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Comparative Evaluation of CBCT Versus CT to Assess Characteristics of Various Osseous Lesions Involving the Maxillofacial Region-A Cross-Sectional Retrospective Study

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ABSTRACT-

Aims and Objectives: To assess the efficacy of cone-beam computed tomography (CBCT) in comparison to computed tomography (CT) in the radiographic evaluation of various osseous lesions in the maxillofacial region. **Materials and Methods:** The study was conducted on 25 subjects with osseous lesions in the maxillofacial region diagnosed by histopathology who were subjected to CT and CBCT as a part of their diagnostic workup. The image pairs were obtained from the departmental archive and were compared for diagnostic quality and dimensional accuracy. **Statistics:** Descriptive statistical analysis was carried out for all the parameters in this study. The data collected were tabulated and subjected to statistical analysis using the software Stata version 13.1 and SPSS version 20 for Windows (SPSS Inc., Chicago, IL, USA) to obtain the results. **Results:**The results of the study showed that CBCT showed more accuracy in comparison to CT in the evaluation of osseous maxillofacial lesions. **Discussion**: The results from the present study showed that CBCT could provide an image with CT-comparable and sometimes superior diagnostic quality and accuracy in case of osseous lesions, with a lesser radiation dose and risk, at a lower cost.

Keywords- CT, CBCT, osseous lesions, dimensional accuracy, radiation dose.

INTRODUCTION-

In diagnostic medicine, imaging is the primary method of investigation for numerous disorders. The advent of three-dimensional (3D) imaging has completely changed how radiologists diagnose lesions. The first original dental roentgenogram was taken by Dr.Otto Walkhoff in January 1896 in his own mouth for an exposure time of 25 mins [1].Since then, dental imaging now broadly termed as oral and maxillofacial imaging has witnessed tremendous progress and its applications in various fields of dentistry has evolved over time [2-3].

The introduction of 3D imaging for maxillofacial region has opened new vistas for diagnostic and treatment planning of various maxillofacial pathologies. The gold standard is, however, multi-slice computed tomography (MSCT), which ensures extremely accurate 3D imaging [4]. However, MSCT's clinical application is constrained by its high cost, and higher doses of radiation exposure. Cone-beam computed tomography (CBCT) was introduced to dentistry three decades ago. The most contemporary CBCT systems offer high spatial resolution images that are as good as bone window computed tomography and often considered a better modality with less radiation exposure (CT). Because of this, there are now more indications for using CBCT to assess the orofacial structures [5-6]. Only a few studies and case reports of osseous lesions of the maxillo-facial region that were imaged using CBCT have been described, and the use of CBCT as a diagnostic imaging modality for benign and malignant tumours is not well reported in the literature. Only a few studies have been conducted in the last decade comparing CT and CBCT. Hence the present study was conducted to compare CT and CBCT in terms of assessment of lesions, cost effectiveness and radiation exposure to the patient.

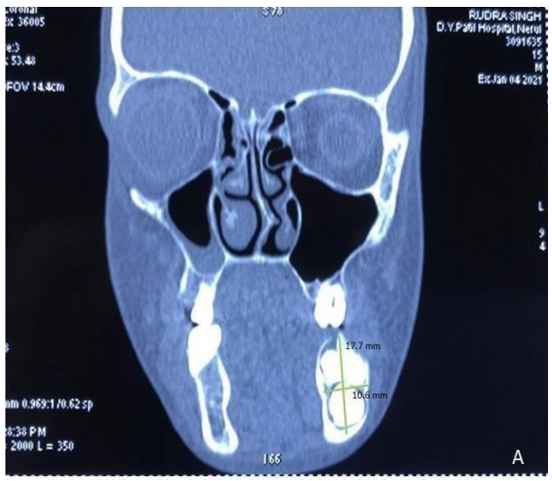
The aim of this study was to compare Computed Tomography (CT) against Cone Beam Computed Tomography (CBCT) in evaluation of various osseous lesions in the maxillofacial region.

The objectives were to determine the dimension, internal structure, and periphery of the lesions on CBCT and CT and to assess the relationship of the lesions with their surrounding vital structures and assess the soft tissue involvement in cases where applicable.

Materials and Methods-

The institutional ethical clearance was obtained before the study. IREB Reference No: IREB/2021/OMDR/04.This is a cross-sectional, retrospective study involving scans that have been obtained from 25 patients with maxillofacial pathologies which were retrieved from the archives. The CT scans were recorded using GE OPTIMA CT 660 128 slice CT unit and were viewed on EIZO MX315W 31.1inch medical monitor. The CBCT scans were recorded using KODAK Carestream 9000 3D Unit and were viewed on HP Compaq LCD Monitor LE1911. Imaging software CS 3D; Carestream Healthinc., 2011 was used for the assessment of the scans. The scans have been obtained in the form of DICOM files. The Inclusion Criteria is CBCT and CT scans of patients with maxillofacial pathologies (odontogenic infections, cystic lesions, benign tumours, malignant lesions),lesions confined to either jaw which are completely seen on Cone Beam Computed Tomography (CBCT) and Computed Tomography (CT) and malignant lesions (Up to Stage II- according to TNM classification for Head and Neck Cancer).The Exclusion Criteria is malignant lesions extending beyond the confines of the bone, involving soft tissue and patients with systemic disorders or metabolic disorders.

Scans of males and females were evaluated for the following parameters subjectively- dimension (Fig 1A-1B and 2A-2B), internal structure(3A-3B), periphery(4A-4B), and relationship of the lesions with their surrounding structures(5A-5B). The dimensional accuracy was evaluated by comparing the linear measurements of the lesions, in millimetres calculated on multiplanar reformations (MPR) in the axial, coronal, and sagittal sections, from images acquired by CT and CBCT. The outermost extents on both the ends were considered as the limit while calculating the linear distances The maximum distance for a particular lesion on individual sections (axial/coronal/sagittal) were considered.



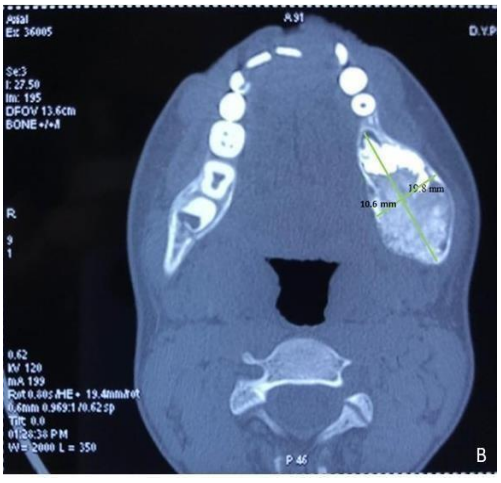


Fig-1A Fig-1B

Figure 1A- Coronal Section of CT (Bone Window) showing measurements of the lesion in the cranio-caudal and medio-lateral planes. **Figure-1B**- Axial Section of CT (Bone Window) showing measurement of the lesion in the Antero-Posterior and Medio-lateral planes.

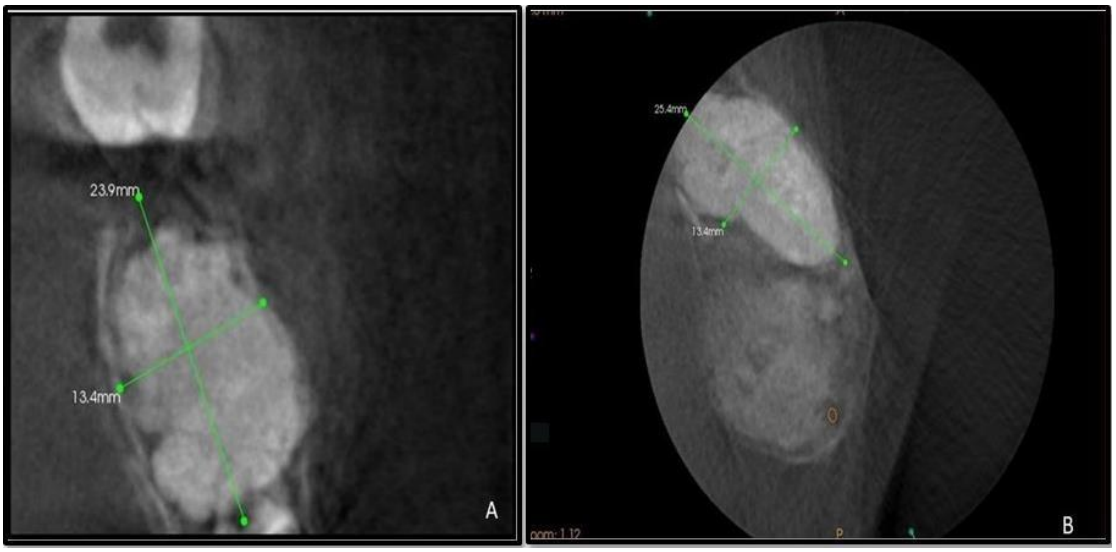


Figure-2A- Coronal Section of CBCT showing measurement of the lesion in the cranio-caudal and medio-lateral planes. **Figure-2B-** Axial Section of CBCT showing measurement of the lesion in Antero-posterior and medio-lateral planes.

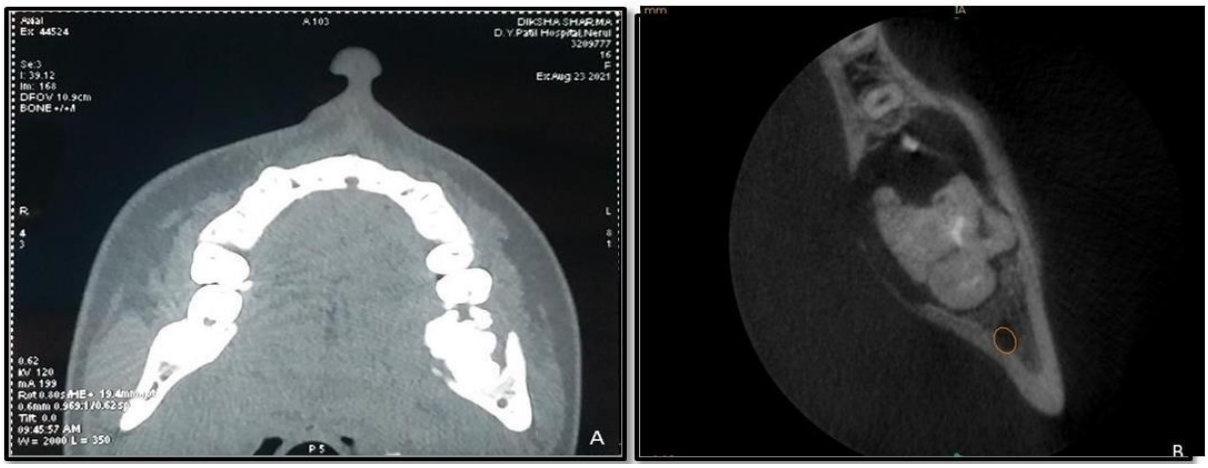


Figure 3A- Axial Section of CT (Bone Window) showing a complex odontome in the left body of the mandible. The lesion appears completely hyperdense. **Figure 3B-** Axial Section of CBCT showing the same lesion. The lesion appears to have mixed density and the varying densities of enamel, dentin and pulp can be appreciated.

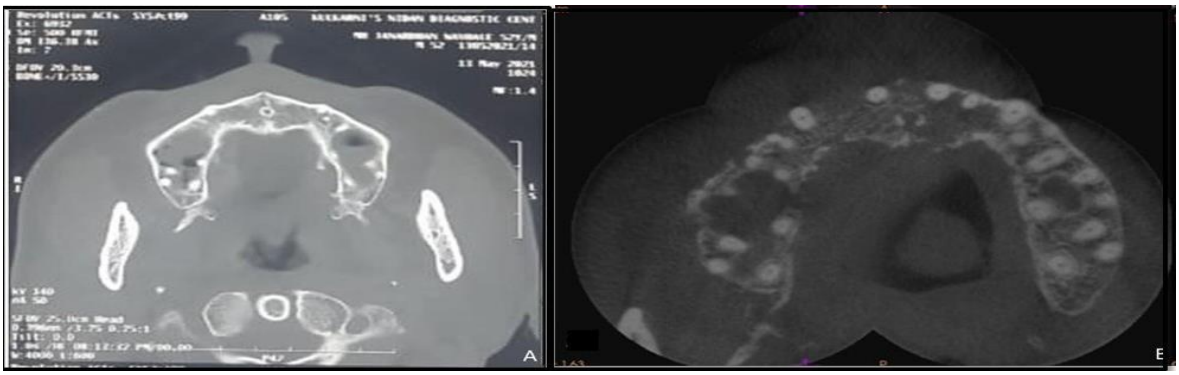


Figure 4A- Axial section of CT (bone window) at the level of the maxillary sinus showing opacification of the maxillary sinus. Finer details of the resorption of the bone and the cortices cannot be appreciated. **Figure 4B-** Axial section of CBCT showing irregular bone loss extending from 21 to 27 and thinning and resorption of buccal and palatal cortical plate noted. (Moth eaten appearance)

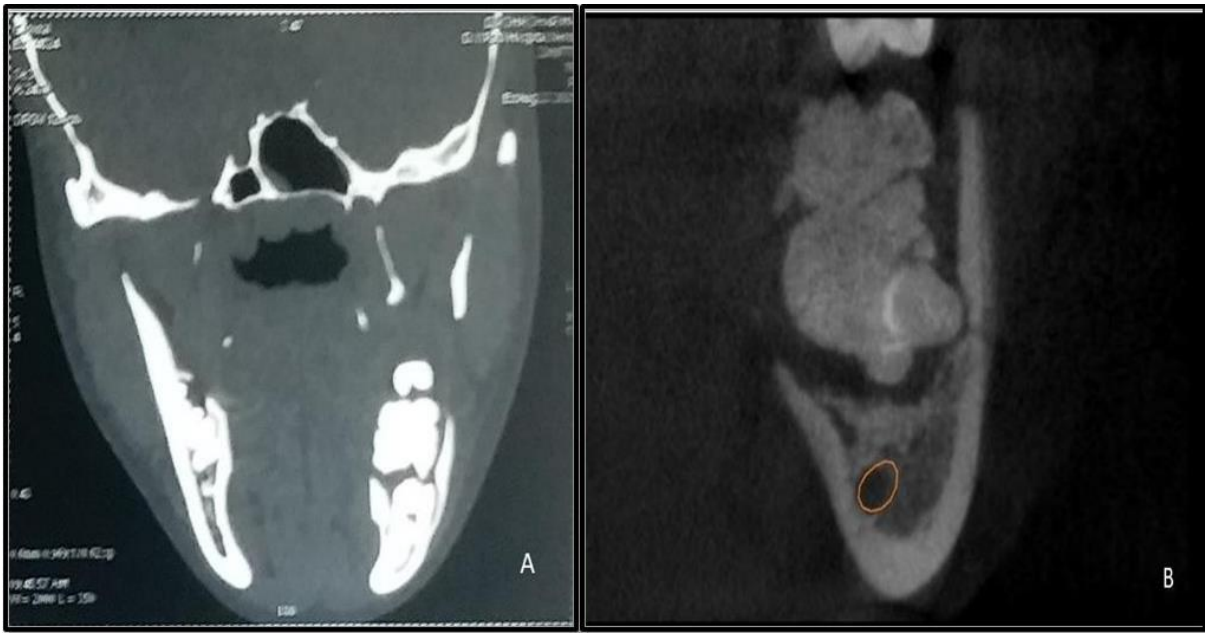


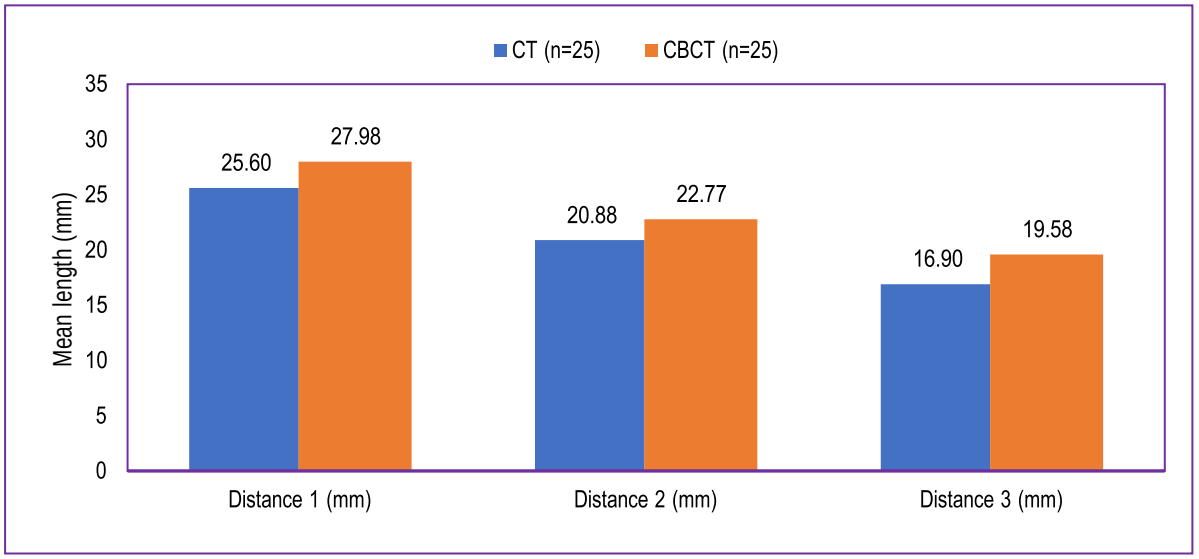
Figure 5A- Coronal section of CT (bone window) showing a complex odontoma in the left body of the mandible. The IAN canal cannot be appreciated. **Figure 5B-** Coronal section of CBCT showing the same lesion. The inferior displacement of the IAN is noted.

The data collected was tabulated and subjected to statistical analysis using the software Stata version 13.1 and SPSS version 20 for Windows (SPSS Inc., Chicago, IL, USA) to obtain the results. Accuracy of the measurements were analyzed using standard descriptives of the measurements using CBCT and CT scan and compared for differences using paired t-tests. The Intraclass Correlation Coefficient (ICC) was analyzed as a measure of the reliability of the superior-inferior length and medio-lateral length with CBCT and CT-scan. A single measure ICC method was used as an index for the reliability of the measurements with CBCT. For comparative analysis of accuracy for location, extent of lesion, approximation, and periphery of the lesion between CT and CBCT, chi square test was used.

RESULTS-

The study included 25 patients between the age group of 14-72 (Mean age 38.08) of which 12 were males and 13 were females with primary untreated pathologically proven maxillofacial pathologies that included odontogenic cysts, benign tumours, maxillo-facial infections, and oral squamous cell carcinoma. The measurements of the lesions in all the 3 planes on CBCT were more specific as compared to MDCT.(Graph 1, Table 1) The internal structures of all the lesions were assessed subjectively on CT and CBCT based on certain features which included the nature of the lesion whether hypodense/hyperdense or having mixed density, presence/absence of septae, nature of the septae, presence of calcification or tooth like structures within the lesions, presence of fluid or soft tissue within. The overall accuracy of detection of internal structure in all the 25 lesions by CBCT was 100 % as against 16 % in CT which was statistically significant ($p = <0.0001$). (Graph 2, Table 2) The periphery of the lesions was assessed as ill-defined or well-defined. The periphery of the lesions was accurately detected in 15 out of 25 cases (60 %) by CT as against 17 out of 25 cases (68%) by CBCT. (Graph 3, Table 3). Relationship of the lesion with the surrounding structures was evaluated based on following parameters erosion/displacement of the cortices of the inferior alveolar nerve (IAN) canal, Resorption of the floor of the nasal cavity/maxillary sinus, elevation of the floor of the maxilla and resorption of roots of teeth. The relationship of the lesions with their surrounding structure were accurate detected in

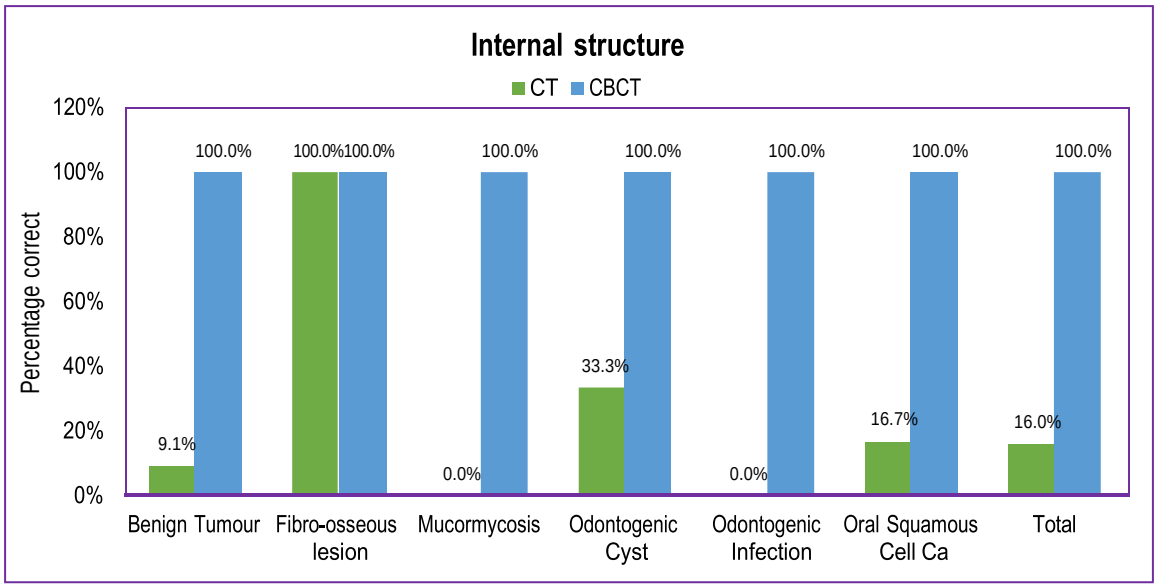
22/25 (88 %) of the cases in CT whereas 25/25 (100%) cases were accurately seen on CBCT (Graph 4, Table 4). Thus, CBCT was found to be more accurate in assessment of this parameter though there was no statistical significance. (Table 5, Graph 5). In view of the assessment of all the parameters, the accuracy of CBCT was found to be 89.3 % as compared to 54.7 % in CT in diagnosis of the various maxillofacial pathologies.



Graph 1- Bar graph showing the measurements of the lesions in all 3 planes in CT and CBCT

						Mean	*95% C.I.*		*Paired t-test*	
		N	*Mean*	*SD*	*SE*	*difference*	*Lower*	*Upper*	*t*	*p*
Distance 1 (mm)	CT	25	25.60	17.14	3.43	-2.38	-12.19	7.43	-0.488	0.628
(Cranio-caudal)	CBCT	25	27.98	17.35	3.47					
Distance 2 (mm)	CT	25	20.88	15.47	3.09	-1.90	-10.61	6.82	-0.437	0.664
(Antero-posterior)	CBCT	25	22.77	15.18	3.04					
Distance 3 (mm)	CT	25	16.90	10.47	2.09	-2.68	-8.54	3.17	-0.921	0.361
(Medio-lateral)	CBCT	25	19.58	10.12	2.02					

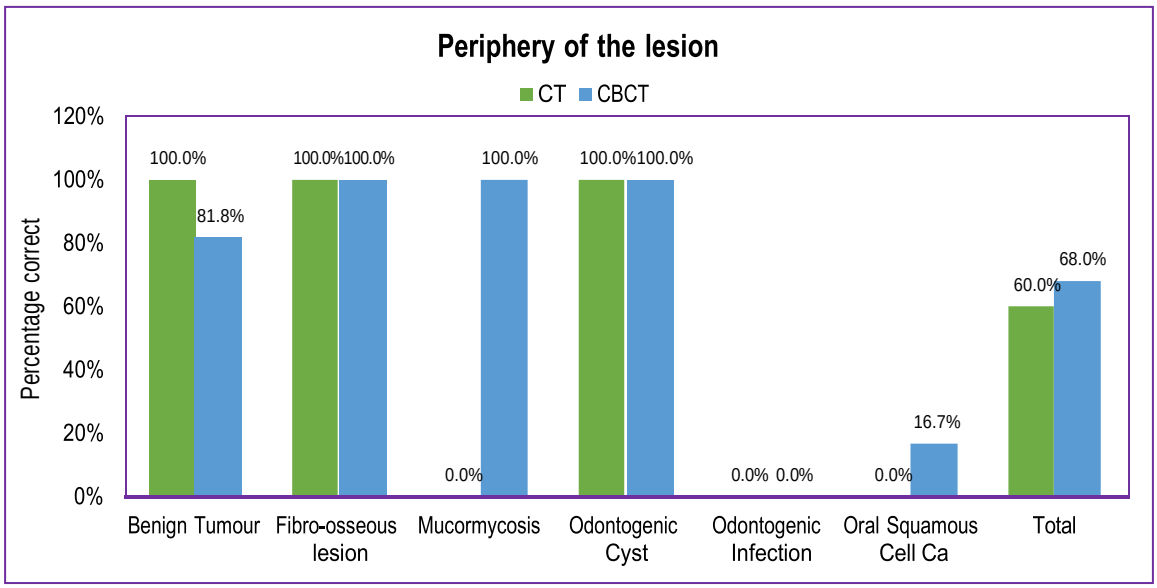
Table 1-Accuracy of CT Vs CBCT in determining the dimensions of the lesions



Graph 2- Bar graph showing percentage of accuracy of CT and CBCT in assessment of internal structures of lesions.

		CT		CBCT			
	N	*No.*	*%*	*No.*	*%*	χ^2	*p'*
Internal structure							
Benign Tumour	11	1	9.1%	11	100.0%	17.500	<0.0001
Fibro-osseous lesion	1	1	100.0%	1	100.0%	-	-
Mucormycosis	3	0	0.0%	3	100.0%	6.000	0.050
Odontogenic Cyst	3	1	33.3%	3	100.0%	3.000	0.200
Odontogenic Infection	1	0	0.0%	1	100.0%	2.000	0.500
Oral Squamous Cell Carcinoma	6	1	16.7%	6	100.0%	8.571	0.008
Total	25	4	16.0%	25	100.0%	36.207	<0.0001

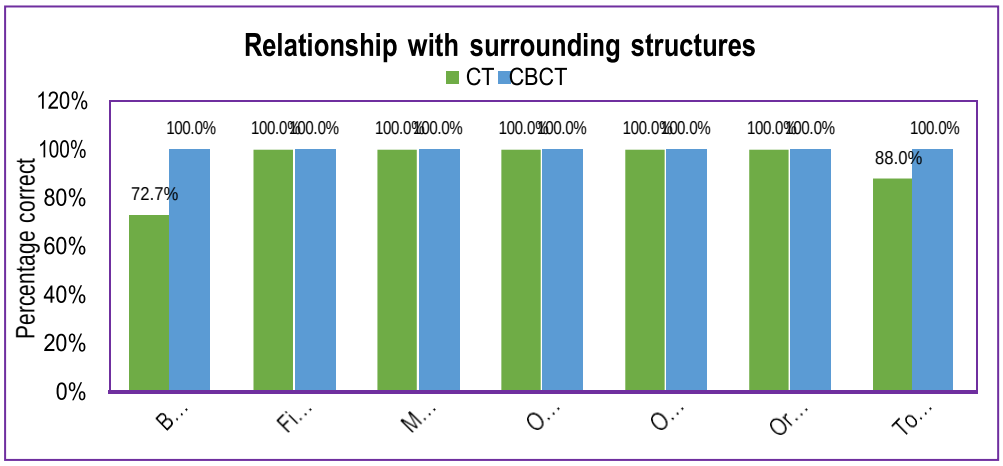
Table 2- Accuracy of CT vs CBCT in detecting the internal structure of the lesions



Graph 3- Bar graph showing percentage of accuracy of CT and CBCT in assessment of internal structures of lesions.

		CT		CBCT			
	N	*No.*	*%*	*No.*	*%*	χ^2	*p'*
Periphery of the lesion							
Benign Tumour	11	11	100.0%	9	81.8%	2.200	0.238
Fibro-osseous lesion	1	1	100.0%	1	100.0%	-	-
Mucormycosis	3	0	0.0%	3	100.0%	6.000	0.050
Odontogenic Cyst	3	3	100.0%	3	100.0%	-	-
Odontogenic Infection	1	0	0.0%	0	0.0%	-	-
Oral Squamous Cell Carcinoma	6	0	0.0%	1	16.7%	1.091	0.500
Total	25	15	60.0%	17	68.0%	0.347	0.384

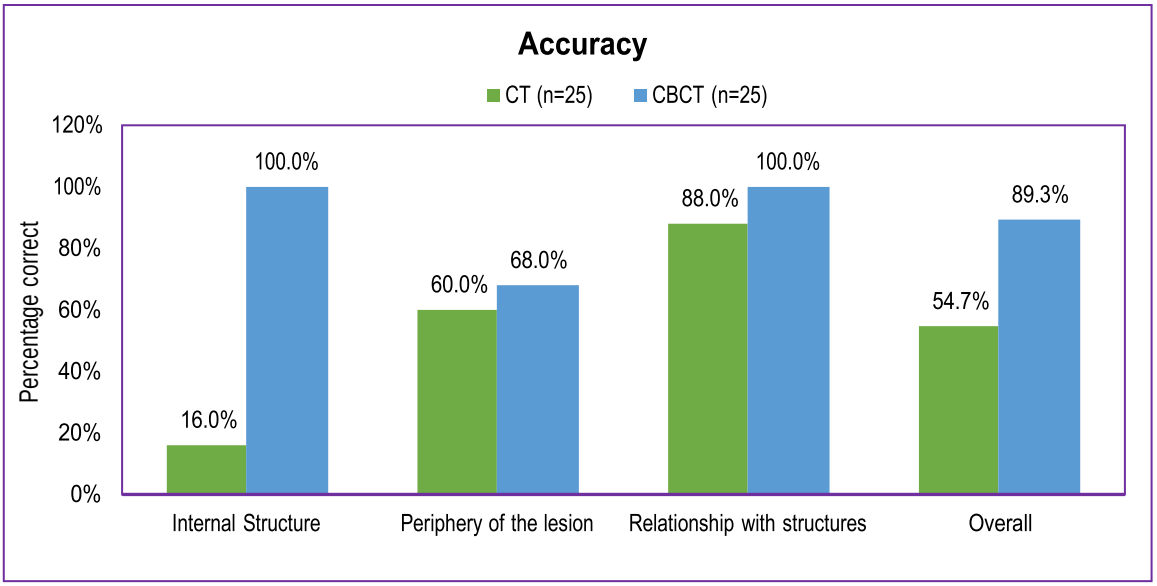
Table 3- Accuracy of CT vs CBCT in detecting the periphery of the lesions



Graph 4- Bar graph showing the percentage of accuracy of CT and CBCT in assessment of the relationship of the lesions with their surrounding structures.

		CT		**CBCT**			
	N	*No.*	*%*	*No.*	*%*	χ^2	*p'*
Relationship with structures							
Benign Tumour	11	8	72.7%	11	100.0%	3.474	0.107
Fibro-osseous lesion	1	1	100.0%	1	100.0%	-	-
Mucormycosis	3	3	100.0%	3	100.0%	-	-
Odontogenic Cyst	3	3	100.0%	3	100.0%	-	-
Odontogenic Infection	1	1	100.0%	1	100.0%	-	-
Oral Squamous Cell Carcinoma	6	6	100.0%	6	100.0%	-	-
Total	25	22	88.0%	25	100.0%	3.191	0.074

Table 4- Accuracy of CT vs CBCT in evaluation of the relationship of the lesions with their surrounding structures



Graph 5- Bar graph showing overall accuracy of CT Vs CBCT in percentage.

		CT		**CBCT**			
	N	*No.*	*%*	*No.*	*%*	χ^2	*p'*
Parameter							
Internal structure	25	4	16.0%	25	100.0%	36.207	<0.0001
Periphery of the lesion	25	15	60.0%	17	68.0%	0.347	0.384
Relationship with structures	25	22	88.0%	25	100.0%	3.191	0.074
Overall accuracy	25	41	54.7%	67	89.3%		

Table 5- **Overall accuracy of CT Vs CBCT**

Discussion-

Imaging plays a pivotal role in the diagnostic assessment, treatment planning and follow-up of patients with maxillofacial lesions. This study was conducted to compare CBCT and MDCT in evaluation of various osseous lesions pertaining to the maxillofacial region. In this study we evaluated the dimensions of the lesions in 3 planes, i.e cranio-caudal, antero-posterior and medio-lateral. CT was found to underestimate the linear measurements of the lesions. In past studies conducted by Rudolf et al. [7] Pinsky et al [8] and Hasimoto et al [9], the authors investigated the accuracy of CBCT and CT of bone defects and found that CBCT was more of an accurate diagnostic tool for osseous defects as compared to CT.

In the present study, the internal structures of all the lesions were assessed on CT and CBCT on the basis of certain parameters which included the density of the lesion, presence/absence of septae, calcifications, fluid or soft tissue. CBCT was able to show the intricate details of the lesions such as nature of the septae, presence of internal calcifications and presence of denticles within the lesions. In case of an Odontome, CT showed the lesion as a homogeneous hyperdense calcified mass whereas CBCT revealed its mixed density and presence of tooth components like enamel, dentin, pulp, and

cementum within the lesion. In all the cases of Mucormycosis, CBCT showed presence of irregular areas of bone loss with interspersed areas of bony sclerosis. Loss of buccal and lingual cortical plate, floor and lateral wall of the maxillary sinus was noted on CBCT than on CT. This could be attributed to the high spatial resolution of CBCT as compared to CT. Similar findings were observed in the study conducted by R.F Lai et. al. [10] and Nakagawa et al [11].

The accuracy in assessing the periphery of the lesions was statistically insignificant. In case of benign tumours CT was found to be more accurate than CBCT in detecting the periphery which could be due to CT being able to detect soft tissue extension of the lesion. However, in case of Mucormycotic lesions and Oral Squamous Cell Carcinomas CBCT showed better accuracy in assessing the periphery, ragged and irregular borders and intricate bony architecture which can be attributed to the better spatial resolution of CBCT than compared to a CT [12]. Similar findings were noted in a study conducted by Zezheng Wang et.al.[13]

Relationship of the lesions with their surrounding structures were discernible in both CT and CBCT however CBCT could more precisely detect the subtle changes like erosion of the cortices of the nerve canals, resorption of the nasal floor and floor of the maxillary sinus, resorption of buccal and lingual cortical plates etc. which were not evident on CT. In the present study, both modalities showed no statistically significant difference in assessment of relationship of the maxillofacial lesions on the surrounding structures ($p < 0.005$) which included changes in the cortical plate, involvement of the maxillary sinus, displacement of inferior alveolar canal.

In the study conducted by Vandenberghe et al. [14] and Noujeim et al. [15] it was observed that CBCT was more accurate in the detection of loss of trabeculae and detection of bone defects. Nakayama et al. [16] reported that CT was unable to detect weak bone invasion infiltrating through the trabecular bone as compared to CBCT. The literature shows several studies which are in accordance with the present study [17,18]. In the present study, the observed advantages of CBCT included: low cost, easy accessibility and low radiation dose, sub-millimetre resolution, high speed scanning and comfortable patient position, and its disadvantage included inferior soft tissue contrast resolution and image artifacts. Advantages of MDCT included bone, soft tissue and air windows, greater LCV and disadvantages of MDCT included: high cost, and high radiation dose.
Therefore, both CT and CBCT are valuable imaging modalities in evaluation of maxillofacial pathologies.

Limitations of the study-

The relationship between Hounsefield unit in CT and Gray value in CBCT was not assessed. The lesions evaluated in this study did not include soft tissue pathologies which limited the spectrum of the lesions to which the results could be applied. A further study is deemed necessary with a wider spectrum of lesions to assess the diagnostic efficacy of CBCT versus CT.

CONCLUSION-

This study was conducted to compare and evaluate the accuracy of CBCT and CT in assessment of maxillofacial pathologies. In this study we found that CBCT may be a more convenient and suitable imaging modality than MDCT for the evaluation of osseous lesions however, where evaluation of soft tissues is required as part of the patient's radiological assessment, the appropriate initial imaging should be CT or MRI, rather than CBCT. CBCT can be considered as the most accurate imaging modality for imaging osseous lesions due to its high spatial resolution and also has the advantage of ensuring

markedly lower effective doses as compared to CT though its major limitation is its less low contrast visibility (LCV) that makes it unsuitable for imaging of soft tissues.

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