International Journal of Enhanced Research in Medicines & Dental Care (IJERMDC),
ISSN: 2349-1590, Vol. 5 Issue 7, July-2018, Impact Factor: 1.338

Comparison of Cone Beam Computed Tomography and Computed Tomography in Maxillofacial Fractures

Lekha Sharma[1]*, Manish Airanb[2], Shweta Airanc[3]

[1]Corresponding author, Ex- Resident, Department of Oral and Maxillofacial Surgery, Manipal College of Dental Sciences, Mangalore, India
[2]MDS Prosthodontics Ex- Resident BPS-GMCW, Khanpur Kalan, Sonepat
[3]MDS Orthodontics Ex-resident PGIMS Rohtak

ABSTRACT

Background & Objectives

Imaging is a vital part in the management of patients suffering from head injuries. Many modalities exist that may be utilized for the purpose of visualizing the fracture defects. Traditionally Computed Tomography scans have been considered as the gold standard even though they have disadvantages such as associated radiation hazards, high cost factor, etc. Cone Beam Computed Tomography is a recently introduced radiographic modality that can be applied in maxillofacial traumatology as a quick, less expensive diagnostic tool which offers the advantages of significant reduction in radiation exposure over conventional use of Computed Tomography. We aimed to explore the diagnostic value of the use of Cone Beam Computed Tomography by the means of this study and compared it to Computed Tomography in detection of fractures of the maxillofacial fractures using parameters like acquisition time, reconstruction time, effective dose, number of fracture sites identified and exposure time. We observed that the acquisition and reconstruction time were significantly higher for Cone Beam Computed Tomography, whereas effective dose was significantly lower for Cone Beam Computed Tomography in comparison with Computed Tomography. The number of fracture sites visible and the mean exposure time were found to have no significant difference. Further research in the technical aspects and training in the application of this method to trauma is likely to witness CBCT becoming the modality of choice as an initial screening tool for detection of uncomplicated maxillofacial fractures and as post-operative check X-ray.

Keywords: CBCT; CT; Maxillofacial Trauma; Imaging

INTRODUCTION

Worldwide survey has revealed that trauma is responsible for more than 3 million deaths and 300 million injuries annually. It is the leading cause of mortality and residual morbidities especially in the individuals younger than the age of 45, in developing nations such as India, making it a significant global public health issue(1)Accurate diagnosis and treatment is very important in management of these traumatic injuries to restore the patients form and function to the pre traumatic status. Imaging plays a vital role in planning the surgical management of maxillofacial fractures. Radiography, which is imaging of tissues using X-rays, is used to rule out facial fractures, or to assess the nature of the fracture

Historically, 2-dimensional radiographic images were used for assessment of maxillofacial trauma; however the complex regional anatomy of the craniofacial skeleton and the soft tissue envelope can make it difficult to interpret these conventional plain film radiographs.

Since the invention of Computed Tomography (CT) scanning by Sir Godfrey Hounsfield in the 1970's, imaging for the assessment of disorders or disruptions in human anatomy has changed drastically. Even in the field of Maxillofacial traumatology, CT scans have revolutionized imaging and presently considered the gold standard in the evaluation of traumatic injuries to the head and neck region. They are presently being used as a routine for detecting fractures and examining soft tissues, and is often needed to determine whether surgery is necessary, but it is more expensive and difficult to obtain(2).

The introduction of cone beam computed tomography (CBCT) has dramatically changed the approach in the field dentistry in general and oral and maxillofacial surgery in particular. Prior to the introduction of cone beam computed

tomography, multi-planar views were obtained from multi detector computed tomography (MDCT) for maxillofacial imaging. Smaller physical dimensions, low cost and compatibility, and easier operation have led to rapid acceptance of cone beam computed tomography (CBCT) for maxillofacial imaging. (3)(4)

However not many studies have been done to assess maxillofacial fractures by using Computed Tomography (CBCT). Hence this study was carried out to evaluate the usefulness of Cone Beam Computed Tomography (CBCT) and to compare its diagnostic value with Computed Tomography (CT) in maxillofacial fractures.

PATIENTS AND METHODS

After obtaining institutional ethics committee approval, this 2 year prospective study was carried out on '15' patients reporting to the Department of Oral and Maxillofacial Surgery, Manipal College of Dental Sciences, Mangalore and K.M.C Hospitals, Mangalore. With 95% confidence level and 80% power, sample size was decided to be '15' in each group.

After explaining the importance and relevance of the study an informed consent was taken from patients who satisfied our inclusion criteria.

Inclusion criteria

1. Male or female participants of any age suspected to have maxillofacial fractures.
2. Subjects willing to sign informed consent form.

Exclusion criteria

1. Subjects unable or unwilling to sign the informed consent form.
2. Subjects with compromised airway and obvious head injuries.
3. Immuno-compromised individuals including those with severe debilitating diseases.

METHODOLOGY

After selection of patient for the study, preoperatively CT-scan was taken and postoperatively CBCT was acquired and the findings were correlated.

CT machine used for this study was **GE BRIVO CT385 16 Slice MDCT, with following specifications**

- **Type : MX-135**
- **Installed 11 months old**
- **mAs: 6.6 Million mAs**
- **DAS: VYPER_DOD_16**

The CBCT unit used for the present study was the Planmeca Pro Max 3D Mid with following specifications

Anode voltage	54–90 kV
Anode current	1–14 Ma
Focal spot	0.5 mm, fixed anode
Image detector	Flat panel
Image acquisition	Single 200 degree rotation
Scan time	7.5–27 s
Reconstruction time	2–25 s

Statistical Analysis: was done using *Mann-Whitney U* test.
A statistical package SPSS vers 15.0 was used. 'P' < 0.05 considered as significant.

Fig. 1: - Planmeca Pro Max 3D Mid

RESULTS

On evaluation of the parameters for overall diagnostic efficacy between Cone Beam Computed Tomography (CBCT) and Computed tomography (CT) in diagnosing and assessing maxillofacial fractures, followings results were observed.

Group Statistics

Table 1: Comparison showing different parameters between CBCT and CT using Mann-Whitney U test. P value less than 0.05 was considered significant.

	GROUP	N	Mean	Std. Deviation	z
Acquisition time (sec)	CT	15	3.533	.516	4.749
	CBCT	15	13.467	2.532	**P<0.001** VHS
Reconstruction time (sec)	CT	15	12.600	1.993	4.681
	CBCT	15	38.467	4.103	**P<0.001** VHS
Effective dose (µsv)	CT	15	2000.000	.000	5.089
	CBCT	15	760.000	50.709	**P<0.001** VHS
Number of fracture sites	CT	15	2.933	1.163	173
	CBCT	15	2.800	.941	P=0.863 NS
Exposure Time (sec)	CT	15	15.000	.000	1.018
	CBCT	15	19.600	5.578	P=0.309 NS

Median values

Table 2. Showing Median values of the parameters *between CBCT and CT*

GROUP	Acquisition time (sec)	Reconstruction time (sec)	Effective dose (µsv)	Number Of fractures	Exposure Time (sec)
CT	4.0000	12.0000	2000.0000	3.0000	15.0000
CBCT	13.0000	38.0000	800.0000	3.0000	24.0000

Table 3: Findings in relation to different parameters

Parameter	Acquisition time (sec)		Reconstruction time (sec)		Effective dose (µsv)		Number of fractures		Exposure Time (sec)	
	CT	CBCT	CT	CBCT	CT	CBCT	CT	CBCT		CBCT
1	3	12	14	36	2000	700	2	2	15	13
2	3	14	11	36	2000	800	1	1	15	24
3	3	12	12	34	2000	700	4	3	15	13
4	4	12	10	38	2000	800	2	3	15	24
5	3	19	13	36	2000	800	2	2	15	24
6	4	15	10	32	2000	800	5	4	15	24
7	4	13	15	36	2000	700	2	2	15	13
8	3	14	15	44	2000	800	3	3	15	24
9	4	15	15	34	2000	800	3	3	15	24
10	4	10	11	46	2000	700	3	4	15	13
11	3	11	11	43	2000	700	4	4	15	13
12	4	12	12	42	2000	800	3	2	15	24
13	3	14	13	41	2000	800	3	3	15	24
14	4	11	11	39	2000	700	2	2	15	13
15	4	18	16	40	2000	800	5	4	15	24

Observations

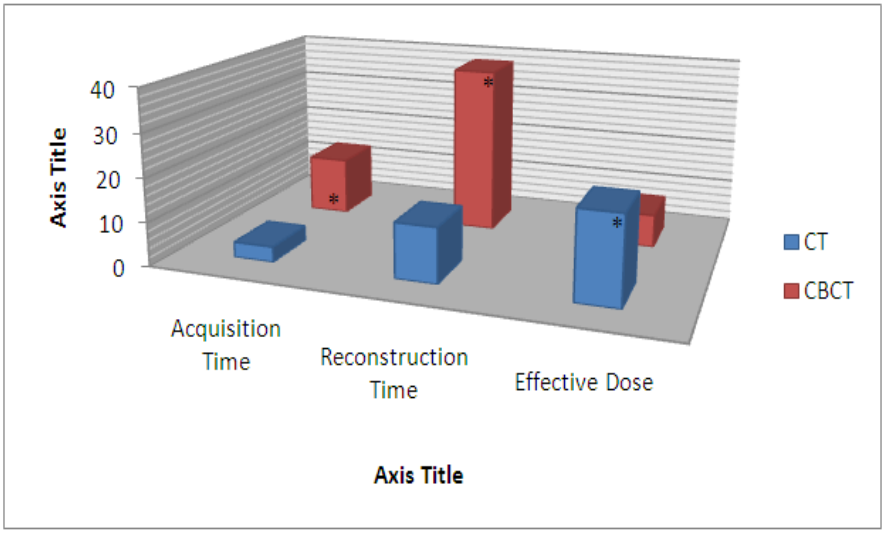
The results obtained revealed that

1. Acquisition time and Reconstruction time were significantly higher for CBCT as compared to CT, whereas effective dose was significantly lower for CBCT as compared to CT.

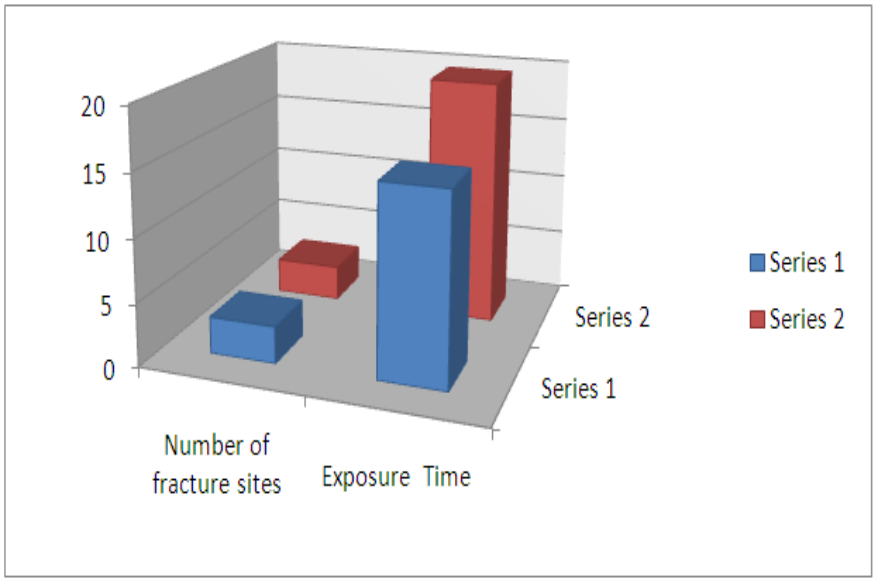
   - ✓ Acquisition time for CBCT (mean=13.46secs, std dev=2.53) was significantly higher as compared to CT (mean=3.53sec, std dev=0.51) with P<.001.
   - ✓ Reconstruction time for CBCT (mean=38.46 sec, std.dev=4.10) was significantly higher than CT (mean=12.60, std.dev=1.99), with P<.001
   - ✓ Effective dose for CBCT mean=760µSv,std.dev=50.70) was significantly less as compared to CT(mean=2000µSv std dev.=00) with P<.001

2. The number of fracture sites visible and the mean exposure time were found to have no significant difference.

   - ✓ Number of fracture sites visible was almost similar for CBCT (mean=2.80, std dev.=.94) and CT(mean=2.93,std.dev=1.16) p value being .863, thus rendering this parameter non-significant.
   - ✓ Exposure time for CBCT (mean=19.60, std deviation=5.57) was also similar to CT (mean=15, std. dev=00) p value being 1.018, thus rendering this parameter non-significant.



Graph 1: Showing significant parameters



Graph 2: Showing parameters with no significant difference

DISCUSSION

Discovery of X-ray is credited to Wilhelm Conrad Roentgen and their introduction in the field of dentistry was by C. Edmund Kells. Imaging in maxillofacial trauma over the last two decades has witnessed a dramatic move of image processing from simple reformatting programmes to a wide range of complex post-processing methods designed to extract further information from image data. This development has been largely due to reduction in radiation dose, processing times and cost of technology.

The development of CT scan revolutionized the field of Radiodiagnosis. In the present day set up, CT is considered as the Gold Standard in imaging. Soft tissue assessment and imaging to rule out associated intra cranial injuries are the main advantages of CT-scan. Furthermore, for a good reduction and fixation of a displaced or comminuted fracture, 3D reconstructed images can be acquired which aids in planning the surgery. Surgeons have been found to add that they not only find 3D images easier to assimilate, but the diagnostic aspect is considered far superior when 3D CT is combined in imaging strategies.[5]

However there are shortcomings with CT scan as a radiodiagnostic modality. It is not only expensive, but in a developing nation like India where there is strong division in the urban and rural health care systems, the logistics and socioeconomical factors often do not find the presence of an installed CT scanning unit easily available in lower levels of health care set ups. A routine CT scan delivers high doses of radiation that has recently triggered a lot of debate especially in pediatric age group.

However these factors do not undermine the importance of CT-scan in the management of a patient with head injury when relative and definite indications for a CT scan have been laid down in a clear set of guidelines followed at majority of tertiary heath care institutions as per the ATLS. [6]

Recently, the principle of ALARA has gained considerable weightage and it has become unethical to subject every traumatized patient to a CT scan, because of hazards associated with radiation exposure such as developments of cataracts and radiation injuries.

Radiation reduction protocol led to the development and introduction of the Cone-beam computed tomography (CBCT) as a recent advancement in the available modalities for imaging the head and neck region. It is rapidly gaining favor with clinicians worldwide especially in the field of dentistry. [7]CBCT predominantly finds its applications in the diagnosisof osseous, pathological lesions of the head and neck, although few conditions have also been described under other special fields such as utility of CBCT in angiographic studies as well.

Studies reveal that CBCT produces images equivalent to conventional CT with the added advantage of lesser radiation exposure.[7]The indication for CBCT in imaging for maxillofacial trauma is when the patient shows no signs of neurological deficits and requires a single imaging modality to evaluate the underlying fracture.

Additionally, for postoperative evaluation, some studies support the contribution of CT [8, 9] but limiting factors such as cost, availability and radiation dosage allow CBCT as an acceptable alternative [10]. Moreover for gunshot injuries CBCT is the imaging modality of choice as it has less scattering due to metal artifact than CT. We obtained CBCT postoperatively and not preoperatively so as to avoid radiation over exposure to the patient.

- **In our study the first parameter (Table 1) which was compared was Acquisition time**. We observed that it was significantly higher for CBCT (mean =13.467 seconds) than for CT (mean=3.53 seconds),**p<0.001**. This was because in CBCT machine the temporal resolution of cesium iodide detectors slows data acquisition. There is no data available in the literature regarding comparison of acquisition time in CBCT and CT.
- **Second comparison wasthe difference in Reconstruction time(Table 1)** which was significantly higher for CBCT machine (mean=38.46 seconds) than for CT machine(mean=12.6 seconds) **p <0.001**, the reason for this could be attributed to the fact that it is time consuming for computationally demanding cone beam reconstruction algorithm. Image captured in CT scan is by a fan shaped beam which makes multiple revolutions around the head taking images in multiple slices, whereas for CBCT image is taken by a single cone beam rotation.
- **Effective dose of radiation was compared (Table 1)** which was significantly higher for CT (mean=2000µSv) than for CBCT (mean=760µSv), **p<0.001**. Our findings were in accordance with M. Loubele et al[11] and Davies et al[12].
- **For the number of fractures (Table 1)** visible, we observed that it was similar for both CBCT (mean=2.933) and CT (mean=2.880), p=0.863, thus rendering the comparison insignificant. Clinically it was observed that dentoalveolar fractures were better visible in CBCT than in CT. However, soft tissue analysis and correlation CT was superior. This is in agreement with the study conducted Marcus Abboud et al[13]
- **Last parameter to be compared was exposure time. (Table 1)** It was almost similar for both CBCT (mean=19.60 seconds) and CT (mean=15), p=0.309, rendering this comparison insignificant.

Preclinical data indicates that CBCT is a reasonable tool for the evaluation of high-contrast structures with quality that remains equivalent to CT. However, owing to the low radiation applied, CBCT suffers from some degree of image noise and lack of soft tissue differentiation. CBCT is considered the modality of choice in ballistic injuries as the metal artifacts produced is significantly lesser that that produced in its counterpart.[14]

CONCLUSION

Imaging is an indispensable part in the diagnosis and management of fractures that involves maxillofacial complex. Even though plain conventional films deliver less radiation, they have inherent drawbacks and often lack important information pertaining to the surgical treatment planning and by and large considered unreliable.

CBCT provides excellent information about bony structures but is ineffective in the assessment of the soft tissue components. CT provides good resolution of both soft and hard tissues, but delivers the greatest amount of radiation.

These advanced imaging modalities have replaced conventional two-dimensional films for maxillofacial trauma. In extensive and emergency poly trauma cases, CT is the imaging modality of choice because of higher image resolution for soft tissues. If unavailable, two-dimensional images may be considered, but they are sometimes inconclusive and inept to shed sufficient information regarding the pattern and severity of the displacement of comminution of the fracture segments. CBCT appears as an acceptable alternative to CT providing important information with less radiation in the absence of an intracranial injury.

Conflict of Interest
None

Ethical approval
Approved by institutional ethical committee

Funding
None

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