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Original Research Article

Accuracy of imaging modalities (CBCT/conventional radiography) in maxillofacial fractures - A cross sectional study

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A B S T R A C T

Introduction: Maxillofacial trauma refers to any injury to the face or jaw caused by physical force, foreign objects, or burns. For all traumatic events imaging examination is an essential component which is done both pre-operatively and post-operatively. This study was to assess the accuracy of CBCT imaging and the conventional imaging in evaluation of maxillofacial fracture.
Aims and Objectives: To assess the maxillofacial fracture using conventional radiography and CBCT. To compare the diagnostic acurracy of cone beam computed tomography (CBCT) with conventional radiography. To validate the best method for assessment of maxillofacial trauma.
Materials and Methods: Depending on type of fracture conventional imaging and CBCT imaging was done. Following which fracture was assessed using AOCMF classification.
Results: The most common fracture was zygomatic complex fracture of about 76.9%. CBCT showed significant P-value in assessment of level-2 fracture evaluation, extension of fracture and in Level-3, number of fragment, angulations, displacement, inferior obital fissure, crown root fracture assessment. The sensitivity and specificity of CBCT was better than conventional imaging.
Conclusion: CBCT assess the maxillofacial fracture more precisely than conventional imaging.

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1. Introduction

Maxillofacial injury is any physical trauma to the facial region, is commonly encountered by maxillofacial surgeons, and is often associated with high morbidity.[1] Facial bone fractures were classified as mandibular, Lefort I, Lefort II, Lefort III, Zygomatico-maxillary fracture including orbit, and Nasal bone fractures.[2] Until the 1980s, diagnostic imaging of facial injuries consisted almost exclusively of standard facial and panoramic radiographs and, if available, tomographic studies. Another approach uses an alternate acquisition x-ray beam geometry incorporating a cone rather than a fan beam is Cone-beam CT (CBCT) scanners.[3] When compared with dental panoramic radiograph, CBCT is useful in identifying the location of cortical plate fracture that is not through and through. Also, when using CBCT, as compared to CT and conventional radiograph, information about dentoalveolar fractures is more detailed. This makes CBCT uniquely useful in alveolar fracture diagnosis.[4]

Therefore, the purpose of this study was to assess the accuracy of CBCT imaging and the conventional imaging in evaluation of maxillofacial fracture.

2. Materials and Methods

This Prospective clinical imaging study was carried out in the out-patient Department of oral medicine and

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radiology with a random sample of 91 maxillofacial trauma patient will be examined clinically according to the proforma**.** Patient with Maxillofacial trauma. Good quality conventional radiographs were included in the study. Patient with Congential Facial deformity, Cleft palate, Syndrome of orofacial region, Poly trauma were excluded. Then the necessary conventional radiographs and CBCT will be done after obtaining informed consent from the patient. Appropriate Conventional radiograph include posterior anterior, caldwell, waters, reverse towne, submentovertex views and orthopantomogram made using conventional X-ray machine GME 500 X-ray unit with Kvp 60-65, 50-60 mA(Figure 4). Following conventional radiograph CBCT imaging made using Vatech CBCT machine, Model PHT-6500 with 90 Kvp, 10mA (Figure 5). Depending on the type of fracture, conventional radiographs and CBCT will be taken, assessed separately by intraobserver, interobserver and compared for effectiveness for presence/absence of fracture, anatomical location, extension, number of fracture segments, displacement, angulation etc., based on AOCMF classification system. This new comprehensive Arbeitsgemeinschaft fur Osteosynthesefragen Cranio maxillofacial(AOCMF) classification system for fractures in the adult craniomaxillofacial skeleton is organized in anatomic modules in a three precision-level hierarchy with a brief account for increasing complexity and other details.

Level-1: Most elementary. It identifies no more than the presence of fractures in 4 separate anatomical units: the mandible (code 91), midface (92), skull base (93) and cranial vault (94).

Level-2: This relates the detailed topographic location of the fractures within each unit.

Level-3: Based on a more refined topographic assessment. It focuses on the morphology—fragmentation, displacement, and bone defects—within specified sub regions.[5]

Fig. 1: Lefort-1 fracture of maxilla

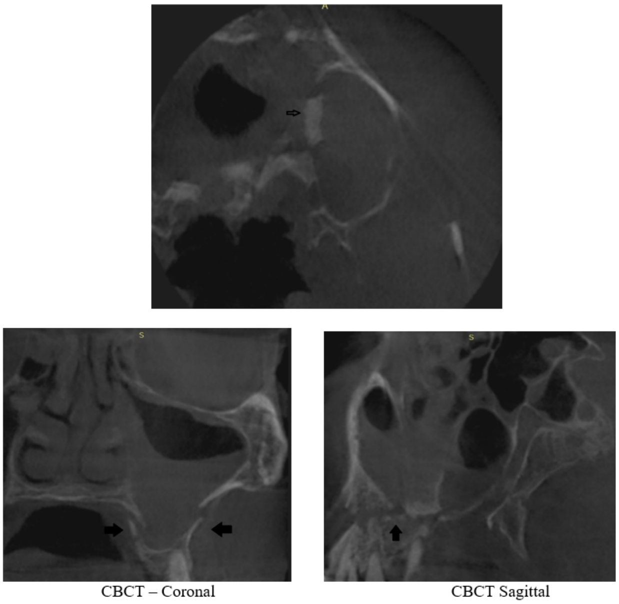

Fig. 2: CBCT image - Axial

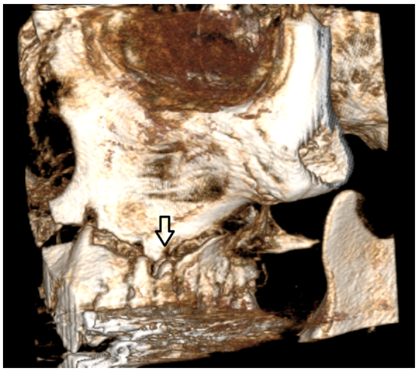

Fig. 3: 3D reconstruction

3. Results

From Department of Oral Medicine and Radiology total of 91 maxillofacial trauma patients were examined, following which participants were subjected to undergo both conventional radiograph (n=91) and CBCT (n=91) and considered as two different groups. The collected data were entered in Microsoft Excel . Percentage, frequencies and t test were used for comparing mean of different groups. Interrater agreement regarding accuracy of CBCT/Conventional radiograph was analysed using Kappa statistics. All the analysis were carried out using SPSS 20 with significant at $p<0.05$.

Distribution of fracture and clinical features in trauma were analysed by frequency and percentage, shown in Tables 1 and 2. Most common fracture was zygomatic complex fracture, most common clinical feature was Abrasion, laceration, ecchymosis, intraoral soft tissue injury, occlusal derangement, nose bleeding and step deformity.

Fig. 4: Extraoral radiograph made using GME 500 unit

Table 1: Distribution of fracture

Type	Frequency	Percentage(%)
Zygomatic complex	70	76.9
Zygomatic arch	9	9.9
LEFORT-1	4	4.4
LEFORT-2	4	4.4
Mandibular	4	4.4
Total	91	100.0

Table 2: Clinical features in maxillofacial trauma

Cinical feature	Present (%)	Absent (%)
Loss of Consciousness	8.8	91.2
Vomiting	9.9	90.1
Ear Bleeding	3.3	96.7
Nose Bleeding	73.6	26.4
Mouth Bleeding	39.6	60.4
Laceration	84.6	15.4
Abarasion	96.7	3.3
Ecchymosis	79.1	20.9
Normal Mouth Opening	74.7	25.3
Occlusion derangement	76.9	23.1
Intraoral Soft Tissue	75.8	24.2
Intraoral Hard Tissue	36.3	63.7
Step Deformity	70.3	29.7
Segmental Mobility	9.9	90.1

Fig. 5: CBCT image tken using vatech CBCT machine

Table 3: Fracture evaluation by conventional imaging and CBCT

Parameter	Conventional imaging (%)	CBCT (%)
Level -1	100	100
Level-2		
Site	98.9	98.9
Extension	31.86	98.9
Level-3		
Location frogment	93.4	98.9
Number of fragment	51.64	98.9
Angulation	0	98.9
Displacement	54.9	98.9
Infra orbital fissure	0	26.3
Apex of orbit	0	0
Optic canal	0	0
Crown fracture	3.3	10.9

Fracture evaluation using AOCMF was done and frequency was calculated for each parameter as shown in Table 3. Comparasion of Conventional imaging with CBCT at each parameter was done using Chi- square test and P-value was calculated, as shown inTables 4, 5, 6, 7, 8 and 9.

P-value was significant in comparison of extension, location of fragment and crown root fracture .

Interobserver reliability was done between observer-1 and observer -2 using Kappa statistic. It was not significant in Level-1, Level-2, Level-3. This is shown in Tables 10 and 11.

4. Discussion

Maxillofacial injury is one of the most commonly involved component following trauma patients presenting in the medical emergency department and is the major cause of death among people in the third to fourth decades of life. Maxillofacial injuries can affect both skeletal and soft tissue components of the facial structure and if not properly managed can negatively influence both the psychosocial and functional activities of the patients.[6] Proper clinical examination and treatment plan, high resolution radiographs are always essential, which will indirectly contribute to render a good medical care to the patients.[2]

In present study total of 91 maxillofacial trauma patients were evaluated clinically, following which conventional and CBCT imaging were done. Among the study group most maxillofacial trauma were seen in men, which is about 98.9%. These result was similar to study done by Farias IPS et al(2017),[7] Akhlaghi F et al (2019).[8] All patients presented with chief complaint of pain and swelling in injured site of trauma. The cause for trauma was Road traffic accident(RTA), Assault, self fall. Among them road traffic accident was most common, accounts for 94%, the cause for RTA was societal shift from agricultural to industrial dependency, resulting in more traffic that might consequently cause more facial injuries from motorcycle accident. The results were similar to study done by Gupta A et al(2018),[9] Chandra L et al(2019),[5] and Prasad C et al(2018).[10]

History Loss of consciousness(LOC) was present 8.8% of cases, which was similar to study done by Rajendra PB et al (2009),[11] the cause for was alcohol intake or syncope. Vomiting was present in 9.9% of cases, which was contradict to study done by Rajendra PB et al (2009)[11] because in their study most of cases associated with head injury but in our study injury limited to facial region.

History of ear bleeding was present in 3.3% of cases, which is seen in mandibular condyle fracture, which corresponds to the side of fracture present. Nose bleeding was present in 73.6% of case, which was associated with zygomatic complex fracture. The side of nose bleeding is corresponding to the side of fracture. Buchanan and Holtmann et al (1983) state that severe nose bleeding after facial fracture is not a common complication. However, nose bleeds quite frequently follow midfacial fractures.[12]

Bleeding from mouth was present in 39.6% of cases, the cause for bleeding from mouth was either soft or hard tissue injury. Soft tissue injury was present in 75.8% of cases, the most common cause was laceration of soft tissue. These results were similar to study done by Lee CW et al (2017).[13] Hard tissue injury for present in 36.3%, the most common cause was tooth fracture and dentoalveolar fracture. These was contradict to study done by Bregagnolo LA et al (2013)[14] because in our study most cases injury was present in mid-face region.

On extraoral examination, swelling was present in most of the cases, the side of swelling present was correspond to the side of fracture present. Laceration was present in 84.6% of cases, abarasion was 96.7%. Sub - conjunctival hemorrhage or ecchymosis was present in 79.1% of cases, which was mostly associated with zygomatic complex fracture. The side of fracture present was corresponds to the side sub- conjunctival hemorrhage or ecchymosis. These results were similar to study done by Mohanavalli S et al (2016).[15] Al-Qurainy et al, Ansari et al and Wood et al found that zygomatic complex fractures had a significantly higher incidence of visual sequelae than other forms of midfacial injury.[15]

Intraoral mouth opening was normal in 74.7% of cases and restricted in 25.3% of cases, these was contradict to study done by Chang MC et al (2012).[16] Because in our study most of cases fracture segment was minimally displaced. Occlusal derangement was present in 23.1% of cases, which mostly associated with condyle fracture, lefort fracture of maxilla.

Step deformity was present in 70.3% of cases, which is usually seen in zygomatic complex fracture and lefort fracture. The step deformity was due to displacement of fracture segment either superior, inferior, lateral or Medial position. The segmental mobility was present in 9.9% of cases, it is mostly seen in lefort -1, 2 fracture. The segmental mobility of fracture segment was due to severe displacement of fracture.

In present study 76.9% of cases were zygomatic complex fracture, zygomatic arch was 9.9%, and lefort 1 & 2 was 8.8% which is similar to study done by Farias IPS et al(2017),[7] mandible fracture was 4.4% contradict with study done by Farias IPS et al (2017) because in our study we selected more of mid face fracture due to complex anatomic structure.

On assessment of level -1 fracture evaluation presence of fracture was examined in mandible, midface, cranial vault and cranial base. Among 91 cases both conventional radiograph and CBCT assessed equally. The p-value was not statistically significant and interobserver reliability was not statistically significant suggestive of interobserver agreement. These findings were similar to study done by Shah B et al (2017),[17] Miracle AC et al (2009).[18]

On Level-2 assessment fracture site and extension was assessed, site was equally assessed by both conventional radiograph and CBCT in all cases. In case of assessment of fracture extension, it was better assessed in CBCT compared

Table 4: Comparing sensitivity and specificity of conventional imaging and CBCT exact site evaluation

Site CR	Site CBCT Absent	Site CBCT Present	Total	Chi-Square	p value
Absent	1 100.0%	0 0.0%	1 100.0%	91.000	0.000**
Present	0 0.0%	90 100.0%	90 100.0%		
Total	1 1.1%	90 98.9%	91 100.0%		

Table 5: Extension

Extension CR	Extension CBCT Absent	Extension CBCT Present	Total	Chi-Square	p value
Absent	5 100.0%	57 66.3%	62 68.1%	2.475	0.116NS
Present	0 0.0%	29 33.7%	29 31.9%		
Total	5 100.0%	86 100.0%	91 100.0%		

Table 6: Fracture location

Location CR	Location CBCT Absent	Location CBCT Present	Total	Chi-Square	p value
Absent	1 100.0%	5 5.6%	6 6.6%	14.324	0.000**
Present	0 0.0%	85 94.4%	85 93.4%		
Total	1 100.0%	90 100.0%	91 100.0%		

Table 7: Fracture number

Number CR	Number CT Absent	Number CT Present	Total	Chi-Square	p value
Absent	1 100.0%	43 47.8%	44 48.4%	1.080	0.299
Present	0 0.0%	47 52.2%	47 51.6%		
Total	1 100.0%	90 100.0%	91 100.0%		

Table 8: Fracture displacement

Displacement CR	Displacement CT Absent	Displacement CT Present	Total	Chi-Square	p value
Absent	1 100.0%	40 44.4%	41 45.1%	1.233	0.267
Present	0 0.0%	50 55.6%	50 54.9%		
Total	1 100.0%	90 100.0%	91 100.0%		

Table 9: Crown and root fracture

Crown CR	Crown CT		Total	Chi-Square	p value
	Absent	Present			
Absent	81 100.0%	7 70.0%	88 96.7%		
Present	0 0.0%	3 30.0%	3 3.3%	25.128	0.000
Total	81 100.0%	10 100.0%	91 100.0%		

Table 10: Interrattor reliability between observer -1 and observer -2 in conventional radiograph

Parameter	Value	Observer 1	Observer 2	Kappa	P value
Level1 CR Man	Absent	0	0		
	Present	4	4		
Level1 CR Midface	Absent	0	1	0.006	0.316
	Present	87	86		
Level2_CR_Exactite	Absent	1	1	0.000	1.000
	Present	90	90		
Level2_CR_Extension	Absent	58	58	0.000	1.000
	Present	33	33		
Level3_CR_Fraglocation	Absent	2	6	0.21	0.148
	Present	89	85		
Level3_CR_NoFrag	Absent	42	34	0.030	0.254
	Present	49	56		
Level3_CR_Angulation	Absent	91	91		
	Present	0	0		
Level3_CR_Displacement	Absent	35	36	0.004	0.879
	Present	56	55		
Level3_CR_IOF	Absent	91	91		
	Present	0	0		
Level3_CR_Apexorbit	Absent	91	91		
	Present	0	0		
Level3_CR_OPCanal	Absent	91	91		
	Present	0	0		
Level3_CR_Crown	Absent	88	88	0.000	1.000
	Present	3	3		

to conventional radiograph. This is because the image was viewed in all three planes(i.e. axial, coronal, sagittal section) and 3D reconstruction to replica the skull model (FIG -3). This similar to study done by Rahman SA et al (2015),[19] Ansari K et al (2015).[20]

On level -3 assessment of fracture, fragment location was assessed by CBCT in 98.9% cases but conventional radiograph assessed it was 93.4% of cases. The sensitivity and specificity of Conventional radiography was compared with CBCT which is about 94.4% and 100% respectively. This is in accordance with study done by Tanrikulu et al(2001).[21] There are different opinions in the literature on the evaluation of fractures of the zygoma with conventional methods. Patria and Blaser have reported that Waters' projection alone is not sufficient to determine the depression and rotation of zygoma and should be supplemented with other conventional methods.[19] Accordingly, Daffner et al. have proposed that the lateral projection is useful in diagnosing dislocation, rotation and depression of the molar prominence.[22] Johnson et al. pointed out that any dislocation can be evaluated adequately from a Waters' view by comparison with the sound side.[23] There is a consensus that conventional methods are adequate for the evaluation of fractures of the zygoma and CT is not required.[21]

Number of fragment was assessed in CBCT was 98.9% of cases and in conventional radiography 51.6%. The sensitivity and specificity of Conventional radiography was compared with CBCT which is about 52.2% and 100% respectively. According to Shintaku WH et al (2009) CBCT is able to show a larger number of fracture lines and fragments when compared with conventional images, depicting precisely the position and orientation of displaced fragments in reasonably short time interval. Because CBCT provides resolution better than conventional imaging.[24]

Displacement was assessed in 98.9% of cases and in conventional radiography 54.9% of cases was assessed.

Table 11: Interrattor reliability between observer -1 and observer -2 in CBCT

Parameter	Value	Observer 1	Observer 2	Kappa	P value
Level 1 CBCT Man	Absent	4	4		
	Present	0	0		
Level 1_CBCT_Mid	Absent	1	1	0.000	1.000
	Present	86	86		
Level 2_CBCT Exactsite	Absent	1	1	0.000	1.000
	Present	90	90		
Level 2_CBCT Extension	Absent	5	5	0.000	1.000
	Present	86	86		
Level 3_CBCT FragLocation	Absent	1	1	0.000	1.000
	Present	90	90		
Level 3_CBCT NoFrag	Absent	1	1	0.000	1.000
	Present	90	90		
Level 3_CBCT Angulation	Absent	1	1	0.000	1.000
	Present	90	90		
Level 3_CBCT Displacement	Absent	1	1	0.000	1.000
	Present	90	90		
Level 3_CBCT IOF	Absent	62	52	0.034	0.125
	Present	29	39		
Level 3_CBCT apexorbit	Absent	91	91		
	Present	0	0		
Level 3_CBCT OPCanal	Absent	91	91		
	Present	0	0		
Level 3_CBCT Crown	Absent	77	80	0.009	0.518
	Present	14	11		

The sensitivity and specificity of Conventional radiography was compared with CBCT which is about 54.9% and 100% respectively. These was similar to study done by Roman R et al (2016),[25] Ansari K et al (2015)[20] because of conventional image was 2D dimensional image of 3D dimensional structure and CBCT image can be viewed in all three planes (i.e. axial, coronal, sagittal section) and 3D reconstruction to replica the skull model.

Angulations were assessed in 98.9% of cases and in conventional radiography angulation was not assessed. Angulation in CBCT was done using tools in software.

Using CBCT Infraorbital fissure was assessed in 26.3% of cases but in conventional radiography, the infraobital fissure was not assessed. Infraorbital fissure was assessed better in CBCT than conventional imaging, this is because CBCT offers 3D data obtained during examination, individual high resolution axial and coronal extracted plane and sagittal plane, dedicated to the orbit itself, in it's axis.[25]

Crown and root fracture was assessed 10.9% of cases and in conventional radiography crown fracture was 3.3% of cases were assessed. This was contradict to study done by Doğan MS et al. (2018),[26] because in their study teeth was full within field of view, but in our cases the portion of tooth and alveolus was not covered in field of view. The sensitivity and specificity of Conventional radiography was compared with CBCT which is about 30% and 100% respectively.

Angulation, infraobital fissure are better assessed by CBCT, when compare to conventional imaging because of Cone-beam computed tomography (CBCT) which provides a new class of 3D images which gives promising good results in determining facial fractures. The sensitivity and specificity of CBCT was better than conventional radiography in evaluation of midface fracture in Level-2 and Level-3 which was similar to study done by Ricci M et al (2019),[27] Borel C et al (2017).[28]

5. Conclusion

The present study states that CBCT was better than conventional imaging in evaluating maxillofacial fracture at level-2 fracture, evaluation extension of fracture and in Level-3, Number of fragment, Angulation, Inferior Obital fissure, crown root fracture. So, CBCT is better in evaluating mid face fracture. It may guide surgeons to appropriate early management, resulting in improved outcome.

6. Source of Funding

None.

7. Conflict of Interest

None.

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