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Original Article

Evaluating the Diagnostic Accuracy of Multi-Detector Computed Tomography in Detecting Bone Erosion Among Pre-Treatment Patients with Oral Cavity Squamous Cell Carcinoma at a Public Hospital

Urooj Kanwal, Shazia Kadri, Mukhtiar Ahmed, Shaista Shoukat, Tariq Mahmood

Department of Radiology, Jinnah Postgraduate Medical Center, Karachi Pakistan

ABSTRACT

Objective: To determine the diagnostic accuracy of multi-detector computed tomography (MDCT) using its bone reconstruction algorithm for evaluating bony erosion in pre-treatment patients of suspected oral cavity squamous cell carcinoma as a primary diagnostic imaging tool.

Study Design: Cross-Sectional Study.

Place and Duration of Study: Radiology Department, Jinnah Postgraduate Medical Center, Karachi, Pakistan, from Dec 21 to May 22.

Methodology: All pre-treatment patients referred for a CT scan of the face and neck with high clinical suspicion of oral cavity malignancy were included. After taking proper history, a multi-planar and multi-sequential CT scan with puffed cheek technique, taking 1-3 mm contiguous slices with reconstruction using bone and soft tissue algorithm was performed. Findings of contrast-enhanced CT (CECT) scan were compared with histopathology, which was taken as the gold standard.

Results: Out of 196 patients, 139(70.9%) were males and 57(29.0%) were females in a ratio of 2:1 with mean age of 50.00+11.09 years. 134(68.3%) patients with enhancing soft tissue lesions of different subsets of the oral cavity, predominantly buccal mucosa, showed adjacent bony erosion. 62(31.5%) patients, despite having soft tissue lesions/ulcerations, were negative for overlying bone involvement. Sensitivity, Specificity, PPV, NPV, and accuracy of MDCT were 95.03%, 89.09%, 95.71%, 87.50% and 93.37 % respectively, which were correlated with histopathology. A good agreement was seen amongst imaging and pathological diagnostic tests.

Conclusion: MDCT reconstructed with a bone algorithm plays an indispensable role, not only in early and prompt detection of bony invasion in oral cavity squamous cell carcinoma, but also provides an optimal guideline for oncologists in planning and management of the disease.

Keywords: Bone erosion, Carcinoma, Mouth (Oral cavity), Multi-detector computed tomography, Squamous cell.

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INTRODUCTION

In a developing world, the most important health risk is the increasing prevalence of cancer owing to a large number of reasons.[1] Oral cancer is one of the rapidly rising causes of cancer in either gender globally; it is the eighth most common malignancy worldwide, while the second most common in Pakistan, according to recent studies and statistics.[2,3] There is some difference in frequency and outcomes of oral cancer due to disparity in the location worldwide, with a relatively high prevalence in South Asian countries. In the subcontinent, Pakistan was reported to have an overall prevalence of 10% while India had a higher risk of oral cancer at 45%. Alarming rise in incidence and mortality according to Globocan Cancer Observatory – Pakistan, which states 13.2 and 6.7 in males, while 10.1 and 6.4 in females respectively, with 9-12% new cases diagnosed yearly.[4]

Correspondence: Dr Urooj Kanwal, Department of Radiology, Jinnah Postgraduate Medical Center, Karachi Pakistan

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Squamous cell carcinoma accounts for approximately 90% of all oral malignancies,[5] of which are buccal mucosa and tongue.[5] These sites are aggressively involved subsets of the oral cavity. Other commonly involved sites include the lip, retromolar trigone, alveolar ridges, and floor of the mouth due to frequent exposure to betel quid chewing, tobacco, and alcohol consumption.[6]

Through the decades, there has been immense progress in the field of research on diagnostic techniques. The chances of survival are high if the tumor is timely detected and staged, as trans-oral wide excision surgery with integration of elective neck dissection and bone resection is done in cases of nodal and bony involvement. Post-operative radiation therapy is also an integral part of treatment.[7] Local bony invasions of the maxilla and mandible can be used to construe a pattern that can be followed to determine the T stage and change the treatment regimen overall.[8]

Therefore, local staging of the cancer is of the utmost importance to pursue with treatment

options and to save lives. Contrast-enhanced computed tomography of the face and neck done with the puffed cheek technique is an indispensable investigation for effective staging, treatment choice, and post-treatment follow-up. It can not only help in the accurate detection of the actual anatomical site of the lesion but also in the perfect assessment of adjacent osseous invasion, as well as clearly delineate cervical lymph nodal involvement.[9] Findings of the CT scan were then correlated with histopathology taken as the gold standard.

The purpose of this study was to ascertain the diagnostic accuracy of multi-slice contrast-enhanced computed tomography with reconstructed bone algorithm in all clinically suspected pre-treatment patients of oral cavity squamous cell carcinoma (OCSCC) with local bony involvement by contrasting its results with histopathology. Improved radiological investigation is expected to enhance survival outcomes by guiding early detection of bone erosion, followed by appropriate clinical management and subsequently preventing unnecessary extensive surgical excision.

METHODOLOGY

The study was conducted at the Radiology Department, Jinnah Postgraduate Medical Centre (JPMC) Karachi, Pakistan, for a period of six months from Dec 21 to May 22, after approval from the institutional ethical review board (NO.F.2-81/2021-GENL/68928-A/JPMC, dated 28/10/2021). A cross-sectional prospective study design was used with clinically suspected OCSCC patients. History of predisposing factors like betel quid chewing, smoking, or use of smokeless tobacco, and alcohol addiction were taken along with other co-morbidities. Patients were recruited via non-probability consecutive sampling technique. A sample size of 196 patients was calculated using online available Open-Epi sample size calculator assuming 50% population proportion, 7% margin of error and 95% confidence interval.

Inclusion Criteria: Patients aged 28-70 years of any gender, referred for a CT scan of the face and neck with high clinical suspicion of oral malignancy with adjacent bone invasion owing to non-healing mouth ulcers with/without jaw movement, and who gave consent for study participation were included.

Exclusion Criteria: Patients treated for oral cavity surgery, chemotherapy, or radiotherapy, having a history of disease recurrence, with renal insufficiency, and allergy to contrast were excluded.

Imaging protocol of multi-planar and multi-sequential study with 1-3 mm contiguous sections using puffed cheek technique was used on Toshiba Activation 64 slice Multi-detector CT scanner, and reconstruction was done in bone and soft tissue algorithm. Volume acquisition was done with a thickness varying from 0.5 to 2.0 mm. Cases were reported on PACS (picture archiving and communication system) using soft tissue and bone window to assess enhancing soft tissue lesions with adjacent bone involvement by an experienced radiologist having more than five years of experience in CT scan reporting of the head and neck. Findings of CECT were compared with operative findings and histopathology (post-biopsy or post-surgery), which was taken as the gold standard.[10]

Data for categorical variables were computed using frequencies and percentages. Numerical variables were summarized as Mean±SD. Cross-tabulation was done using a 2x2 table. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were computed for MDCT, taking histopathology as the gold standard.

RESULTS

In our study, out of 196 patients with clinical suspicion of oral cavity cancers, 139(68%) were males and 57(32%) were females. The average age of the patients was 50.05+11.65 years (Table-I).

Table-I: Demographic Characteristics of study Population (n=196)

Variables	Values
Age (in years) Mean±SD	50.02±11.65
Gender	
Male	139(70.90%)
Female	57(29.1%)
Site of Lesion	
Right Buccal Mucosa	92(49.6%)
Left Buccal Mucosa	58(29.6%)
Tongue	24(12.2%)
Lip	22(11.2%)

A favorable result with the use of CECT in the detection of local bone invasion was collected i.e., detection of mandibular and maxillary alveolar arches involvement in OCSCC as shown in (Figure-1A & 1B), (Figure-2A & 2B). Histopathology specimen picture of the same patient with low and high power field views shows moderate atypia, nuclear pleomorphism, and hyperchromasia. (Figure-3A & 3B).

The results showed that 134 patients were true positives (TP), correctly diagnosed with bone invasion of alveolar arches due to squamous cell carcinoma predominantly of either right (49%) or left (29.6%) buccal mucosa, along with loco-regional lymphadenopathy. Whereas 06 patients were reported to have a false positive (FP) on CT scan, subsequently not proven to have any bone involvement on histopathology. 49 patients were

true negatives (TN) correctly diagnosed, and 07 were false negatives (FN) for neoplastic involvement of bone despite having an enhancing soft tissue lesion of different subsets of the oral cavity. Sensitivity, specificity, PPV, NPV, and accuracy of multi-detector computed tomography were 95.03%, 89.09%, 95.71%, 87.50% and 93.37 % respectively (Table-II).

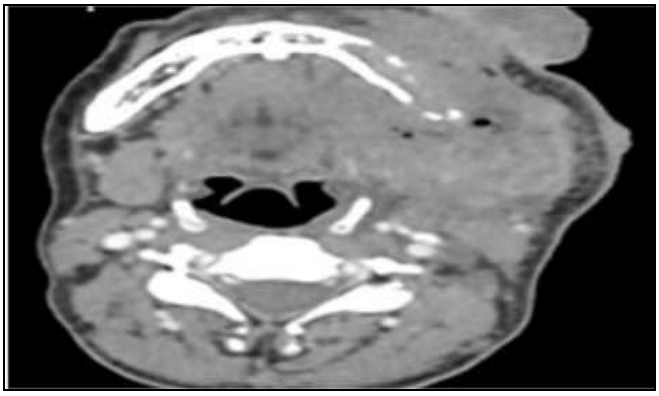

Figure-1A: Axial Images of Contrast-Enhanced CT Scan of Oral Cavity Soft Tissue Window Highlighting the Soft Tissue Mass Lesion in The Left Bucco-Gingival Sulcus With Local Extensions in Adjacent Soft Tissues

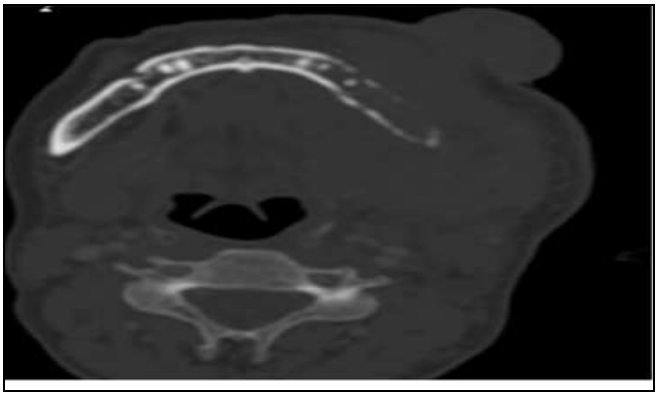

Figure-1B: Axial images of the same patient bone window showing involvement of adjacent mandibular bone with erosive changes

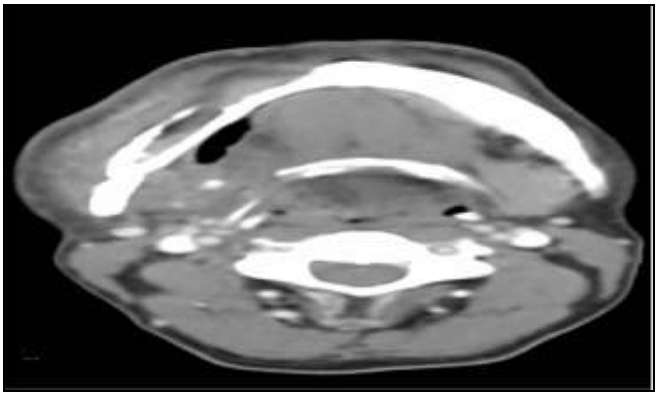

Figure-2A: CECT axial images of oral cavity soft tissue window showing diffuse buccal mucosal thickening involving right cheek

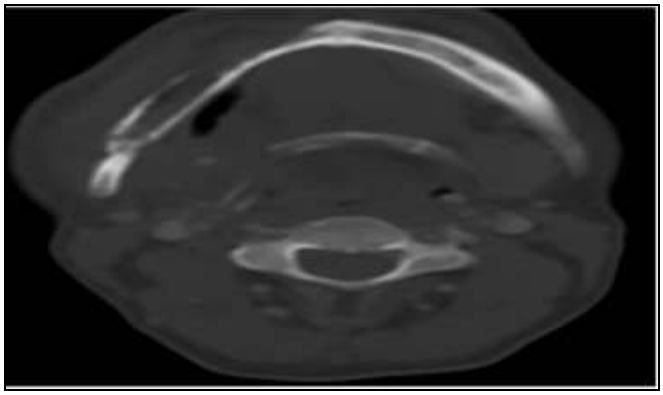

Figure-2B: CECT axial Images Bone Window Showing Erosive Changes Along Right Hemi-Mandible Where the Thickening Noted in Soft Tissue

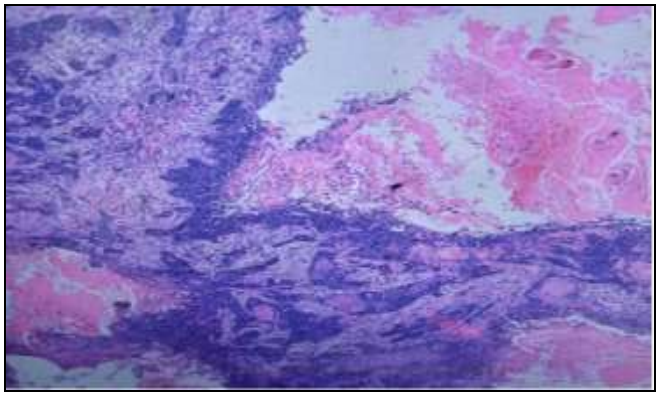

Figure-3A: Histopathology slide of same patient with suspicious lesion on CECT showing hyperchromasia. At places keratin pearls are also visible

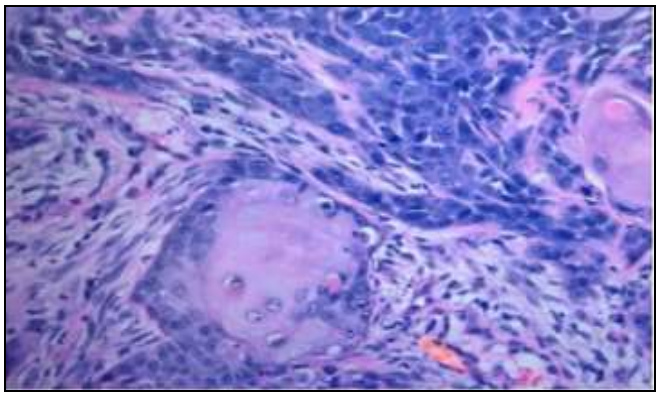

Figure-3B: Histopathology Slide of Same Patient with Suspicious Lesion on CECT Showing Moderate Nuclear Atypia and Pleomorphism

Table-II: Diagnostic Accuracy of Multi-Detector Computed Tomography for Detecting Bone Erosion in Ocscc Versus Histopathology (N=196)

MDCT findings	Histopathologically Positive (n=141)	Histopathologically Negative (n=55)	Total
MDCT Positive	134(68.3 %)	06(3.1%)	140(71.4%)
MDCT Negative	07(3.57%)	49(25.0%)	56(28.6%)
Total	141(71.9%)	55(28.1%)	196(100.0)

Sensitivity= TP/(TP+FN) = 134/(134+7)*100=95.03%
Specificity= TN/(TN+FP) = 49/ (49+6)*100=89.09%
Positive Predictive Value= TP/(TP+FP) *100= 134/(134+6)= 95.71%
Negative Predictive Value= TN/(TN+FN) *100=49/(49+7)= 87.50%
Diagnostic Accuracy=(TP+TN)/All patients*100 = (134+49)/196=93.37%

MDCT = Multi-detector Computed Tomography

DISCUSSION

The study found a favorable result with the use of CECT in the detection of local bone invasion i.e., detection of mandibular and maxillary alveolar arches involvement in OCSSC. Histopathology specimen picture of the same patient with low and high power field views shows moderate atypia, nuclear pleomorphism and hyperchromasia. At places, keratin pearls are also visible. These histopathological findings suggest moderately differentiated squamous cell carcinoma. The study demonstrates that early diagnosis of rapidly spreading oral cavity squamous cell carcinoma, with the addition of bone algorithm reconstruction, provides a reliable assessment of local bony invasion, showing diagnostic accuracy comparable to histopathology.

In Pakistan, oral cancer is on an upward trajectory and raises a major health concern, with products containing carcinogens readily available to the public in various forms like betel quid substitutes (BQS) found in gutka, naswar, and pan masala. It is coherent with the global figures on prevalence and reported frequency of Oral carcinoma.[11]

A study conducted by Yasin *et al*., reported that rates of oral squamous cell carcinoma are higher in males than females, with a mean age at the time of diagnosis being less than 50 years. Frequently placing gutka in the buccal vestibule against the buccal mucosa is responsible for making buccal mucosa the most common tumor site. This study provides baseline information regarding habits.[12] Oral cancer has a very poor prognosis, which is fatal in the long term to its victims. For the past three decades, the growth in survival rate has consistently been inadequate for the undiagnosed, untreated patients. This agrees with a study conducted by Lane *et al*., which also shows CECT is a reliable technique for adjacent bone invasion detection of OCSCC.[13] A sensitivity of 95.03%, a specificity of 89.09%, a PPV of 95.71%, an NPV of 87.50%, and a diagnostic accuracy of 93.38% were noted in our study, further increasing its reliability. This was also consistent with the study by Mukherji *et al*., which had a sensitivity, specificity, positive predictive value, and negative predictive value of 95.83%, 96.4%, 97.7%, and 92.85%, respectively.[14]

The need of the hour is to diagnose oral cancer at the earliest. A study conducted by Uribe *et al*., in 2013 on the accuracy of CT scan, MRI, and PET CT found diagnostic accuracy of 85.7% - 86.7% for CT scan, 87.0% for PET CT, and 85.0% for MRI.[15] Therefore, we found that a thoroughly conducted contrast-enhanced CT scan of the face and neck with thin 1-3 mm slice thickness using the puffed cheek technique is highly precise and reliable, as deduced by higher specificity and positive predictive values.

In our study, we have also noticed that the frequency of bone involvement in newly diagnosed patients of OCSCC has increased significantly, maybe due to late referral or due to an increase in addiction tendency, which, however, is best delineated with the use of a CT scan bone algorithm. A study conducted by Qureshi *et al*., described that the head and neck surgeons gain useful intel through a thorough pre-surgical evaluation of the bone invasion by the tumor via imaging, such as CT scan, MRI, or PET CT, to consider surgical planning like hemi, partial, or total mandibulectomy/maxillectomy accordingly.[16]

Sung *et al*., conducted a detailed global report of incidence and mortality due to oral cancer, which showed the inherent potential of CT to precisely identify the involvement of the alveolar arches in squamous cell carcinoma of the oral cavity.[17] Aliya *et al*., demonstrated that diagnostic accuracy due to the use of a bone algorithm to access bones and obtained their images utilizing 4 to 5 mm thick sections.[18] CT procedures detecting the bone invasion were also explained in the study conducted by Slieker *et al*.[19]

A study carried out by Cao *et al*. also acquired data through comparative analysis of PET-CT, CT Scan, and MRI Scan based on a bone invasion algorithm. It is now understood that the bone algorithm should be utilized for reconstructed images, and the maximum slice thickness should be kept at 3 mm. Furthermore, volumetric acquisition from 0.5 mm to 2.0 mm can also be used for well-founded diagnosis.[20] Multi-detector CT scan with helical acquisition is proficient in the detection of the whole pathologic process, providing quicker image acquisition, concluding primary lesion staging, involvement of the loco-regional lymph nodes, along with adjacent bone erosion, for which it is superior to MRI and PET-CT, which are mandatory to know beforehand at the start of treatment. These comparisons were also highlighted by Abhishek et al., describing imaging recommendations for diagnosis, staging, and management of Oral cancer.[21] Another study by Bouhir *et al*., also highlighted that CT and MRI are complementary for preoperative assessment of mandibular bone invasion, be it cortical and/or medullary, and in some cases may allow mandibular bone-sparing.[22] Hence, with the findings of this study and the literature, it is evident that radiological and histopathological investigations require precision and accuracy in early detection of life-threatening

cancers. Thus, enhancing the quality of life through less invasive treatment planning for the patients.

LIMITATIONS OF STUDY

One of the limitations of our study is that it is uncertain if our results can be applicable worldwide, or even locally, since we analyzed a pool of patients in a single institute of an urban city, where patient turnover is quite high. More future trials should be conducted to demonstrate the diagnostic accuracy of this trusted procedure with newer acquisition techniques, as discussed.

CONCLUSION

The study concludes that MDCT is an impeccable diagnostic tool in the early diagnosis of rapidly spreading squamous cell carcinoma of the oral cavity, and reconstruction with bone algorithm is an additive to the definitive diagnosis with respect to local bony invasion, which proved comparable with histopathology.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

UK & SK: Study design, drafting the manuscript, data interpretation, critical review, approval of the final version to be published.

MA & SS: Data acquisition, data analysis, approval of the final version to be published.

TM: Critical review, concept, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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