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Diagnostic Efficacy Of 3D CT Vs Conventional Radiographs In Maxillofacial Trauma -A Comparative study

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ABSTRACT

Conventional plain radiographs are the first line of investigation in maxillofacial trauma but bear limited advantages. CT is now a preferred diagnostic tool due to its accurate diagnosis. Many studies have been done regarding the efficacy of CT scan in the diagnosis and management of maxillofacial trauma but most of them have been performed in radiologist perspective. In this study we did a comparative study of conventional radiographs and 3D CT in the evaluation of maxillofacial trauma based solely on Oral and maxillofacial surgeon's perspective (i.e. How much an oral and maxillofacial surgeon finds radiographs / 3D CT valuable in the diagnosis and management of maxillofacial trauma patients). Forty five patients of either sex ranging 3 to 55 years (mean average age 27.1+_11.9 years) were included in this study and were advised conventional radiographs and non-contrast CT scan with 3D reconstruction. Cases with maxillofacial fracture were divided into three groups 1) Middle third face fracture, 2) Lower third face fracture and 3) Both middle third and lower third face fracture. In each group, the conventional radiographs and 3D CT were done and analyzed. The result of our study indicate that 3D CT is statistically more significant ($Z= 8.8$, $p<0.001$) in terms of *fracture sites detection* as compared to conventional radiographs. Further 3D CT is superior in displaying extent of fractures and comminution as well as for displacement and it provides additional conceptual information as compared to conventional radiographs in majority of patients having maxillofacial trauma.

Keywords: 3D CT in Maxillofacial trauma, Fracture Middle third and lower third facial skeleton

Introduction

Facial injury may range from simple laceration to craniofacial disjunction with severe soft tissue damage. Management of facial injuries is challenging for the clinician as they are often complex in nature and may have serious functional and cosmetic sequelae. This makes accurate diagnostic evaluation essential. Single or combinations of conventional plain films form baseline radiographic screening assessment for the investigation of facial fractures. Their diagnostic accuracy has been shown as 38% for orbital and maxillary fractures and they significantly underestimate the extent of blowout, Le fort I, and Le fort II fractures [1].Also practical interpretation of facial fractures using conventional radiographs becomes quite difficult for limited experience staff and for experienced staff too. These limitations are overcome by Spiral CT which provides rapid acquisition (less than 20 seconds) of thin section axial CT data and facilitates multi-planner reformatted (MPR) 2-dimensional (2D) and 3D image reconstruction assisting fracture detection. CT's accurate representation of facial fractures and their spatial relationships facilitates surgical exploration, fracture reduction, and the selection and contouring of rigid reconstruction plates. CT, therefore, decreases complications resulting from delays in diagnosis and treatment. Recent introduction of 3D reconstructions have further facilitated the diagnosis and treatment of facial injuries [2, 3], and are superior to 2D CT for pre-surgical planning in complex trauma [2, 4].

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Materials and methods

Forty-five patients with maxillofacial trauma who were referred to Department of Oral and Maxillofacial Surgery, Dr. Ziauddin Ahmad Dental

College and Hospital, Aligarh Muslim University, Aligarh, India were included in this study. The patient selected for the study were requested to sign a consent form, if conscious and adult, or by his/her attendant/ guardian, if unconscious or a minor. The study was conducted after approval from institutional ethical committee. There were 38 males and 7 females with ages 3-55 years (mean average age 27.1+_11.9 years). Their age, sex and region wise distribution has been shown in Table 1. All patients were evaluated clinically and then with the conventional plain radiographs e.g., PA view mandible, Waters view, Submentovertex view, Occlusal view, Orthopantomogram etc. according to the need, followed by non-contrast CT scan of the face. The CT examination was performed on the Siemens Somatom Balance (spiral rotating system) at settings of 130 kVp, 90 mA and scan time of 20s. The examination was performed in axial and coronal scans on a bone window basis. 5mm contiguous axial and coronal sections of the face were obtained and 3D reconstruction was performed on the axial images, using the threshold technique, at a threshold of +150 HU using a 512x512 matrix.

Cases were divided into three groups

1. Middle third facial skeleton fracture
2. Lower third (mandible) facial skeleton fracture.
3. Both middle third and lower third facial skeleton fracture.

In each case, the conventional radiographs and 3D CT images were analyzed under the headings of fracture sites detection, Extent of fractures and comminution and fragment displacement by same observer. The observer studied each case separately for fracture detection using a score [Table 2] and then gave an overall score for extent of fractures and comminution as well as for displacement for that case. The data for extent of fractures and comminution and fragment displacement were recorded using a scoring system (Table 3)[5]. The findings of the conventional radiographs and 3D CT were recorded on especially designed format and then studied, compared and reviewed. The results of the study for fracture sites detection were obtained using "Z test of proportion".

Table 1: Break up number, age, sex and region wise distribution of cases in maxillofacial trauma (N=45)

Cases	Middle third facial skeleton		Lower third facial skeleton		Both middle third and lower third facial skeleton	
	Age	Sex	Age	Sex	Age	Sex
1	40	M	07	F	20	M
2	25	M	23	M	23	M
3	46	M	27	M	21	F
4	40	M	19	M	17	M
5	30	M	25	M	17	M
6	38	M	45	M	40	M
7	19	M	07	F	21	M
8	22	M	13	F	18	M
9	24	M	30	F	30	M
10	22	M	55	M	25	M
11	30	M	18	M	45	M
12	37	M	26	M	45	M
13	30	M	06	F	25	M
14	-	-	30	M	25	M
15	-	-	40	M	50	M
16	-	-	03	F	22	M

Table 2: Score for fracture detection

0	**No fracture site detected**
1	**Fracture site/ sites detected**

Table 3: Comparative scoring system: 3D CT Vs conventional radiography [5].

Score	3D assessment
1	Inferior
2	Similar
3	Superior- similar information more rapidly assessed
4	**Superior- additional conceptual information provided**

Results

The cases were grouped into three different classes according to region of face involved (Table 4). Overall assessment of the result has been shown in Table 5.

Table 4: Distribution of injuries according to region of face (n=45)

Region of face	No. of patients
Isolated midface fracture	13
Isolated lower third of face (Mandible) fracture	16
Both midface and lower third of face fracture	**16**

Table 5: Fracture assessment (CONVENTIONAL RADIOGRAPHS Vs 3D CT)

Region of face involved	Total No. of fracture sites detected by both conventional radiographs and 3D CT	Total No. of fracture sites detected by conventional radiographs	Total No. of fracture sites detected by 3D CT	Result	% of patients with scores for extent of fractures and comminution	% of patients with scores for displacement
Both upper third and lower third facial skeleton	87	37	87	Z=8.4,p<0.001 (significant)	87.5%(4) 6.25%(3) 6.25%(2)	100%(4)
Middle third facial skeleton	49	22	49	Z=6.0, p<0.001 (significant)	92.4%(4) 7.6%(2)	92.4%(4) 7.6%(2)
Lower third facial skeleton (Mandible)	37	35	30	Z= 1.7 (not significant)	37.5%(4) 18.75%(3) 37.5%(2) 6.25%(1)	50%(4) 12.5%(3) 31.25%(2) 6.25%(1)
Total (n=45)	**173**	**94**	**166**	**Z=8.8,P<0.001 (significant)**	**71.1%(4) 8.9%(3) 17.78%(2) 2.22%(1)**	**80%(4) 4.45%(3) 13.33%(2) 2.22%(1)**

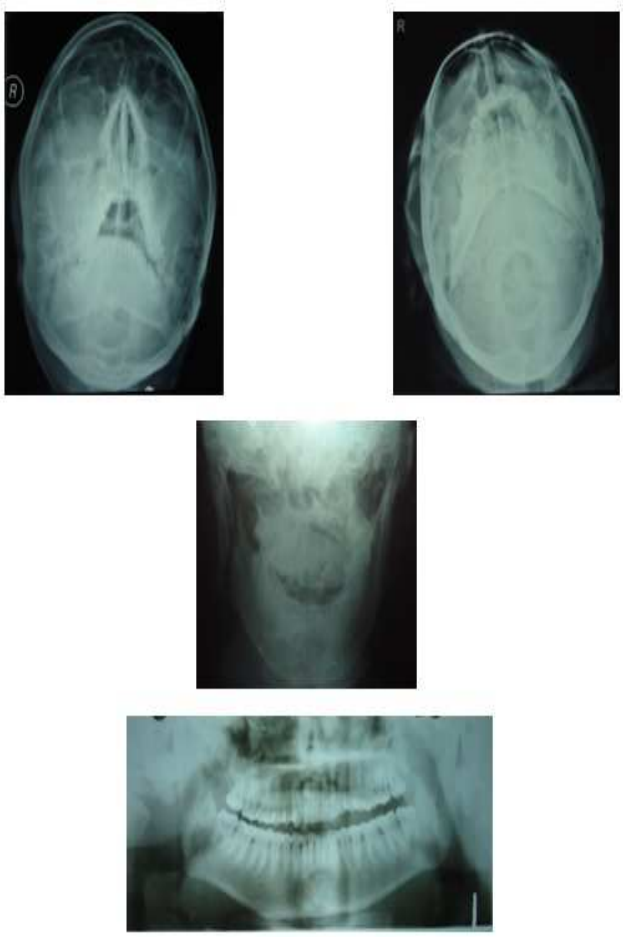

Fig.1: Conventional radiographs (Waters view, SMV view, PA view mandible and OPG) of patient 1 with fractures Lefort II, right zygomatic maxillary complex, and right ramus of mandible

Both midface and lower third facial skeleton fracture

Sixteen patients from the sample (15 males and 1 female, mean age of 27.7+_10.9 years) were having both midface and mandible fractures (fig.1, 2 &3). See Table 5.

Midface Fracture

Thirteen patients from the sample (all males, mean age 31.0+_8.5 years) were having exclusively midface fractures (fig.4 &5). See Table 5.

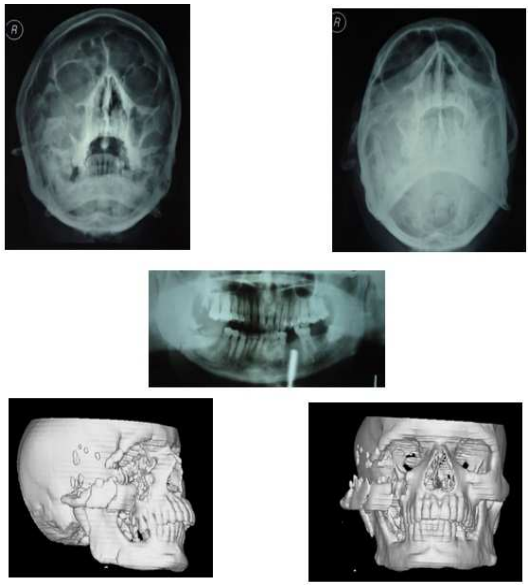

Fig.2: 3D CT images of the patient 1 showing comminuted fracture of right zygomatic maxillary complex, and Lefort II fracture. Fracture right ramus of mandible is also evident. Facture displacement is more clearly demarcated on 3D CT

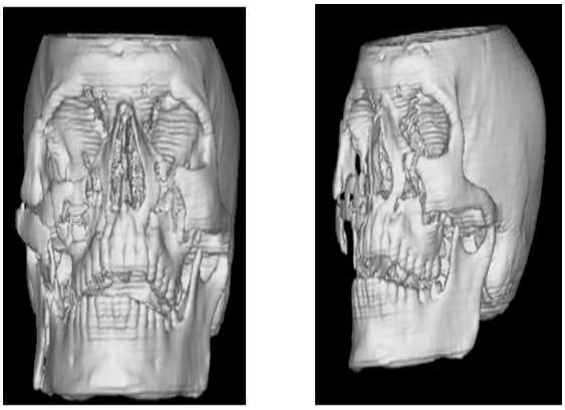

Fig.3: Radiographs (Waters view, SMV view and OPG) and 3D CT images of patient 2 showing comminuted fracture of right zygomatic maxillary complex and fracture right body of mandible. Degree of comminution, extent of fracture & displacement are much better appreciated on 3D CT

Fig.4: Waters view and SMV view of patient 3 showing right zygomatic maxillary complex fracture

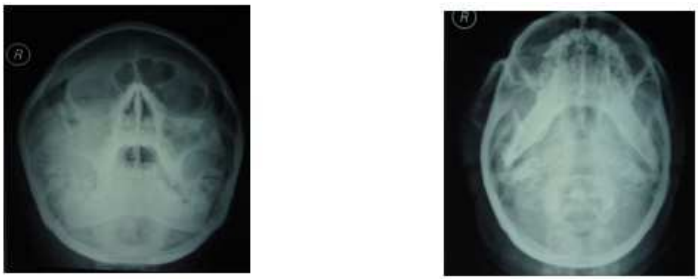

Fig.5: 3D CT images of patient 3 showing well demarcated fracture lines and displacement of right zygomatic maxillary complex

Lower Third Face (Mandible) Fracture

Sixteen patients from the sample (10 males and 6 females, mean age 23.4+_14.7 years) were having exclusively mandible fractures (fig.6 &7). See Table 5.

Fig.6: OPG and Occlusal view of patient 4 showing fracture of left body of mandible

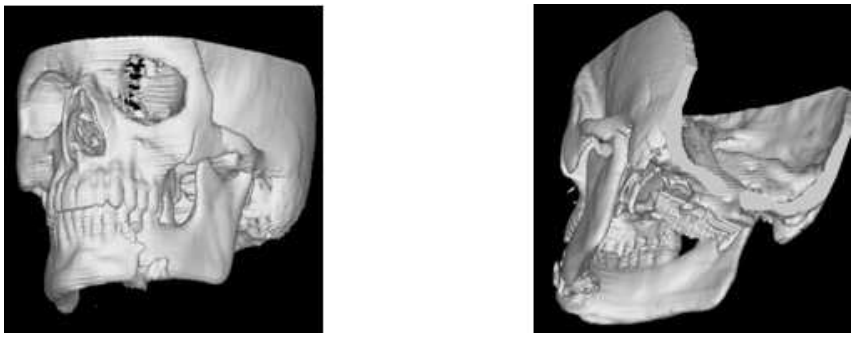

Fig.7: 3D CT images of patient 4. Fracture comminution, extent and displacement are more clearly visible in 3D images

Discussion

Along with thorough clinical examination, an accurate imaging of distorted or affected maxillofacial skeleton is necessary for proper anatomic reduction of fractured segments. Plain film radiography has limited value since it produces inadequate contrast between bone and soft tissue components and makes it difficult to detect all fractures which are present. CT has largely replaced these conventional plain radiographs. Development of three dimensional (3D) CT further facilitates diagnosis and treatment plan of facial injuries.

A number of authors have described the diagnostic efficacy of 3D CT in maxillofacial trauma [6,7,8,9].

The present study was undertaken to compare and evaluate the utility of plain radiographs and 3D CT in maxillofacial trauma patients and encouraging results have been obtained in our study.

In the 35.5% cases of isolated mandibular fractures 35 fracture sites were detected on conventional radiographs and 30 fracture sites were detected on 3D CT. No statistical difference was obtained between 3D CT and conventional radiographs for fracture detection of mandible. It means that for isolated fracture of mandible, conventional radiographs are equally useful as 3D CT for fracture site detection. Our study corroborates the observation by Gentry et-al [10] that mandibular fractures can be adequately diagnosed by using clinical examination and standard plain X- ray film including panorex. It was his impression that CT scanning was not required in this injury and our findings confirm that 3D CT does not detect more fracture sites than conventional radiographs.

Mayer *et al* [6] also found that an accurate diagnosis of fracture mandible was obtained without the aid of 3D CT.

However the result of our study found that in majority of patients with fracture mandible 3D CT is superior in displaying extent of fracture and comminution as well as displacement.

Costa *et al* also concluded that 3D imaging provided better visualization of the position and displacement of bone fragments, as well as the comminution of fractures[11].

In the 28.8% cases of isolated midface fractures, 49 fracture sites were detected on 3D CT and only 22 fracture sites were detected on conventional radiographs. When compared, 3D CT was found statistically more significant in terms of fracture sites detection compared to conventional radiographs.

We found that 3D CT was superior in displaying extent of fractures and comminution as well as fragment displacement and it provided additional conceptual information as compared to conventional radiographs. Out of 13 patients involving midface fractures, 92.4% patients scored 4 and 7.6% patients scored 2. Similar was the result in terms of assessment for displacement.

This is in accordance with a study done by Mayer *et al* [6] who found 3D CT to be accurate and precise in the display of fractures of the midface.

Alder *et al* [12] concluded that 3D images are of greatest benefit for the assessment of mid-face injuries. 35.5% patients were having both midface and lower third facial skeleton fractures. 87 fracture sites were detected on 3D CT and only 37 fracture sites were detected on conventional radiographs. When compared, 3D CT was found statistically more significant in terms of fracture sites detection compared to conventional radiographs.

Also 3D CT was superior in displaying extent of fractures and comminution as well as displacement and it provided additional conceptual information as

compared to conventional radiographs. In terms of extent of fractures and comminution detection, out of 16 patients 87.5% scored 4, 6.25% scored 3, 6.25% scored 2. In terms of displacement, 100% patients scored 4.

Overall out of total of 173 fracture sites as detected by both conventional radiographs and 3D CT in forty five patients, 94 fracture sites were detected on conventional radiographs and 166 fracture sites were detected on 3D CT. 3D CT was found statistically more significant ($Z= 8.8$, $p<0.001$) in terms of fracture sites detection as compared to conventional radiographs for patients having maxillofacial trauma.

In terms of extent of fractures and comminution detection, 71.1% patients scored 4, 8.9% patients scored 3, 17.78% patients scored 2 and 2.22% scored 1. In terms of displacement, 80% patients scored 4, 4.45% patients scored 3, 13.33% patients scored 2 and 2.22% scored 1. Thus in majority of the patients of maxillofacial trauma 3D CT was found superior in displaying extent of fractures and comminution as well as for displacement and it provided additional conceptual information as compared to conventional radiographs.

Gillespie *et al* [13] in their study found 3D to be of greatest value in patients with severe trauma and multiple fractures but less useful in minor trauma where there was no fragment displacement.

We found that many linear undisplaced fractures especially in case of midface (e.g. fracture of lateral and posterior antral wall, fracture of hard palate, medial orbital wall etc.) were not detected on 3D CT but was detected on axial or coronal images. This is due to the fact that 3D CT shows only the surface skeletal deformity, the internal anatomy (posterior antral region, pterygoid, nasal septum, sphenoid wings etc.) being hard to evaluate.

Gillespie *et al* and Mayer *et al* [6,13] found that overall 3D CT is inferior to conventional CT in terms of actual fracture detection, especially in the undisplaced linear fracture of orbits and malar complex regions.

Thus we conclude that although 2D axial and coronal CT images detect more fracture sites than 3D CT, overall 3D CT is more significant in terms of fracture sites detection compared to conventional radiographs. Our observations also indicate that 3D CT enable clinicians to better assess the localization of bone fragments and their direction of displacement.

We also found 3D CT to greatly enhance diagnostic speed and accuracy. The interpretation of 3D CT took less time than conventional radiographs. From the detailed information available with 3D CT, we were able to plan the exact placement of internal fixation devices, whether they are wires or plates. Since stabilization is generally applied along the facial pillars, 3D CT proved to be advantageous as it provided accurate preoperative localization of the fracture lines involving the major buttresses.

Since the degree of comminution is better appreciated on 3D CT, surgeons can anticipate preoperatively that standard internal fixation techniques may not be applicable and primary bone grafting or external fixation may be required.

Thus technical results are improved, efficiency is improved, and operating time is reduced. Patients will also benefit because anesthesia time will be reduced, and they can be more accurately and completely informed about the surgical procedure. The bottom line is that surgeons are no longer entering the operating room blind with only a non specific idea of where the fractures lie. They now can have a detailed three dimensional reconstruction of the injury to refer to and guide the surgical approach.

Reuben *et al* [14] reported that individuals at different levels of experience showed differential appreciation for the traumatic injuries illustrated by radiograph, 2D CT, and 3D reconstruction. Non radiologist viewers correctly diagnosed the fractures in 75.7% of 3D cases, 71.5% of radiographs, and 64.7% of conventional CT. Viewers showed a preference for 3D CT over conventional CT over radiograph in a survey conducted as a part of this study.

Thus we found 3D CT to be more useful in terms of fracture sites detection as compared to conventional radiographs especially in midface and complex maxillofacial trauma. Because plain radiographs in severe midface injuries did not offer sufficient information for either the diagnosis or surgical treatment planning, they are not indicated at all. However for isolated mandibular fracture conventional radiographs was found to be equally useful as 3D CT for fracture sites detection. Also 3D CT was found to be more valuable in detecting extent of fracture and comminution as well as fragment displacement in maxillofacial trauma either involving middle third or lower third of facial skeleton.

Conclusion

It is concluded from the results of the study that axial, coronal and 3D computerized tomography is of crucial importance to assess the extent of maxillofacial trauma. It should be preferred for all suspected comminuted and displaced fractures over plain radiographs. 3D computerized tomography should also be advised for comminuted fractures of the mandible. The technique also offers to choose the suitable fixation methods

during the surgery. It is not recommended for the diagnosis of minimally displaced fractures.

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