DOI: https://doi.org/10.54393/pjhs.v6i12.3448

PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (E): 2790-9352, (P): 2790-9344
Volume 6, Issue 12 (December 2025)

Original Article

OPEN ACCESS

Diagnostic Accuracy of Computed Tomography with Intraoperative Findings in Prediction of Metastatic Cervical Lymph Nodes in Oral Squamous Cell Carcinoma by Taking Histopathology as Gold Standard

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ARTICLE INFO

Keywords:
Oral Squamous Cell Carcinoma, Computed Tomography, Intraoperative Lymph Node Assessment, Cervical Lymph Node Metastasis, Diagnostic Accuracy, Histopathology

How to Cite:
Sagar, B., Hamid, K., Khalique, A., Asghar, S., Irfan, B., Mehak, ., Varsha, ., & Devi, P. (2025). Diagnostic Accuracy of Computed Tomography with Intraoperative Findings in Prediction of Metastatic Cervical Lymph Nodes in Oral Squamous Cell Carcinoma by Taking Histopathology as Gold Standard: CT Accuracy for Cervical Node Metastasis in OSCC. Pakistan Journal of Health Sciences, 6(12), 92-97. https://doi.org/10.54393/pjhs.v6i12.3448

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Received Date: 23rd August, 2025
Revised Date: 9th December, 2025
Acceptance Date: 19th December, 2025
Published Date: 31st December, 2025

ABSTRACT

Oral squamous cell carcinoma is a common cancer with a high risk of cervical lymph node metastasis. Accurate identification of metastatic nodes is vital for staging and treatment planning. Computed tomography (CT) is widely used for pre-surgical assessment, while intraoperative lymph node evaluation offers additional diagnostic value. **Objectives:** To assess the diagnostic accuracy of CT and intraoperative findings in predicting metastatic cervical lymph nodes in oral squamous cell carcinoma, using histopathology as the gold standard. **Methods:** A cross-sectional study was conducted at the Department OF Radiology, Dr. Ziauddin University Hospital, Karachi, from November 2023 to November 2024. A total of 323 patients with clinically suspicious oral squamous cell carcinoma underwent CT neck scans and intraoperative lymph node assessment based on size, consistency, shape, and adherence. Histopathology of resected nodes was the reference standard. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated. **Results:** The mean patient age was 51.5 years, with an average lymph node size of 20.9 mm. CT showed sensitivity 97.2%, specificity 84.6%, PPV 76.3%, NPV 98.4%, and accuracy 88.8%. Intraoperative scoring demonstrated sensitivity 89.3%, specificity 88.8%, PPV 80.3%, NPV 94.5%, and accuracy 89.2%. **Conclusions:** Both CT and intraoperative scoring demonstrated high diagnostic accuracy for detecting metastatic cervical lymph nodes. Their combined application is recommended to enhance staging, guide surgery, and improve patient outcomes.

INTRODUCTION

Oral squamous cell carcinoma (OSCC) is among the most prevalent malignancies of the head and neck, representing over 90% of oral cancers worldwide [1]. It arises from the squamous epithelium of the oral mucosa and is known for its locally aggressive behavior and tendency to metastasize to cervical lymph nodes. Despite advances in treatment modalities, including surgery, radiotherapy, and chemotherapy, survival rates for OSCC remain unsatisfactory, primarily due to late diagnosis and nodal metastasis [2]. Early detection and accurate staging of cervical lymph nodes are therefore critical for optimizing treatment planning and improving patient prognosis. The burden of OSCC is particularly high in South Asia, including Pakistan, where it ranks among the top three cancers in

DOI: https://doi.org/10.54393/pjhs.v6i12.3448

incidence [3]. This high prevalence is strongly linked to region-specific risk factors such as tobacco use, betel quid, and areca nut chewing, along with contributory elements like alcohol consumption and poor oral hygiene. The aggressive nature of OSCC, combined with the widespread presence of risk factors, results in a growing incidence and mortality rate [4]. Consequently, early identification of nodal involvement has become a cornerstone of effective management in this population. Cervical lymph node metastasis is a major prognostic indicator in OSCC, with levels I–III most commonly involved [5]. The presence of metastatic nodes, particularly with extracapsular spread, is associated with advanced disease, increased recurrence, and poorer survival outcomes. Clinical examination alone often falls short in detecting small or deep-seated nodal metastases, while reactive nodes can mimic malignancy. To address these challenges, imaging modalities such as computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), and ultrasonography are increasingly relied upon, with CT being the most widely used due to its accessibility and detailed anatomical imaging [6]. However, CT has limitations, particularly in differentiating reactive from metastatic lymph nodes based on size alone and in detecting subtle extracapsular spread [7]. Intraoperative assessment during neck dissection provides an additional opportunity to evaluate nodes based on consistency, shape, and adherence to adjacent tissues. Scoring systems have been developed to standardize intraoperative evaluation, and evidence suggests that combining CT findings with intraoperative assessment enhances diagnostic accuracy. Nevertheless, there is limited local data from Pakistan to validate these approaches in OSCC patients. This study hypothesizes that the integration of CT imaging with intraoperative lymph node scoring improves diagnostic accuracy for detecting metastatic cervical lymph nodes in OSCC patients.

This study aimed to determine the sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy of CT and intraoperative scoring, using histopathology as the gold standard. Also, to analyze the influence of factors such as age, gender, necrosis, and extracapsular spread on diagnostic performance.

METHODS

This cross-sectional diagnostic accuracy study was conducted in the Department of Radiology at Dr Ziauddin University Hospital, Karachi, from November 2023 to November 2024. Ethical approval was obtained from the institutional review board before commencement, and the research synopsis was approved by the College of Physicians and Surgeons Pakistan (CPSP) under reference number CPSP/REU/RAD-2022-201-3687. The sample size was calculated using the Open-Epi diagnostic test sample size calculator, which applies the Buderer formula for studies of diagnostic accuracy. The formula considers sensitivity, specificity, disease prevalence, desired precision, and confidence interval. For sensitivity: $n = (Z^2 \times Se \times (1 - Se)) \div (d^2 \times P)$. For specificity: $n = (Z^2 \times Sp \times (1 - Sp)) \div (d^2 \times (1 - P))$. Where: Se = expected sensitivity, Sp = expected specificity, P = prevalence of disease, d = precision (margin of error), Z = 1.96 at 95% confidence interval. Using values from a previous study by Sharma et al. (2021) [8], sensitivity = 92%, specificity = 42%, and prevalence = 70.58%. With a 95% confidence interval and a margin of error of 10%, the required sample size was calculated to be 319 patients. To ensure adequate power, 323 patients were finally included in this study. Inclusion criteria were male and female patients aged between 30 and 70 years presenting with clinically suspicious oral squamous cell carcinoma and undergoing evaluation through computed tomography followed by surgical resection. The age range of 30–70 years was selected to minimize confounding, as oral squamous cell carcinoma is rare in younger patients, while those above 70 often have multiple comorbidities, higher perioperative risk, and reduced likelihood of undergoing curative surgery in our setting. Patients who had received radiotherapy or chemotherapy, those with inoperable disease or distant metastasis, and those who refused surgery were excluded from the study. Tumor stage was recorded according to the AJCC TNM classification, based on clinical and radiological findings. The targeted population for this study was patients with clinically suspected oral squamous cell carcinoma presenting to a tertiary care center for diagnostic evaluation and surgical management. After informed consent was obtained, each patient underwent a CT scan of the neck from the base of the skull to the clavicle. All scans were performed using a 16-slice multidetector Toshiba Alexion (Japan) with intravenous contrast. Radiological features were assessed using predefined malignancy criteria, including short-axis diameter >10 mm, rounded shape (short-to-long axis ratio >0.5), loss of fatty hilum, presence of central necrosis, irregular margins suggesting extracapsular spread, vascular invasion, and nodal conglomeration. It should be noted that CT-based scoring and intraoperative scoring differ in their parameters. CT scoring is based on radiological features such as size, necrosis, and extracapsular spread, whereas intraoperative scoring relies on tactile and visual assessment by the surgeon. Based on these criteria, each lymph node was classified as malignant or non-malignant for analysis. During surgery, intraoperative assessment of lymph nodes was performed by evaluating four key features, including size, consistency,

DOI: https://doi.org/10.54393/pjhs.v6i12.3448

shape, and adherence to surrounding structures. Each parameter was scored as 1 if present and 0 if absent, with a total score ranging from 0 to 4. A score of 3 or more was considered suggestive of malignancy, while scores between 0 and 2 were considered non-malignant. This cutoff was adapted from surgical practice experience and available literature, though formal external validation is still warranted. All resected lymph nodes were submitted for histopathological examination, which served as the gold standard for confirmation of metastatic involvement. Specimens were fixed in 10% buffered formalin, embedded in paraffin, sectioned at 4–5 µm thickness, and stained with hematoxylin and eosin (H&E). Each node was examined microscopically for metastatic deposits, nodal necrosis, and extracapsular spread. Immunohistochemistry was performed if the morphology was equivocal. Information was gathered through a standardized proforma and subsequently entered into SPSS version 23.0 for statistical evaluation. Descriptive statistics were generated to summarize demographic and clinical characteristics. Sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy were computed for both CT and intraoperative scoring using established formulas. Stratified analyses were performed according to age, gender, presence of necrosis, and extracapsular spread to control potential confounders and evaluate diagnostic performance within subgroups. Chi-square test was applied to compare proportions, and p-values <0.05 were considered statistically significant. Receiver operating characteristic (ROC) curve analysis was also performed to determine the diagnostic performance of CT and intraoperative scoring, with the area under the curve (AUC) calculated.

RESULTS

A total of 323 patients with clinically suspected oral squamous cell carcinoma were included. The mean age was 51.51 ± 10.92 years, and the mean lymph node size on CT was 20.87 ± 5.82 mm. Among the participants, 187 (57.9%) were male and 136 (42.1%) female. Tumor staging revealed 160 patients (49.5%) with T1, 113 (35.0%) with T2, 39 (12.1%) with T3, and 11 (3.4%) with T4. Central necrosis was observed in 62 patients (19.2%), while extracapsular spread was detected in 64 patients (19.8%) (Table 1).

Table 1: Patient Demographics and Clinical Characteristics (n=323)

Variables	Mean ± SD	Median	IQR
Age (Years)	51.51 ± 10.92	55	16
Lymph Node Size (mm)	20.87 ± 5.82	24	10

Comparison of CT findings with histopathology showed that 106 lymph nodes (32.8%) were true positives, 181 (56.0%) true negatives, 33 (10.2%) false positives, and 3 (0.9%) false negatives. The sensitivity and specificity of CT were 97.2% (95% CI: 92.1–99.4) and 84.6% (95% CI: 79.1–89.2), respectively. Positive predictive value (PPV) was 76.3% (95% CI: 68.2–83.2), negative predictive value (NPV) was 98.4% (95% CI: 95.5–99.7), and overall diagnostic accuracy was 88.8% (95% CI: 84.8–92.1). The association between CT and histopathology was statistically significant (χ^2 = 142.6, p<0.001) (Table 2).

Table 2: : CT Scan Results Compared with Histopathology (n=323)

CT Result	Histopathology Positive	Histopathology Negative	Total	% of Total	χ^2	p-value
Positive	106 (32.8%)	33 (10.2%)	139	43.0%	142.6	<0.001
Negative	3 (0.9%)	181 (56.0%)	184	57.0%		
Total	109 (33.7%)	214 (66.3%)	323	100%		

Chi-square test applied; level of significance p<0.01. The ROC curve for CT demonstrated an AUC of 0.91 (95% CI: 0.87–0.95), confirming excellent diagnostic performance (Figure 1).

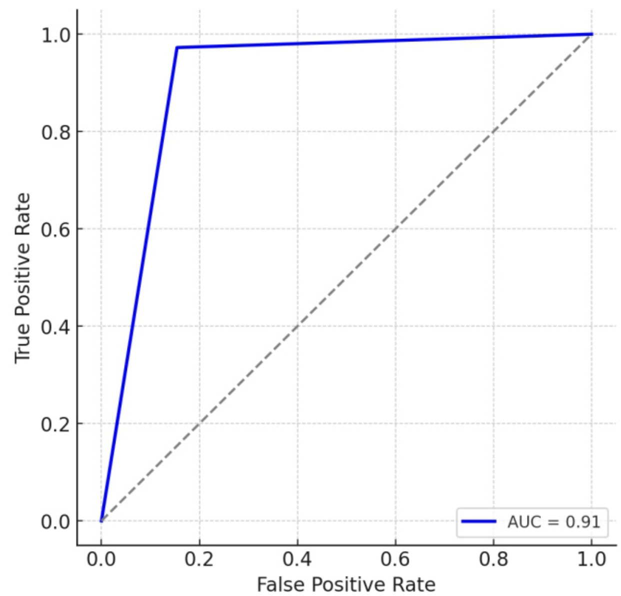

Figure 1: ROC Curve of CT vs Histopathology

Intraoperative scoring based on lymph node size, consistency, shape, and adherence showed variable distribution. Scores of 0 included 189 nodes (all histopathology negative, 58.5% of total); score 1 included 1 positive case (0.3%); score 2 included 10 positive and 1 negative case (3.4%); score 3 included 74 positive and 24 negative cases (30.3%); and score 4 included 24 nodes, all histopathology positive (7.4%) (Table 3).

Table 3: Distribution of Intraoperative Scores vs Histopathology (n=323)

Score	Histopathology Positive	Histopathology Negative	Total	% of Total
0	0 (0%)	189 (58.5%)	189	58.5%
1	1 (0.3%)	0 (0%)	1	0.3%
2	10 (3.1%)	1 (0.3%)	11	3.4%

DOI: https://doi.org/10.54393/pjhs.v6i12.3448

3	74 (22.9%)	24 (7.4%)	98	30.3%
4	24 (7.4%)	0 (0%)	24	7.4%
Total	109 (33.7%)	214 (66.3%)	323	100%

When applying a cutoff score of ≥3 for malignancy, intraoperative scoring yielded 98 true positives (30.3%), 190 true negatives (58.8%), 24 false positives (7.4%), and 11 false negatives (3.4%). Sensitivity was 89.3% (95% CI: 82.0–94.3), specificity 88.8% (95% CI: 83.7–92.9), PPV 80.3% (95% CI: 71.7–87.1), NPV 94.5% (95% CI: 90.5–97.2), and diagnostic accuracy 89.2% (95% CI: 85.4–92.3). The association between intraoperative scoring and histopathology was statistically significant (χ^2 = 165.8, p<0.001) (Table 4).

Table 4: Intraoperative Scoring (≥3) Compared with Histopathology (n=323)

Intraoperative Score	Histo-pathology Positive	Histo-pathology Negative	Total	% of Total	χ^2	p-value
≥3 (Malignant)	98 (30.3%)	24 (7.4%)	122	37.8%	165.8	<0.001
0–2 (Non-malignant)	11 (3.4%)	190 (58.8%)	201	62.2%		
Total	109 (33.7%)	214 (66.3%)	323	100%		

Chi-square test applied; level of significance p < 0.01. The ROC curve for intraoperative scoring demonstrated an AUC of 0.89 (95% CI: 0.84–0.94), reflecting high diagnostic performance (Figure 2).

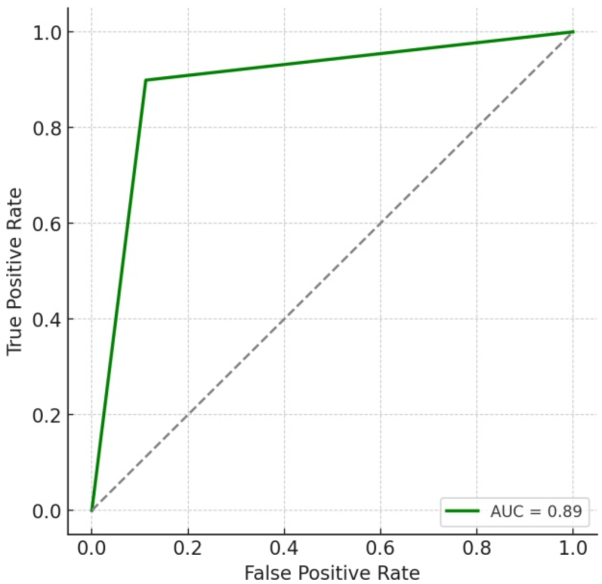

Figure 2: ROC Curve of Intraoperative Scoring vs Histopathology

When comparing diagnostic performance, CT demonstrated higher sensitivity (97.2% vs. 89.3%) and NPV (98.4% vs. 94.5%), while intraoperative scoring showed comparable specificity (88.8% vs. 84.6%) and overall accuracy (89.2% vs. 88.8%) (Figure 3).

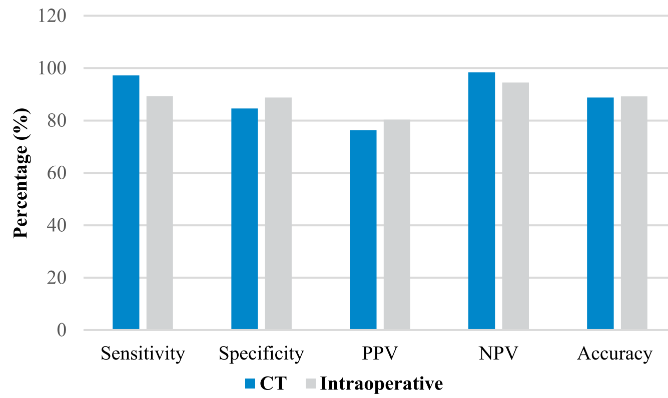

Figure 3: Comparative Diagnostic Performance: CT vs Intraoperative Scoring

DISCUSSION

Oral squamous cell carcinoma (OSCC) remains a significant health burden worldwide and is particularly prevalent in South Asia, including Pakistan [9]. The presence of metastatic cervical lymph nodes is a well-established prognostic factor and directly influences survival and treatment planning. Accurate and timely identification of nodal metastasis is therefore critical [10]. In the present study, both computed tomography (CT) and intraoperative lymph node scoring were evaluated against histopathology as the gold standard. A statistically significant association was observed between both modalities and histopathological findings (p<0.001), confirming their diagnostic reliability [11]. The sensitivity of CT was 97.2%, consistent with previously published data, where CT demonstrated high accuracy for detecting metastatic nodes using size criteria, central necrosis, and extracapsular spread. Specificity was slightly lower, reflecting the tendency of reactive or inflammatory nodes to mimic metastatic involvement. These findings echo prior studies that also highlighted false positives as a limitation of CT [12]. The predictive values further support the utility of CT in clinical decision-making. With an NPV of 98.4%, CT can confidently rule out nodal metastasis, minimizing unnecessary neck dissections in negative patients [13]. This observation is in line with earlier reports, where CT reliably excluded metastasis when nodes appeared normal radiologically [14]. Intraoperative lymph node scoring, based on parameters such as size, consistency, shape, and adherence, demonstrated a sensitivity of 89.3% and specificity of 88.8% [15]. These values, though slightly lower in sensitivity compared to CT, were statistically significant (p<0.001) and comparable with other studies that support the role of intraoperative evaluation as an adjunct to preoperative imaging [16]. Importantly, intraoperative scoring provided additional tactile and visual cues of firmness and adherence that are not available on imaging. Such real-time information is

DOI: https://doi.org/10.54393/pjhs.v6i12.3448

particularly relevant for assessing extracapsular spread, where intraoperative adherence findings may supplement radiological suspicion [17]. The overall diagnostic accuracies of CT (88.8%) and intraoperative scoring (89.2%) were nearly identical, a finding corroborated by previous literature [18]. This reinforces the concept that both modalities are complementary: CT is invaluable for preoperative planning, while intraoperative scoring adds real-time confirmation and may guide the extent of neck dissection. From a clinical perspective, the implications are noteworthy. In low-resource settings such as Pakistan, where access to advanced imaging or PET-CT may be limited, combining CT with intraoperative scoring represents a cost-effective and practical approach [19]. The ability to make intraoperative judgments reduces dependence on expensive imaging modalities and provides surgeons with an evidence-based framework to tailor the extent of surgery. This is particularly beneficial in resource-constrained environments, where avoiding both under- and over-treatment is crucial for patient outcomes and healthcare efficiency. Extracapsular spread (ECS), observed in nearly one-fifth of patients in this study, remains a major prognostic concern [20]. While CT may suggest ECS through radiological features such as irregular margins, intraoperative findings of nodal adherence can serve as a real-time surrogate marker, helping surgeons anticipate the need for more extensive resections and adjuvant therapy [21]. False positives and negatives observed with both modalities underline the importance of a combined strategy. While CT may misclassify reactive nodes, and intraoperative scoring may misinterpret firm reactive nodes as malignant, their combined use reduces the likelihood of diagnostic error. These findings parallel those of international studies emphasizing the need for multimodal approaches [22]. The strengths of this study include a relatively large sample size and the use of histopathology as the gold standard, while limitations involve its single-center design and the absence of interobserver reliability testing. Future studies incorporating multi-institutional data and evaluating observer variability would further strengthen the evidence base. Another limitation is that the intraoperative scoring cutoff (≥3) was adapted from surgical practice experience and available literature, and while it performed well in this cohort, it requires formal external validation in larger, multicenter studies.

CONCLUSIONS

In this study, computed tomography demonstrated a sensitivity of 97.2%, specificity of 84.6%, and diagnostic accuracy of 88.8% for detecting metastatic cervical lymph nodes in oral squamous cell carcinoma, while intraoperative scoring showed a sensitivity of 89.3%, specificity of 88.8%, and accuracy of 89.2%. Both methods showed statistically significant associations with histopathology and comparable overall diagnostic performance.

Authors Contribution

Conceptualization: KH
Methodology: KH, SA, BI, AK, M, BS
Formal analysis: SA, AK, BS, PD
Writing review and editing: KH, BS, V, M

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

Source of Funding

The author received no financial support for the research, authorship and/or publication of this article.

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