is superior in detecting occult metastases, extra nodal extension (ENE), and deep tissue invasion.

Detection of Non-Palpable Lymph Nodes: Many lymph nodes may appear normal on clinical examination but harbour microscopic disease, which can only be detected through imaging techniques such as MRI and PET-CT (Sung et al., 2023)**(11)**

Assessment of Extra nodal Extension (ENE): Radiological features like irregular nodal margins, loss of fat planes, and necrosis suggest ENE, a critical factor influencing prognosis and treatment decisions (Henson et al., 2022).**(12)**

Delineation of Tumour Extent: Advanced imaging helps in determining tumour invasion into surrounding structures, guiding decisions on surgical resectability (Abraham et al., 2023)**(13)**

Guiding Treatment Planning: Accurate nodal staging influences decisions regarding neck dissection, radiation therapy, and chemotherapy, ultimately improving patient outcomes (Sophie et al., 2023). **(14)**

Subsite-Specific Nodal Involvement

Among the five subsites analyzed, buccal mucosa 9(50.0%) had the highest proportion of N0 (node-negative) cases, suggesting a lower tendency for nodal metastasis in early-stage disease. Conversely, lower alveolus and tongue exhibited higher proportions of N3b disease 4 & 7(44.4% and 41.2%, respectively), reflecting their aggressive nature and propensity for advanced nodal involvement. The tongue, known for its rich lymphatic network, has been consistently associated with a higher risk of nodal metastasis, as confirmed by previous studies (Lydiatt et al., 2017; Patel et al., 2018)**(15)**

Clinical Implications of Nodal Staging

The overall distribution of nodal stages across all subsites shows that 21(33.33%) of patients were N0, 13(20.63%) were N1, 7(11.66%) were N2b, 5(7.93%) were N2c, and 17(26.98%) were N3b. The significant proportion of N3b cases 17(26.98%) indicates a high burden of advanced nodal disease, which is critical for treatment planning, as such patients often require multimodal therapy, including surgery, chemotherapy, and/or radiotherapy (D'Cruz et al., 2015). **(16)**

The high incidence of N2-N3 disease in subsites such as the lower alveolus and tongue aligns with previous research emphasizing the importance of elective neck dissection (END) in managing these cancers, even in clinically node-negative patients (Kowalski et al., 2018). The presence of bilateral nodal disease (N2c: 7.93%) further underscores the necessity of comprehensive radiological assessment, as clinical palpation alone often underestimates nodal spread (Ng et al., 2006). **(17)**

The highest rate of occult metastasis was observed in patients with T3 and T4 tumours, reinforcing the need for elective neck dissection in advanced cases.

Moreover, all patients in this study had M0 disease, confirming the absence of distant metastasis at diagnosis. While this is a positive prognostic indicator, the presence of advanced N staging in a significant proportion of patients suggests a higher risk of recurrence and poorer overall survival, as highlighted by Gupta et al. (2014) **(8)**. This further reinforces the importance of comprehensive nodal evaluation using imaging techniques such as PET-CT and MRI to accurately stage disease extent and guide treatment decisions.

Clinical Implications and Future Directions

The findings of this study underscore the critical need for early detection, comprehensive nodal assessment, and multimodal treatment strategies for patients with head and neck carcinoma. The high prevalence of advanced T and N stages suggests that many patients present at a stage where treatment options become more complex and survival outcomes are compromised.

Given the predominantly rural population in this study (98.41% rural residents), the lack of early diagnosis may be attributed to limited access to healthcare facilities, financial constraints, and low awareness regarding the early signs of head

and neck cancers. This aligns with studies by Gupta et al. (2014)**(8)** and Kowalski et al. (2018)**(18)**, which emphasized that rural patients tend to have more advanced disease at presentation, highlighting the need for targeted screening programs in rural areas【Gupta et al., 2014】**(8)**【Kowalski et al., 2018】**(18)**

V. CONCLUSION

Clinical Implications

The study highlights the late-stage presentation of HNSCC, particularly in rural populations, where delayed diagnosis contributes to poor prognosis and higher treatment burden. The high incidence of advanced tumor and nodal stages (T3/T4a and N2/N3) indicates an urgent need for strengthening early detection programs, patient education, and accessibility to specialized care. Given the significant impact of radiological upstaging (7.94%), integrating routine imaging in initial staging protocols can enhance treatment planning, improve surgical decision-making, and reduce the risk of under-treatment.

Future Recommendations

- Enhancing early detection programs through public awareness and routine screening in high-risk populations.
- Expanding access to radiological imaging (CT, MRI, PET-CT) to improve nodal staging accuracy and early metastasis detection.
- Implementing multidisciplinary treatment approaches incorporating surgery, radiotherapy, and chemotherapy for advanced-stage cases.
- Promoting tobacco and alcohol cessation programs, given their strong correlation with disease incidence and progression.

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