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Comparison Of Efficiency Of CBCT With MRI Or Conventional CT For Bone Invasion Or Erosion In The Identification Of Oral Squamous Cell Carcinoma

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Abstract
Background: *Oral squamous cell carcinoma (OSCC), the most common malignant neoplasm within the oral cavity, frequently exhibits bone invasion or erosion, significantly impacting both treatment planning and prognosis. Precise evaluation of osseous involvement is essential for successful surgical intervention and accurate staging of disease progression. Diverse imaging modalities, including Cone-Beam Computed Tomography (CBCT), Magnetic Resonance Imaging (MRI), and Conventional Computed Tomography (CT), are employed to evaluate bone invasion in patients diagnosed with OSCC.*
Objective: *This study aimed to evaluate the diagnostic performance of Cone-Beam Computed Tomography (CBCT) and Magnetic Resonance Imaging (MRI) in detecting bone invasion in patients with oral squamous cell carcinoma (OSCC).*
Materials and Methods: *A cross-sectional comparative study was conducted at Mymensingh Medical College Hospital, Bangladesh, involving 100 consecutive OSCC patients diagnosed between May and December 2024. All patients underwent CBCT, MRI, and conventional CT scans within two weeks before planned surgery. The diagnostic accuracy of each imaging modality was assessed by comparing imaging findings with histopathological results.*
Results: *The study population comprised 53% male and 47% female patients, with a mean age of 58.5 years (±11.3). The buccal mucosa (50%) was the most often occurring main tumor site; the tongue came second (30%). A significant proportion of patients had a history of betel nut chewing (75%) and tobacco use (68%). Regarding tumor staging, 20% were Stage I, 30% were Stage II, 25% were Stage III, and 25% were Stage IV. Both CBCT and MRI demonstrated high sensitivity and specificity in detecting bone invasion. CBCT exhibited a sensitivity of 95.6%, specificity of 87.0%, and accuracy of 89.5%, while MRI showed a sensitivity of 88.9%, specificity of 91.7%, and accuracy of 90.8%.*
Conclusion: *CBCT and MRI are proficient imaging techniques for identifying bone invasion in OSCC patients, exhibiting good diagnostic precision. These findings suggest the regular application of CBCT in clinical practice for assessing bone involvement in OSCC.*
Keywords: *Oral squamous cell carcinoma, bone invasion, CBCT, MRI, diagnostic accuracy*

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I. Introduction

Oral squamous cell carcinoma (OSCC) is a prevalent malignancy of the head and neck [1]. As the sixth most common cancer of the oral cavity, OSCC affects over 500,000 individuals annually [2]. It represents more than 90% of all oral cancers and exhibits the highest mortality rate among these malignancies globally [3,4,5]. Approximately 21% of oral cancer patients present with cervical lymph node metastases at the time of diagnosis [6]. Precise staging and assessment of local spread, particularly bone invasion or erosion, are critical for determining patient prognosis and appropriate treatment strategies. Accurate identification of osseous involvement enables clinicians to personalize treatment plans, potentially avoiding unnecessary procedures while ensuring complete tumor eradication [7]. Although conventional CT and MRI have historically been utilized to assess bone structures, cone-beam computed tomography (CBCT) has arisen as a significant instrument, particularly in the oral and maxillofacial area [8].

Conventional CT remains a standard imaging modality for evaluating bone structures due to its high spatial resolution and ability to depict cortical bone detail. It provides cross-sectional images that allow for visualization of bone destruction, periosteal reaction, and soft tissue involvement. However, conventional CT has limitations, including higher radiation exposure compared to CBCT and MRI, and potential artifacts from dental restorations. Furthermore, its sensitivity for early bone invasion can be limited [9].

MRI offers excellent soft tissue contrast, making it highly sensitive for detecting marrow infiltration and subtle changes in bone structure. It is particularly useful in differentiating tumor from edema and inflammation. MRI is considered the gold standard for evaluating soft tissue extension and perineural invasion in OSCC [10]. However, MRI has limitations, including longer scan times, higher cost, and contraindications for patients with certain metallic implants or claustrophobia. Its bone detail can be inferior to CT, and it is more susceptible to motion artifacts [11].

CBCT has gained popularity in dentistry and maxillofacial imaging due to its lower radiation dose, relatively low cost, and ability to acquire high-resolution images of the maxillofacial region. It offers isotropic voxels, allowing for multiplanar reconstruction and detailed visualization of bone structures [12]. CBCT has shown promising results in detecting bone invasion in OSCC, particularly in the mandible [13]. Its high spatial resolution allows for the identification of subtle cortical bone changes. However, CBCT's soft tissue contrast is inferior to MRI, and its ability to detect early marrow involvement may be limited [14].

Several studies have compared the diagnostic accuracy of CBCT, conventional CT, and MRI for detecting bone invasion in OSCC. While some studies have shown comparable results between CBCT and conventional CT for detecting cortical bone destruction, others have suggested that CBCT may be more sensitive for detecting early bone invasion due to its higher spatial resolution [15,16]. MRI remains superior for evaluating soft tissue extension and marrow involvement. A meta-analysis concluded that CBCT has high sensitivity and specificity for detecting mandibular bone invasion in OSCC, comparable to conventional CT [17].

II. Objective

The aim is to evaluate whether CBCT can offer a comparable, or even superior, alternative for assessing bony involvement in OSCC, considering factors such as image quality, radiation dose, cost-effectiveness, and diagnostic accuracy.

III. Methods

Study Design

A comparative cross-sectional study was conducted at Mymensingh Medical College Hospital in Mymensingh, Bangladesh, to evaluate the efficacy of Cone-Beam Computed Tomography (CBCT), Magnetic Resonance Imaging (MRI), and conventional Computed Tomography (CT) in detecting bone invasion or erosion in patients with oral squamous cell carcinoma (OSCC).

Study Population

One hundred (n=100) consecutive patients diagnosed with OSCC at Mymensingh Medical College Hospital were enrolled in the study between May 2024 and December 2024. The study population consisted of patients who met the following inclusion criteria.

Inclusion Criteria:

- Histopathologically confirmed diagnosis of OSCC.
- Clinically suspected or radiologically suggestive of bone invasion.
- Patients who are planned to undergo surgical resection of the tumor.
- Patients who can undergo all three imaging modalities (CBCT, MRI, and conventional CT).
- Age ≥ 18 years.
- Patients giving their informed consent to take part in the research.

Exclusion Criteria:

- Patients with contraindications to MRI (e.g., certain metallic implants, claustrophobia).
- Patients with severe co-morbidities that preclude surgical intervention.
- Pregnant or lactating women.
- Patients who have received prior treatment for OSCC (e.g., radiotherapy, chemotherapy).
- Patients with other head and neck malignancies.

Imaging Procedures

All patient participants underwent Cone-Beam Computed Tomography (CBCT), Magnetic Resonance Imaging (MRI), and Conventional Computed Tomography (CT) scans within two weeks before the scheduled operation.

CBCT:

- Scans were acquired using the AUGE SOLIO Series CBCT machine, featuring a field of view (FOV) of 97 mm × 100 mm, a tube voltage ranging from 50 to 90 kVp, and an anode current between 2 to 10 mA.

MRI:
- Performed on a 1.5 Tesla MRI system (e.g., Siemens MAGNETOM Avanto), utilizing T1-weighted, T2-weighted, and contrast-enhanced sequences with a slice thickness of 3 mm.

Conventional CT:
- Performed with a 16-slice CT scanner (e.g., GE BrightSpeed), including a slice thickness of 3 mm, a tube voltage of 120 kVp, and a current of 100 mA.
- These imaging protocols were selected to ensure optimal visualization of bone invasion or erosion in patients with oral squamous cell carcinoma.

Image Analysis

Two experienced radiologists, blinded to each other's assessments and the clinical and histopathological findings, independently evaluated the images from each modality. They assessed the presence or absence of bone invasion or erosion. Discrepancies between the two radiologists were resolved through consensus.

Reference Standard

The reference standard for bone invasion or erosion was the histopathological examination of the resected surgical specimens. Pathologists, blinded to the imaging results, evaluated the specimens for bone involvement.

Data Analysis

Concerning the histopathological findings, the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy of each imaging modality (CBCT, MRI, and conventional CT) were estimated.

Statistical analyses were performed using the statistical software SPSS version 26. Comparisons between the modalities were conducted using the McNemar test for paired proportions, with a significance level set at $p < 0.05$.

Ethical Considerations

Mymensingh Medical College Hospital's Institutional Review Board approved the study. All participants provided written informed consent before enrollment. The study was conducted by the ethical principles of the Declaration of Helsinki.

IV. Result

One hundred patients with oral squamous cell carcinoma (OSCC) participated in the study.

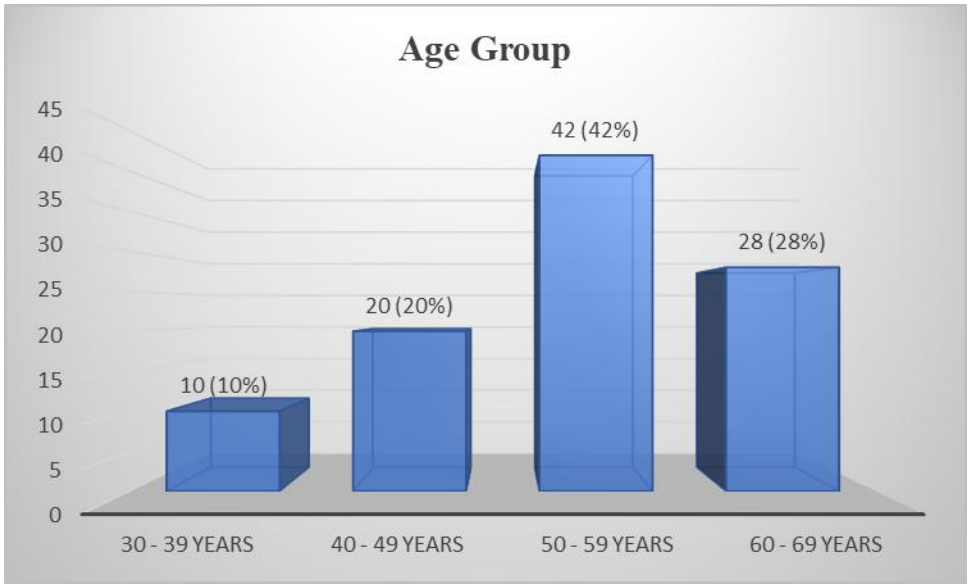

Figure 1: Age Group (n=100)

Figure 1 displays a four-dimensional bar chart which shows how population numbers split between age groups. The chart shows four age groups from 30-39 years to 40-49 years 50-59 years and 60-69 years which are

displayed on the x-axis and the number of individuals in each group appears on the y-axis. The 30-39 years age group contains ten people representing 10% of the total, the 40-49 years group contains twenty people at 20% and the 50-59 years group is the largest with forty-two people at 42% and twenty-eight people belonging to the 60-69 years group at 28%. Each group is displayed through blue 3D bars in the chart which shows percentage values above the bars to demonstrate the 50-59 years group as the most prevalent.

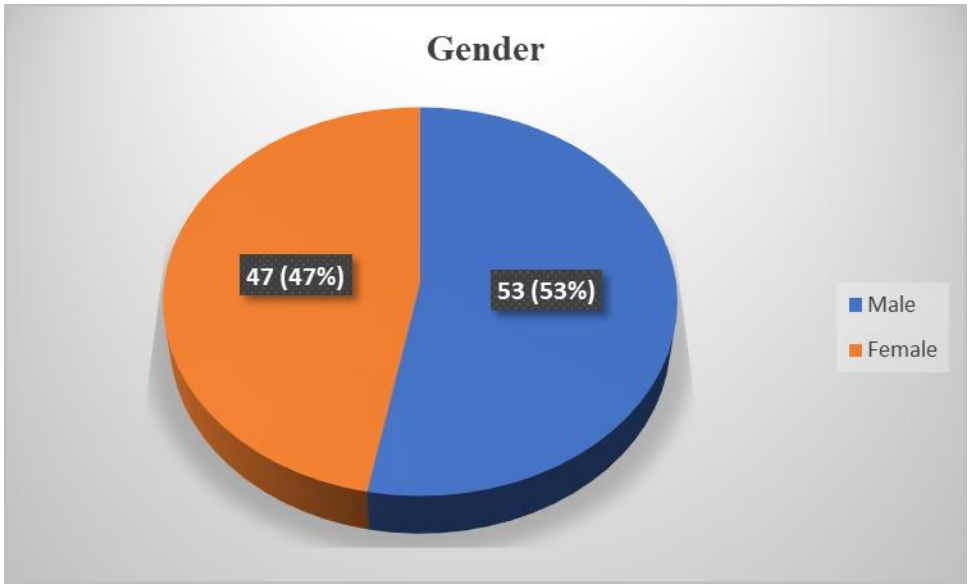

Figure 2: Gender (n=100)

The dataset gender composition appears in Figure 2 through a two-dimensional pie chart representation. Two distinct sections appear in the chart where blue indicates male distribution and orange represents female distribution. A total of 53 individuals or 53% belong to the male gender and 47 individuals or 47% belong to the female gender. The right section of the chart includes a legend which separates male and female categories. The pie chart shows a clear distribution pattern which reveals that males form a larger segment than females in the collected data**.**

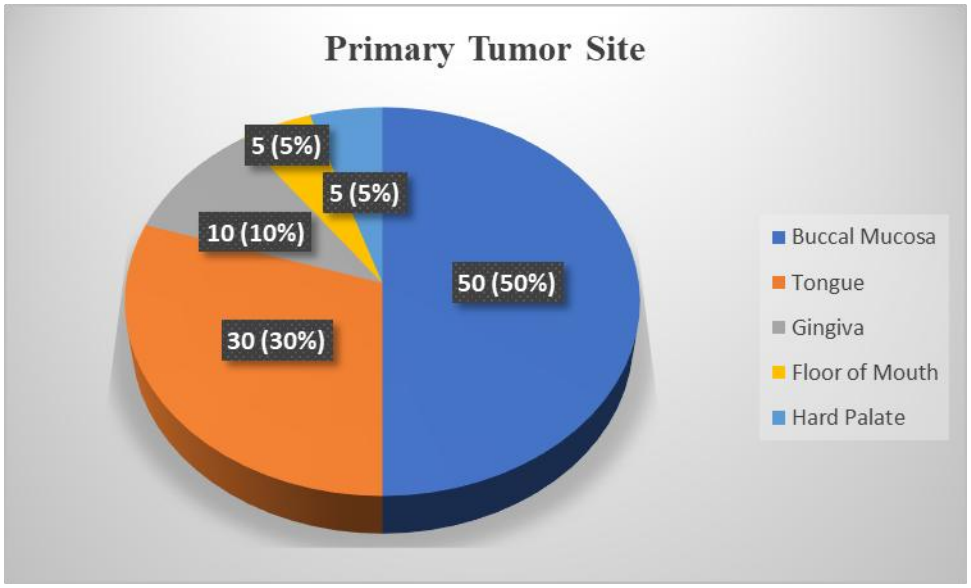

Figure 3: Primary Tumor Site

The figure in Figure 3 demonstrates the frequency distribution of initial tumor locations. The buccal mucosa stands as the most frequent site for oral cancer development at 50% while the tongue comes second at 30% and the gingiva and floor of the mouth and hard palate each represent 5% of cases. Most tumors develop within the buccal mucosa and tongue according to the presented chart.

Table 1 presents the distribution of habits among 100 patients. Betel nut chewing is the most common habit, observed in 75% of patients, followed by tobacco use at 68%. Alcohol consumption is reported by 20% of patients. The total count sums to 100 patients (100%), indicating that some individuals may have multiple habits**.**

Table 1: Habits of the Patients

Habits	Number of Patients (n=100)	Percentage (%)
Tobacco Use	68	68
Betel Nut Chewing	75	75
Alcohol Consumption	20	20
Total	**100**	**100.0**

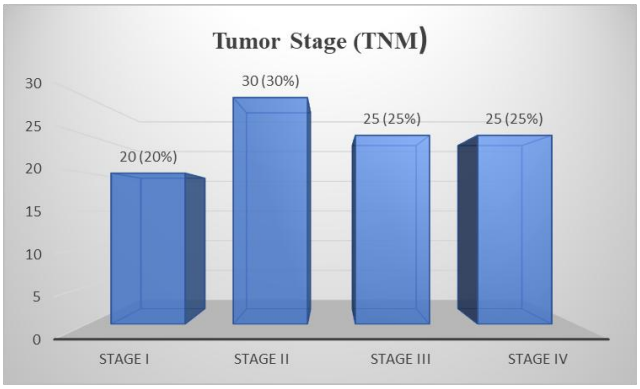

Figure 4: Tumor Stage (TNM) (n=100)

Figure 4 shows how tumor stages (TNM) affect patients. Stage II tumors represent the most frequent condition with 30% (30 cases) of patients affected while Stage III and Stage IV each affect 25% (25 cases) of patients. Stage I tumors represent the smallest group among patients with a prevalence rate of 20% (20 cases). Stage II and later tumors represent the largest proportion of diagnosed cases according to the presented chart.

Table 2 presents the baseline characteristics of the study population based on **nodal status**. The majority of patients (**60%**) fall under **N0**, indicating no lymph node involvement. **N1** status is observed in **25%** of patients, while **N2** accounts for **15%**. The total sum is **100 patients (100%)**, reflecting the distribution of nodal involvement among the study population.

Table 2: Baseline Characteristics of the Study Population (Nodal Status)

Nodal Status	Number of Patients (n=100)	Percentage (%)
N0	60	60
N1	25	25
N2	15	15
Total	**100**	**100.0**

Figure 5 is a pie chart illustrating the distribution of histopathological grades among patients. The most common grade is moderately differentiated, comprising 45% (45 cases), followed by well-differentiated at 40% (40 cases). The least common is poorly differentiated, accounting for 15% (15 cases). The chart visually highlights that most cases fall into the well and moderately differentiated categories.

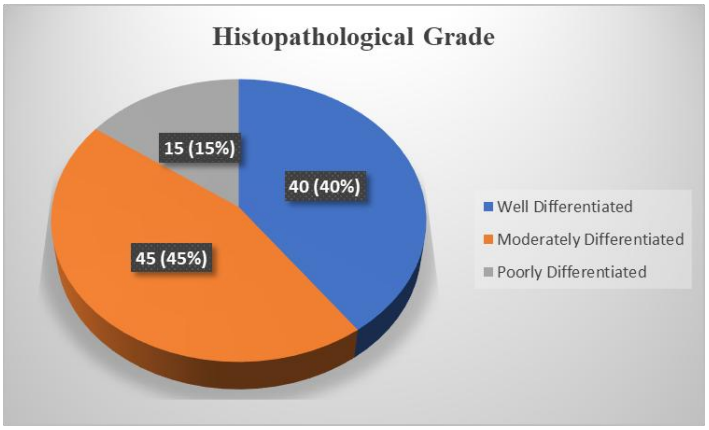

Figure 5: Histopathological Grade

Table 3 indicated that both imaging modalities demonstrated high sensitivity and specificity. CBCT exhibited a sensitivity of 95.6%, specificity of 87.0%, and accuracy of 89.5%. MRI showed a sensitivity of 88.9%, specificity of 91.7%, and accuracy of 90.8%.

Table 3: Frequency of Imaging Modalities in Detecting Bone Invasion in Oral Squamous Cell Carcinoma

Imaging Modality	Sensitivity (%)	Specificity (%)	Accuracy (%)
CBCT	95.6	87.0	89.5
MRI	88.9	91.7	90.8

V. Discussion

Assessing imaging techniques for identifying bone invasion in oral squamous cell carcinoma (OSCC) is essential for precise staging and treatment planning.

In our study, the mean age of the patients was 58.5 years (±11.3), with the majority (42%) in the 50–59 age group. A slight male predominance was observed, with 53% male and 47% female patients. These findings are consistent with global trends, where OSCC predominantly affects older adults, with a higher incidence in males. The most common primary tumor site was the buccal mucosa (50%), followed by the tongue (30%). A significant proportion of patients had a history of betel nut chewing (75%) and tobacco use (68%), which are well-established risk factors for OSCC. The tumor stages were distributed as follows: Stage I (20%), Stage II (30%), Stage III (25%), and Stage IV (25%). These findings are consistent with the known association between tobacco and betel nut use and the development of OSCC [18].

Our study assessed the diagnostic performance of Cone-Beam Computed Tomography (CBCT) and Magnetic Resonance Imaging (MRI) in this context. The results indicated that both CBCT and MRI exhibit high sensitivity and specificity in detecting bone invasion in OSCC patients. CBCT demonstrated a sensitivity of 95.6%, specificity of 87.0%, and accuracy of 89.5%, while MRI showed a sensitivity of 88.9%, specificity of 91.7%, and accuracy of 90.8%.

These findings align with previous research highlighting the efficacy of CBCT in diagnosing bone erosion and invasion in OSCC patients. A prospective study reported that CBCT's diagnostic accuracy is comparable to that of CT and MRI, supporting its routine use in clinical practice [19].

Regarding inter-observer agreement, our study did not explicitly assess this parameter. However, the literature suggests that both CBCT and MRI exhibit high inter-observer agreement in evaluating bone invasion in OSCC. For instance, a study reported good to excellent inter-observer agreement for both MRI and CT in assessing mandibular invasion, with kappa values ranging from 0.65 to 1.00 [20].

VI. Conclusion

Our research indicates that both Cone-Beam Computed Tomography (CBCT) and Magnetic Resonance Imaging (MRI) provide significant diagnostic precision in identifying bone invasion in individuals with oral squamous cell carcinoma (OSCC). The findings align with existing literature, which reports that CBCT and MRI offer comparable sensitivity and specificity in assessing bone involvement in OSCC cases. These findings underscore the reliability of CBCT and MRI as imaging modalities for evaluating bone invasion in OSCC, thereby aiding in accurate staging and treatment planning. Given the high diagnostic accuracy observed, incorporating these imaging techniques into clinical practice is recommended to enhance patient management and outcomes.

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