Evaluation And Comparison of Osteolysis In 2d & 3d Imaging In Patients With Mandibular Carcinoma

Jebarani Jeevitha[1], Devika S Pillai*[2]

[1]Postgraduate student, Department of Oral Medicine, Radiology, and Special Care Dentistry, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, 162, Poonamalle High Road, Chennai- 600077, India.

[2]Senior lecturer, Department of Oral Medicine, Radiology, and Special Care Dentistry, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, 162, Poonamalle High Road, Chennai- 600077, India.

***Corresponding Author:** Devika S Pillai, Senior Lecturer, Department of Oral Medicine, Radiology, and Special Care Dentistry, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, 162, Poonamalle High Road, Chennai- 600077, India.

Abstract

Introduction: Mandibular carcinoma, often referred to in the literature as squamous cell carcinoma of the mandible or mandibular malignancy, is an aggressive oral malignancy frequently associated with bone invasion and osteolysis. Accurate assessment of osteolysis is critical for treatment planning, surgical guidance, and prognostic evaluation. Traditionally, two-dimensional (2D) imaging modalities such as panoramic radiographs, also known as orthopantomography, have been employed for diagnosis. However, their limitations in spatial resolution and inability to provide comprehensive structural details have led to the increased adoption of three-dimensional (3D) imaging. Cone-beam computed tomography (CBCT) has emerged as a potential alternative for osteolysis detection due to its superior spatial resolution and volumetric analysis capabilities. This study aimed to evaluate and compare the efficacy of 2D and 3D imaging modalities in detecting osteolysis in patients diagnosed with mandibular carcinoma.

Materials and Methods: A retrospective study was conducted on a cohort of 50 participants, comprising 32 males (64%) and 18 females (36%). The sample size was determined based on power analysis to ensure adequate statistical significance. Among these participants, 15 cases exhibited osteolysis. Data on demographic characteristics, tumor site involvement, and osteolysis staging based on both imaging modalities were collected and analyzed using IBM SPSS Statistics version 23. Statistical comparisons were performed to determine significant differences in osteolysis detection between 2D and 3D imaging.

Results: Osteolysis staging showed statistically significant differences across age groups (**$p = 0.029$**), lesion location (**$p = 0.015$**, higher in posterior regions), and laterality (**$p < 0.001$**). Imaging modality also influenced staging, with 3D imaging detecting higher stages than 2D (**$p < 0.001$**). CBCT identified osteolysis in **84%** of cases, compared to **80%** with 2D imaging (**$p = 0.03$**).

Conclusion: The findings of this study indicate that CBCT demonstrates superior efficacy in detecting osteolysis compared to 2D imaging. The advantages of 3D imaging include enhanced spatial resolution, a more comprehensive assessment of bone structures, and improved staging accuracy. Given these benefits, CBCT emerges as the preferred imaging modality for osteolysis assessment in mandibular carcinoma patients, potentially reducing the reliance on 2D imaging. Future studies with larger sample sizes and diverse patient populations are recommended to validate these findings further.

Keywords: Mandibular Cancer, Osteolysis, Cone-Beam Computed Tomography, Imaging Modalities, Diagnosis, Treatment Planning, Prognostic Evaluation.

Introduction [1]:

Osteolysis, the progressive resorption of bone tissue, is a common and debilitating complication in mandibular carcinoma, a type of head and neck cancer affecting the jawbone. This process involves the destruction of bone by osteoclasts, leading to severe complications such as impaired jaw function, pathologic fractures, and an increased risk of metastasis. Accurate assessment of osteolysis is essential for treatment planning and prognosis.

Traditional two-dimensional (2D) imaging modalities, such as panoramic radiography (OPG), have been widely used for assessing bone destruction in mandibular carcinoma. However, their limitations in spatial resolution and lack of depth perception have led to the increased use of three-dimensional (3D) imaging modalities, including cone-beam computed tomography (CBCT) and multidetector computed tomography (MDCT). These modalities provide enhanced visualization of bone structures, allowing for a more precise evaluation of osteolysis. CBCT has gained particular importance due to its superior spatial resolution compared to 2D imaging and its lower radiation dose compared to MDCT, making it more suitable for repeated assessments. While MDCT offers even higher spatial resolution and is useful for evaluating extensive bone involvement or suspected metastasis, CBCT remains the preferred option for localized mandibular evaluations. The adoption of 3D imaging facilitates optimized treatment planning, reduces the risk of pathologic fractures, and provides valuable prognostic insights, ultimately improving patient outcomes.

Materials and methods:

A retrospective study was conducted in the Department of Radiology between June 2023 and November 2023. After reviewing 50 patient records, 15 cases of clinically and histopathologically confirmed Oral Squamous Cell Carcinoma (OSCC) were included in the study. The remaining 35 cases were excluded due to unclear imaging.

Criteria	Inclusion	Exclusion
Diagnosis	Clinically and histopathologically confirmed OSCC	All other oral cavity lesions (e.g., benign tumors, infections)
Age	(Specify age range, e.g., 18 years and older)	Patients younger than the specified age
Gender	(No specific gender restriction)	(If applicable, exclude specific genders)
Site of Involvement	Mandibular only	Maxilla, trauma cases

A retrospective study was conducted in the Department of Radiology between June 2023 and November 2023. After reviewing 50 patient records, 15 clinically and histopathologically confirmed cases of Oral Squamous Cell Carcinoma (OSCC) were identified. Their corresponding radiographic images, including both orthopantomography (OPG) and cone-beam computed tomography (CBCT), were obtained. The imaging data were acquired using the Carestream CS8100SC (Carestream Dental LLC, Atlanta, Georgia, United States).

For CBCT, the exposure parameters were 120 kV, 4 mA, and 15 seconds, with a total radiation dose of 496 mGy·cm². The voxel size was 150 × 150 × 150 micrometers, ensuring high-resolution imaging. CBCT images were collected in DICOM (Digital Imaging and Communications in Medicine) format and analyzed in the orthogonal plane for evaluation.

For OPG, the exposure parameters were 78.00 kV, 10.00 mA, and 10.78 seconds, with a total radiation dose of 119.42 mGy·cm². The images were reviewed for comparative analysis with CBCT findings.

Two researchers were involved in the study: a primary researcher and a subject expert. Data accuracy was ensured through cross-verification using patient records and clinical photographs. Additionally, sampling bias was minimized by avoiding any sorting process and including all relevant data. The study included patients diagnosed with OSCC who had undergone both OPG and CBCT imaging before any surgical intervention. Patients with other carcinoma diagnoses or those who had prior CT or MRI reports were excluded. Data collection was conducted from existing departmental records and compiled into an Excel spreadsheet. This data was then imported into SPSS software (IBM Version 23) for statistical analysis. The dependent variables in the study were the osseous changes observed in both OPG and CBCT images, including the involvement of surrounding structures. Independent variables included patient age, sex, site involved, and osteolysis staging based on both 2D and 3D imaging modalities.

Data collection was conducted from existing departmental radiology records, including patient demographics, imaging findings, and osteolysis staging. The collected data were manually entered into Microsoft Excel.The dataset included variables such as patient age, sex, tumor site, osteolysis severity, and imaging modality (OPG vs. CBCT).The compiled Excel sheet was then imported into SPSS software (IBM Version 23) for statistical analysis.

Statistical Analysis: Descriptive analysis was performed using Chi-square test (IBM SPSS 23) and the analysis used was correlation and association.

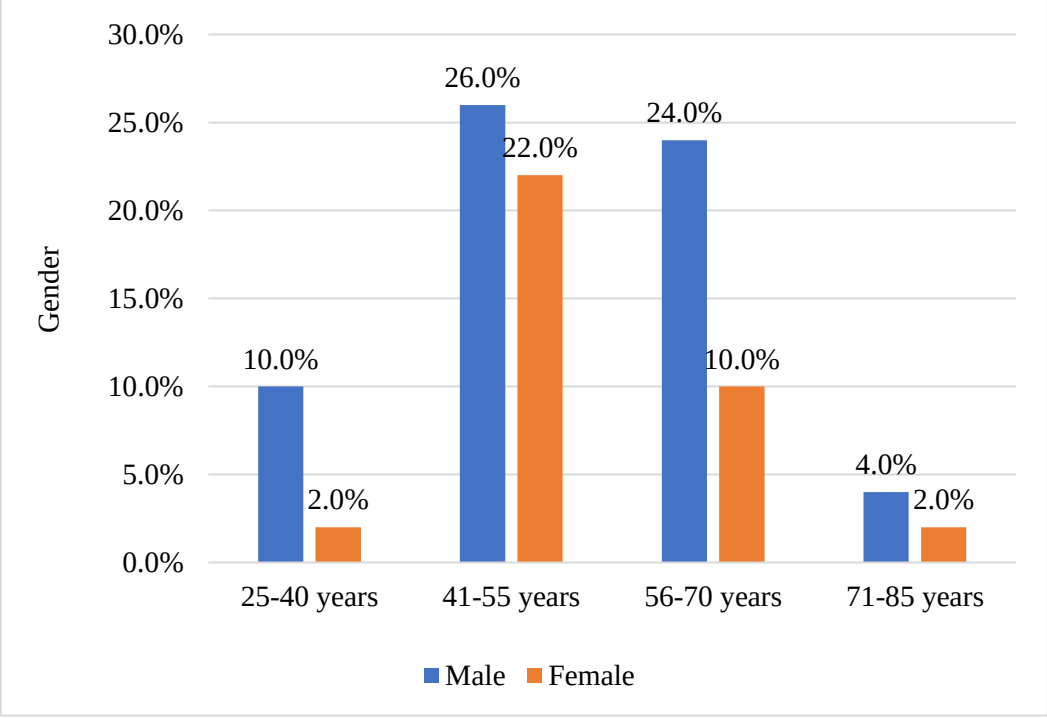
Results and Discussion:

The present study has 50 participants including 32 males (64%) and 18 females (36%). The minimum age of the participants was 25 years and the maximum age was 85 years. The mean±SD age was 51.72±11.02 years. Around 48% of the study population were aged 41 to 55 years group followed by 34% aged 56-70 years. were aged 51 to 60 years. The graph 1 depicts the distribution of the study population based on age and gender. The X-axis depicts the age group of the patients and Y-axis depicts the gender of patients in the study population. The majority of the study population did not have osteolysis (70%). Graph 2 depicts the distribution of osteolysis in the study population. Based on the location, 12% had osteolysis in the right, 16% in the left, 6% in the anterior and 30% in the posterior sides. Graph 3 depicts the location of osteolysis among the present study participants. Graph 4 shows the presence of osteolysis in OPG and CBCT imaging.

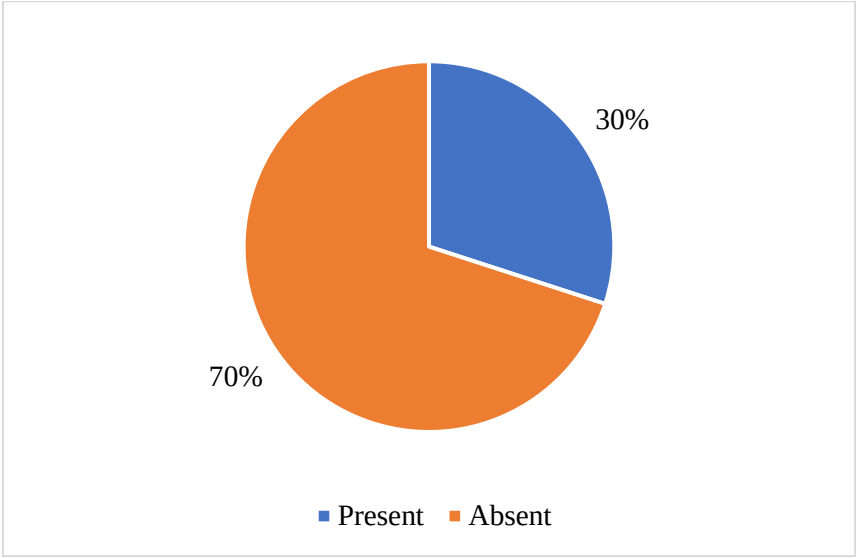
In the present study an increased incidence of OSCC was found in males than in females which were consistent with the studies done by Tandon et al [2] and Singh MP et al [3]. 3D imaging identified osteolysis in 16% of patients compared to 20% detected using 2D imaging (Graph 4). In the present study, an increased incidence of OSCC was found in females than in males which were consistent with the studies done by Astrid L., Marius B et al [5]. A higher female median age (65.36 vs. 61.04 years) and female predominance was found in the group of patients older than 70 years, with a gender distribution of 53:46. Out of 23 female patients with oral maxillary SCC, 15 (65%) were without the risk factors of tobacco and alcohol, and from the 16 male patients suffering from oral maxillary carcinoma, only three (19%) were without the mentioned risk factors. A study done by Reddy et.al [7] showed that the incidence rate of oral cancer for women rising from 966 in 1985–1986–1762 in 2005–2006. With an approximate gender distribution of 3:4 (female/male) in comparison to a ratio of 1:3 in most Western countries, the female proportion is higher in our study population. Another factor often discussed is the rising consumption of tobacco and alcohol by women in accordance to the

study done by Girod et al. [10] which demonstrated a rate of 48.5% for tobacco use in females and 34.5% for alcohol. In the literature, the proportion of women with SCC of the oral cavity and oropharynx who are not exposed to the risk factors of tobacco and alcohol use seems to be higher than that of men (27%–41% vs. 1.56%–11%). According to another study by Wey PD et al. [12], 22 (13.8%) of 159 male patients neither used tobacco nor drank alcohol, and in the female group it was 46 (38.7%) of 119 patients. Luce et al. [14] also noted that more women suffered from oral cancer than from hypopharynx cancer. Kruse AL et al. [15], in his study noted that out of 23 female patients, 15 (65%) were without the tobacco and alcohol risk factors; but from the 16 male patients suffering from oral maxillary carcinoma, only three (19%) were without the mentioned risk factors. In a recent study done by Laveniya S et al [16]. The number of young (< 45 years) females recorded with OSCC increased by 4.9% per year (IRR 95% CI 1.034 – 1.063, p < 0.001) and the number of young males with OSCC increased by 2.4% per year (IRR 95% CI 1.010 – 1.039, p < 0.001). The proportion of patients with OSCC that were young females increased from 3.6% in 1990 – 1994 to 8.2% in 2010 – 2014. The patients were classified according to the TNM classification existing at the time, without any later modification. In addition, the patients were grouped according to their stage into early-stage tumours (TNM stage I and stage II) and advanced-stage tumours (TNM stage III and stage IV), in order to conduct the statistical analysis. Among the patients having osteolysis, The TNM staging of our study group was Stage-IV (16%), Stage-III (8%), Stage - II (4%) and Stage-I (2%). TNM staging showed similar results like the osteolysis grading. The graphs 5 and 6 shows the osteolysis staging and TNM staging among the study population. A significant association was found between the osteolysis staging and age, location as well as imaging procedure (p<0.05, Chi Square test). Table 1 depicts the distribution of study population based on osteolysis staging.

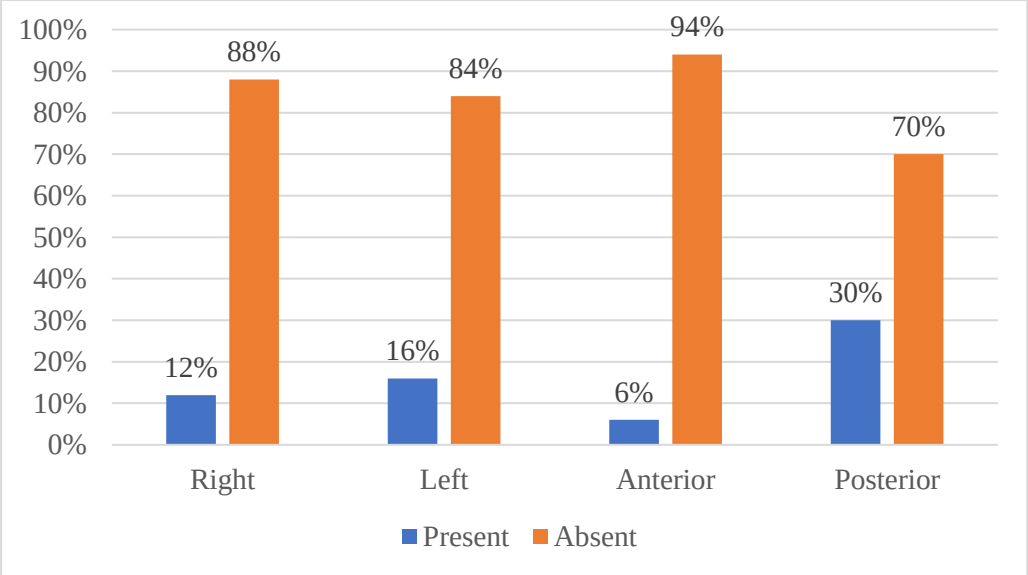
Graph 1: Distribution of study population based on age and gender



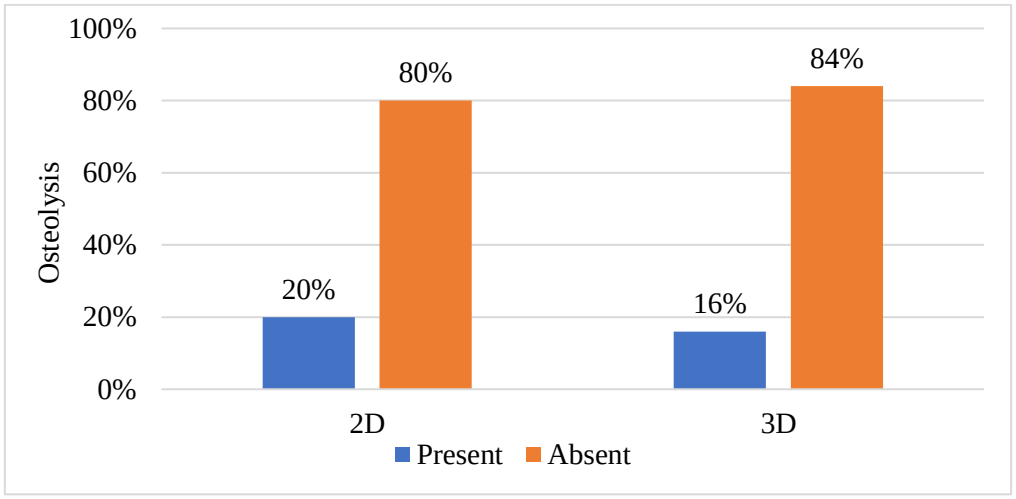
Graph 2: Distribution of osteolysis in the study population



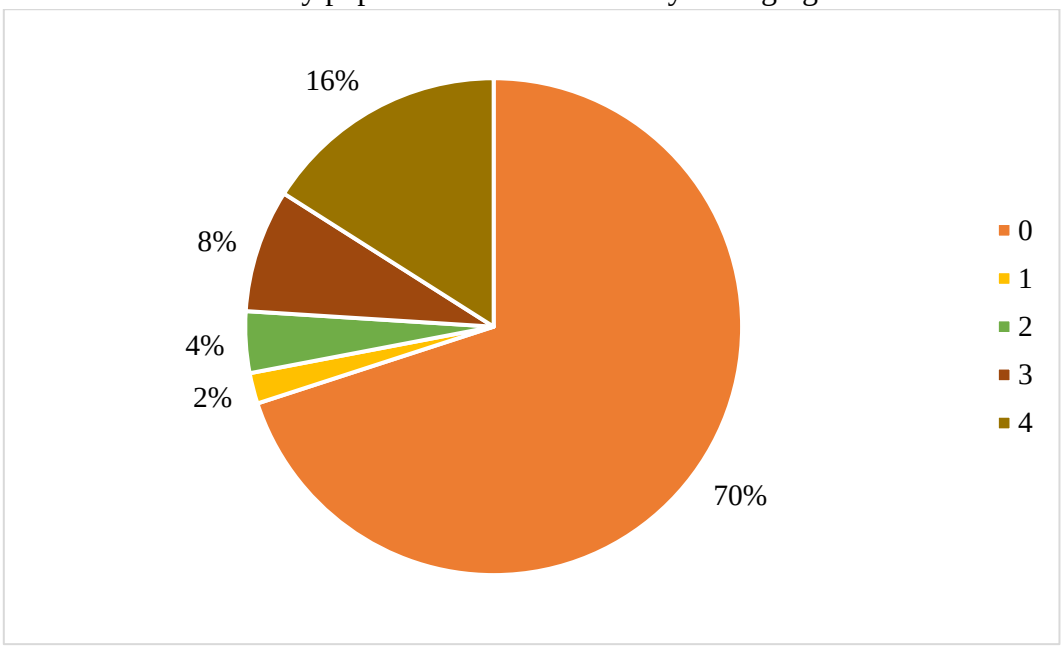
Graph 3: Distribution of study population based on the location of osteolysis



Graph 4: Distribution of osteolysis in the study population based on the imaging procedure



Graph 5: Distribution of study population based on osteolysis staging



Graph 6: Distribution of study population based on TNM staging

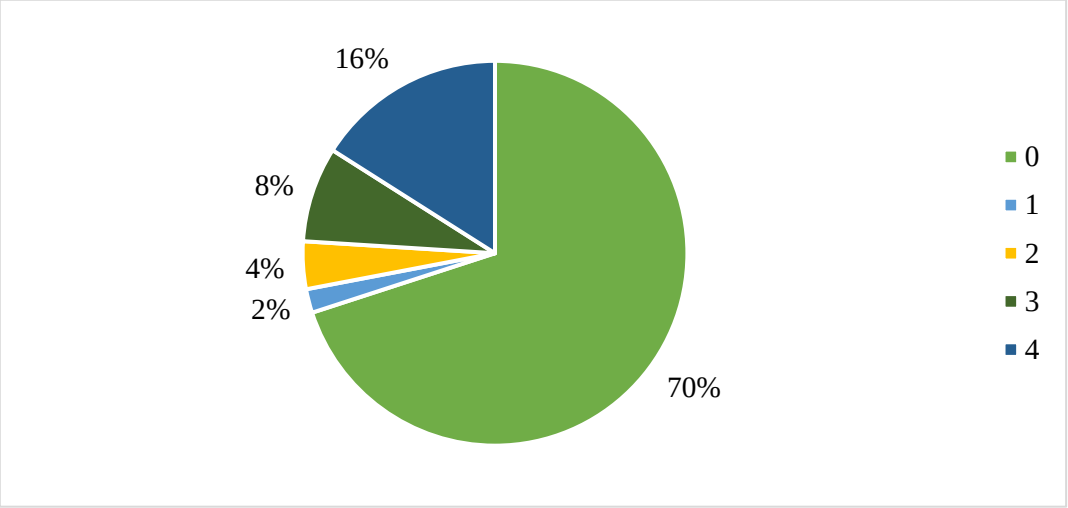


Table 1: Distribution of study population based on osteolysis staging

			Osteolysis Staging					Total n (%)	p-value
			0 n (%)	1 n (%)	2 n (%)	3 n (%)	4 n (%)		
Age group		25-40 years	2 (4)	0	2 (4)	1 (2)	1 (2)	6 (12)	0.029*
		41-55 years	19 (38)	1 (2)	0	0	4 (8)	24 (48)	
		56-70 years	12 (24)	0	0	2 (4)	3 (6)	17 (34)	
		71-85 years	2 (4)	0	0	1 (2)	0	3 (6)	
Gender		Male	21 (42)	1 (2)	1 (2)	3 (6)	6 (12)	32 (64)	0.808
		Female	14 (28)	0	1 (2)	1 (2)	2 (4)	18 (36)	
Location	Left	Present	0	0	1 (2)	2 (4)	5 (10)	8 (16)	<0.001*
		Absent	35 (70)	1 (2)	1 (2)	2 (4)	3 (6)	42 (84)	
	Right	Present	0	1 (2)	0	2 (4)	3 (6)	6 (12)	<0.001*
		Absent	35 (70)	0	2 (4)	2 (4)	5 (10)	44 (88)	
	Anterior	Present	0	0	1 (2)	1 (2)	1 (2)	3 (6)	0.015*
		Absent	35 (70)	1 (2)	1 (2)	3 (6)	7 (14)	47 (94)	
	Posterior	Present	0	1 (2)	2 (4)	4 (8)	8 (16)	15 (30)	<0.001*
		Absent	35 (70)	0	0	0	0	35 (70)	
Imaging	2D	Present	0	1 (2)	2 (4)	4 (8)	3 (6)	10 (20)	<0.001*
		Absent	35 (70)	0	0	0	5 (10)	40 (80)	
	3D	Present	0	0	0	2 (4)	6 (12)	8 (16)	<0.001*
		Absent	35 (70)	1 (2)	2 (4)	2 (4)	2 (4)	42 (84)	

* Statistically significant at p<0.05, Chi Square test

CONCLUSION: In conclusion, 3D imaging, particularly cone beam computed tomography (CBCT), has emerged as the superior modality for osteolysis assessment in patients with mandibular carcinoma due to its higher spatial resolution, comprehensive visualization of bone structures, and improved staging accuracy. This advancement renders 2D imaging obsolete as an adjunct investigation for this purpose. As 3D imaging readily provides more accurate diagnoses for intraosseous lesions, it can be considered the sole diagnostic imaging modality in routine practice.

Declarations:

Conflicts of interest: The authors declare that there are no conflicts of interest associated with this work.

Author contributions: Jebarani Jeevitha- conceptualization, data curation, formal analysis, investigation, methodology, and writing (original draft); conceptualization, supervision, validation, visualization, and writing (review and editing).

REFERENCES:

1) Abhinaya Lm, Muthukrishnan A., Rajendran D. "Evaluation Of Osseous Changes In Oral Carcinoma - 2D Vs 3D Imaging." *International Journal of Current Research And Review*, Vol. 12, No. 5, Jan. 2020, Pp. 15-18, Doi:10.31782/IJCRR.2020.122515.
2) Tandon A, Bordoloi B, Jaiswal R et al. Demographic and clinicopathological profile of oral squamous cell carcinoma patients of North India: A retrospective institutional study. SRM J Res Dent Sci 2018;9:114.
3) Singh MP, Kumar V, Agarwal A, et al. Clinico-epidemiological study of oral squamous cell carcinoma: A tertiary care centre study in North India. J Oral Biol and Craniofac Res 2016;6:32– 35
4) Petti S, Masood M, Scully C. The Magnitude of Tobacco Smoking-Betel Quid Chewing-Alcohol Drinking Interaction Effect On Oral Cancer in South-East Asia. A Meta-Analysis of Observational Studies. PLoS ONE 2013;8:e78999.
5) Kruse AL, Bredell M, Grätz KW. Oral squamous cell carcinoma in non-smoking and non-drinking patients. *Head Neck Oncol.* 2010 Oct 4;2:24. doi: 10.1186/1758-3284-2-24. PMID: 20920351; PMCID: PMC2958869.
6) Venugopal A, Maheswari TNU. Expression of matrix metalloproteinase-9 in oral potentially malignant disorders a systematic review. J Oral Maxillofac Pathol 2016; 20(3): 474–479.
7) Reddy V, Cundall-Curry D, Bridger M (2010) Trends in the incidence rates of tonsil and base of tongue cancer in England, 1985–2006. Ann R Coll Surg Engl [Epub ahead of print]
8) Muthukrishnan A, Kumar LB. Actinic cheilosis: early intervention prevents malignant transformation. Case Rep 2017;2017:bcr2016218654.
9) Maheswari TNU, Venugopal A, Sureshbabu N, et al. Salivary micro RNA as a potential biomarker in oral potentially malignant disorders: A systematic review. Tzu Chi Med J 2018;30.
10) Girod A, Mosseri V, Jouffroy T, Point D, Rodriguez J (2009) Women and squamous cell carcinomas of the oral cavity and oropharynx: is there something new? J Oral Maxillofac Surg 67 (9):1914–1920
11) Subashri A, Uma Maheshwari TN. Knowledge and Attitude of Oral Hygiene Practice among Dental Students. Res J Pharm Tech 2016;9:1840–1842.
12) Wey PD, Lotz MJ, Triedman LJ (1987) Oral cancer in women nonusers of tobacco and alcohol. Cancer 60(7):1644–1650.
13) Dharman S, Muthukrishnan A. Oral mucous membrane pemphigoid – Two case reports with varied clinical presentation. J Ind Soc Periodontol 2016;20:630.
14) Luce D, Guenel P, Leclerc A, Brugere J, Point D, Rodriguez J (1988) Alcohol and tobacco consumption in cancer of the mouth, pharynx, and larynx: a study of 316 female patients. Laryngoscope 98(3):313–316.

15) Kruse AL, Grätz KW (2009) Cervical metastases of squamous cell carcinoma of the maxilla: a retrospective study of 9 years. Head Neck Oncol 1(1):28
16) Satgunaseelan L, Allanson BM et al. The incidence of squamous cell carcinoma of the oral tongue is rising in young non-smoking women: An international multi-institutional analysis. *Oral Oncol.* 2020;110:104875. doi: 10.1016/j.oraloncology.2020.104875.
17) Warnakulasuriya S, Muthukrishnan A. Oral health consequences of smokeless tobacco use. Ind J Med Res 2018;148:35.
18) Chaitanya N, Muthukrishnan A, Gandhi Babu D, Kumari CS, Lakshmi MA, Palat G, et al. Role of vitamin E and vitamin A in oral mucositis induced by cancer chemo/radiotherapy-a metaanalysis. J Clin Diagn Res. 2017 May; 11(5): ZE06–ZE09.
19) Rao LP, Das SR, Mathews A, et al. Mandibular invasion in oral squamous cell carcinoma: investigation by clinical examination and orthopantomogram. Int J Oral Maxillofac Surg 2004;33:454–457.
20) Hakim SG, Wieker H, Trenkle T, et al. Imaging of mandible invasion by oral squamous cell carcinoma using computed tomography, cone-beam computed tomography and bone scintigraphy with SPECT. Clin Oral Investig 2014;18:961–967.
21) Van Cann EM, Koole R, Oyen WJG, de Rooy JW, de Wilde JD, Slootwrg PJ, et al. Assessment of mandibular invasion of squamous cell carcinoma by various modes of imaging: construct- ing a diagnostic algorithm. Int J Oral Maxillofac Surg 2008 Jun;37(6):535-41.