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Role of 3D-CT in Management of Maxillofacial Trauma

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Abstract **Original Research Article**

Introduction: Maxillofacial trauma usually presents in the Emergency Department (Casualty) as either an isolated injury or as a part of polytrauma. Due to the evolution of more effective emergency transportation facilities and advanced life support, even patients that are severely injured survive to reach specialized trauma centres which are increasing successful in rescuing patients. ***Objective:*** The purpose of our study was to describe the advantages of three-dimensional (3D) reconstructed images over axial images in the imaging of patients with facial fractures and to describe and compare the detection of fractures in the axial and coronal planes. ***Materials and Methods*:** The study population included 30 patients who underwent 3D-CT evaluation of facial bones when they presented with evidence of fracture of maxillofacial bones to the casualty and Department of Dentistry at Indian Institute of Medical Science and Research. Evaluates various fractures involving the facial bones that were detected in these patients. MDCT evaluation is done only on patients who satisfy the inclusion criteria and only after getting their consent. All the 3D-CT scans in this study were performed using 6-Slice CT scanner (Siemens Somatom Emot-6). 3D images were compared with axial images and assessed under the headings – fracture detection, extent of fracture and displacement. Coronal images were compared with axial images for detection of fractures. ***Results***: In this study group which comprised of a total number of 30 patients, the age at presentation ranged from <20 to >61 yrs. The NOE, Maxilla and Mandible was noted to be the most commonly involve bone with 23.3% of patients having a fracture in this bone. Zygomatic bone region was the next commonly affected region with fractures detected in 20% of patients. Frontal bone fractures were less common in the five regions of the face studied with 10% of patients detected to have fractures in that region. ***Conclusion:*** The advantages of 3D images in the assessment of facial trauma could be described especially in mandible and zygomatic bone. The easier detection of fractures in the frontal and maxillary bones as well as their displacement in patients with complex mid facial fractures could be described. The coronal reconstructed images were superior in the detection of fractures in the orbit and maxilla. 3D images have a limited role in fractures involving the naso-orbito-ethmoid region and also when there is minimal fracture displacement.

Keywords: Facial Injury; MDCT; Trauma.

INTRODUCTION

Maxillofacial trauma usually presents in the Emergency Department (Casualty) as either an isolated injury or as a part of poly-trauma. Such injuries are clinically important as the disruption of soft tissues and bones of the face causing facial disfigurement and asymmetry which may cause Functional, cosmetic as well as emotional concerns [1]. Their incidence ranges from 20% to over 50% of cases admitted to Traumatic Emergency Room. The most frequent causes of these Maxillofacial Trauma include Road Traffic Injuries (up to 80% of cases), use of a direct force, mostly during an assault, Interpersonal violence (up to 60% of cases), falls (up to 25% of cases), and accidents during sports (up to 10% of cases) [2]. Imaging examination is an essential component of diagnosis and treatment planning for the management of traumatic patients.

However Modern imaging modalities, especially 3-D images permit a direct view of anatomic relationships, enhanced by the ability to observe images from any angle-with operator control of image rotation and magnification [3]. 3-Dimensional CT, have been shown to be of value in the assessment and management of acute facial trauma [4]. 3-Dimensional images provide a global view of the face, superior in localization of complex fractures involving multiple planes, in perception of fracture displacement and in the assessment of facial symmetry, Surgeons frequently need to make their own evaluation of the degree of skeletal disruption revealed by imaging studies when

planning initial treatment of facial fractures [5]. As experienced radiologists use axial images in the interpretation of facial trauma, the utility of reconstructed images in cases of complex facial trauma may be assessed in detail [6].

In addition, over the past few years, we have witnessed significant advances in 3-D imaging. The denser and larger the bony structure, the more optimal is its 3-D reconstruction [7]. In the reconstruction of the maxillofacial/calvarial skeleton the larger bones are well displayed, but the smaller and thinner bones- orbit, cribriform plate, ethmoid, maxilla-are less accurately reconstructed [8]. The pathologic diagnosis is usually made on the two-dimensional images, while reconstruction of the information into a 3- D image improves the display of the fracture site, extent of fracture, the presence and extent of step-off and the extent of fracture-fragment rotation [9].

The role of 3-D imaging for facial injury is not primarily diagnostic. Two-dimensional images usually provide the basic diagnosis, but 3-D re-constructions enhance perception of pathology and enable precise planning for therapy. The future objective for 3-D imaging should aim to expand the direct application of imaging data to patient management, such as the intraoperative use of 3-D data to actively guide surgical repair of facial injuries and craniofacial anomalies.

Aim and Objective

To evaluate the patients with facial injuries and fractures with multidetector CT (MDCT).

To describe the advantages of three-dimensional (3D) reconstructed images over axial images in the imaging of patients with facial fractures.

To describe and compare the detection of fractures in the axial and coronal planes.

MATERIALS AND METHODS

Source of Data

The prospective study population included 30 patients who underwent CT evaluation of facial bones when they presented with evidence of fracture of maxillofacial bones to the casualty and Department of Dentistry at Indian Institute of Medical Science and Research, from February 2017-December 2018.

Inclusion Criteria

- Patients with CT evidence of fracture of the maxillofacial bones.
- Patients of all age group & both sexes are included.

Exclusion Criteria

- Patients without any evidence of fracture of the maxillofacial bones
- Patients with maxillofacial fractures in whom a CT examination is contraindicated Pregnancy (1sttrimester) etc.

Data Acquisition MDCT evaluation is done only on patients who satisfy the inclusion criteria and only after getting their consent. Their age, sex and region wise distribution were taken. All the CT scans in this study were performed using 6-Slice CT scanner (Siemens Somatom Emot-6).

CT Protocol consisted of the following:

- Non-contrast axial 6-Slice helical series.
- Beam collimation: 2-3 mm
- Detector configuration 6 x 0.63
- Pitch 1.2
- Tube current 220mAs
- Voltage 120KV

Total exposure time 18 sec Along with the axial images, Coronal-plane multi-planar reformation (MPR) images were reconstructed with 1.5mm increment. Three-dimensional volume-rendering images were also obtained. The MDCT scans were reviewed using clinical workstation. The fractures detected on CT examination were classified according to the region involved. 3D images were compared with axial images and assessed under the headings – fracture detection, extent of fracture and displacement. Coronal images were compared with axial images for detection of fractures.

These were assessed in 5 regions

- Frontal bone fractures
- Zygomatic bone fractures
- Nasoorbito ethmoid (NOE)fractures
- Maxillary fractures
- Mandibular fractures

RESULTS

In this study 30 patients with history of trauma and suspected to have maxillofacial trauma underwent 3-D CT scan. The Images obtained by axial, coronal & 3D reformation was studied and evaluated in terms of detection, displacement & extent of fracture.

Age distribution

In this study group which comprised of a total number of 30 patients, the age at presentation ranged from less than 20 to more than 61 years. More number Patients belonged to the 41-60years and least age groups < 20 years with 11 and 2 patients respectively [Table 1].

Table-1: Distribution of Age

Age group	No. of patients	Percentage (%)
<20	2	6.6
21-40	9	30
41-60	11	36.6
>61	8	26.6
Total	30	100

Table-2: Distribution of gender

Gender	No. of patients	Percentage (%)
Male	23	76.66
Female	7	23.34
Total	30	100

Table-3: Distribution of different modes of injury

Mode of injury	No. of patients	Percentage (%)
Road traffic accidents	23	76.66
Fall from height	5	16.66
Assault	2	6.66
Total	30	100

Sex distribution

There were 23 males (76.6%) and 7 females (23.3%) in the patients included in the study group [Table 2].

Mode of injury

The most common mode of injury in patients presented with maxillofacial trauma was road traffic accidents, comprising 76.66% of cases followed by fall from height and assault were the other causes, comprising of 13 and 6% respectively [Table 3].

Frontal Bone Fractures

Frontal bone fracture detection and displacements were seen better on 3D images in more percentage of patients. However, their extensions, especially into the posterior wall of sinus or roof of orbit were not adequately visualized on the 3D images.

Coronal images were found to be similar to axial images in the detection of fractures in frontal bones.

Zygomatic Bone Fractures

3D images were found to be similar or better for the detection and description of the extent in most patients with zygomatic bone fractures. In the assessment of displacement, it was found to be superior to axial images in most patients. Coronal images were similar to axial images in the detection of zygomatic bone fractures.

NOE Fractures

The 3D images were found to be inferior in the assessment of detection, extent and displacement of fractures in the naso-orbito-ethmoid region when compared with axial images in most patients.

Coronal images were superior to axial images in the detection of fractures in the region especially in the floor and medial wall of orbit.

Fractures in Maxilla

3D images were superior in the detection of fractures in the maxilla especially with involvement of anterior wall of the sinus. However, the extent of involvement and its displacement were better seen on axial images.

Coronal images were similar or better than axial images in the detection of fractures in maxilla of most patients.

Fractures in Mandible

The detection and extent of involvement assessed by 3D and axial images were similar in most patients with mandibular fractures. However, there was a definite advantage in assessment of displacement of fracture fragments with the use of 3D images.

Coronal images were similar to axial images in the detection of mandibular fractures.

Scoring system

The data for extent of fractures and comminution and fragment displacement were recorded using a scoring system [Table 5]. The findings of the Conventional CT and 3D CT were recorded on especially designed format and then studied, compared and reviewed.

Table-4: Distribution of fractures in different bones

Types of bones	Occurrence of fractures	Percentage (%)
Frontal bone fractures	3	10
Zygomatic bone fractures	6	20
NOE fractures	7	23.33
Fractures in Maxilla	7	23.33
Fractures in Mandible	7	23.33
Total	30	100

Table-5: Comparative scoring system: 3D CT Vs conventional CT

Score	3D assessment
A	Inferior
B	Similar
C	Superior- Similar information more rapidly assessed
D	Superior-additional conceptual information provided

Table-7: Frontal fracture

Frontal fracture	No. of fractures (8)	Percentage
Frontal sinus collection	2	25
Frontal sinus involvement	3	37.5
Comminuted	2	25
Displaced	-	-
Depressed	1	12.5
Linear	-	-

Table-8: Zygomatic fracture

Zygomatic fracture	No. of fractures (10)	Percentage
Diastasis of adjacent suture	2	20
Bilateral	1	10
Displaced	2	20
Segmental	1	10
Tripod	1	10
Body	1	10
Arch	2	20

Table-9: NOE fracture

NOE fracture	No. of fractures (25)	Percentage
Lamina papyrecea	3	12
Orbital Rim	2	8
Lateral wall	6	24
Medial wall	7	28
Floor	3	12
Roof	3	12
Isolated orbital fracture	1	4

Table-10: Maxillary fracture

Maxillary fracture	No. of fractures (25)	Percentage
Herniation of infratemporal fat	1	4
Herniation of orbital fat	2	8
Hard palate	1	4
Hemosinus	4	16
Roof	1	4
Lateral wall	5	20
Medial wall	2	8
Posterior wall	3	12
Anterior wall	4	16
Bilateral Maxilla fractures	2	8

Table-11: Mandibular fracture

Mandibular fracture	No. of fractures (16)	Percentage
Body	2	12.5
Condyle	4	25
Ramus	-	-
Coronoid	-	-
Alveolar Ridge	4	25
Parasymphyseal	4	25
Symphyseal	2	12.5

DISCUSSION

The human face is an individual aesthetic identification. Loss of facial aesthetics due to facial fractures are more common today with increasing RTAs. One of the important factors determining the success of treatment of facial fractures is early and correct diagnosis [10]. MDCT is the imaging modality of choice to display the multiplicity of fragments, the degree of rotation and displacement, or any skull base involvement supported by the study conducted by Wang *et al*. and Moustafa*et al*. [11].

This study demonstrates that surgical viewers to find 3D reconstruction from routine CT data is useful in visualizing bone fragments from all angles and planes and also in the ready assessment of the mechanism of the injury [12]. 3D reformatted images to be greatest clarity and easiest to interpret the available imaging modalities in facial trauma. 3D imaging is often preferred by surgeons because it simulates a surgeon's process of visualizing fractures in operative planning and also has helped a lot in patient and family education.

A total of thirty patients under the all age group who presented with a history of injury to the maxillofacial region, who were subsequently found to have fractures involving the facial bones were included in this study. A 16-slice CT scanner was used for the axial imaging of the maxillofacial region.

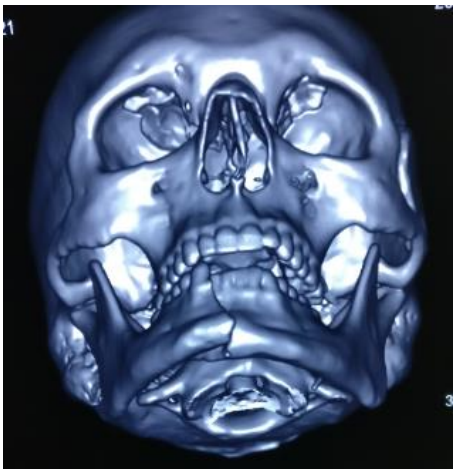

Fig-1: 3-D CT showing Fracture of Mandible

Fig-2: 3-D CT showing Fracture of Mandible and maxilla

Fig-3: 3-D CT showing Fracture of Multiple Fracture of Mandible

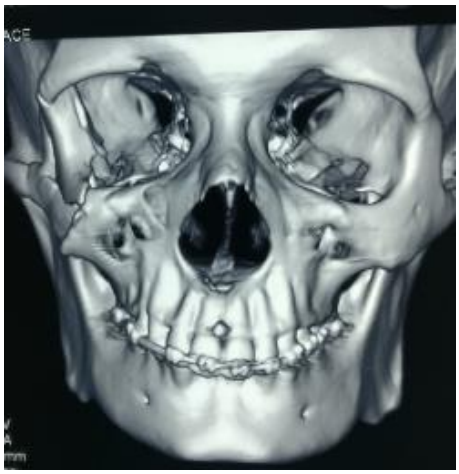

Fig-4: 3-D CT showing Fracture of Multiple Zygoma and Ethmoid-Orbit

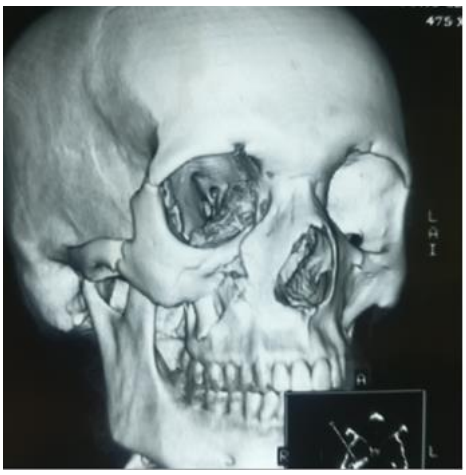

Fig-5: 3-D CT showing Fracture of Maxilla and Zygoma

In this study, the maxillofacial injuries were most common in 41-60 years and followed by 21-40 years age group accounting for 36% and 30% of total cases respectively. The injuries were found to be overwhelmingly common in male population (77 % of cases) compared to females (23%) similar study in that male predominance of facial trauma was noted consistent with the study conducted by Kaur J [13].

In our study RTA accounted for majority of cases of maxillofacial injuries was RTA comprising 76% of cases followed by fall from height and with other causes being physical assault, 16% and 6% respectively. The location of the hospital midway along

the highway of the state could explain for increased number of RTA cases presenting to the hospital. These results are in the study is consistent with the popular studies [14]. Although the frequent mode of facial injuries in developing countries in studies by Adekeye *et al*. Bochlogyros et al. and Haug *et al*. was road traffic accidents [15-17]. On the other hand, various results in developed countries, high incidence of assault as the commonest cause of maxillofacial injury. Because of social, cultural, and environmental factors the causes of maxillofacial fractures vary [18].

The most common site of fracture in decreasing order were that of the mandible, maxilla, NOE (23.3%) followed by zygomatic bone and frontal (20% and 13.3%) respectively. Obuekewe *et al*. found that road traffic accidents were responsible for most zygomatic complex fractures [19]. In a meta-analysis of maxillofacial trauma by Ravindran *et al*. the most prevalent midface injury was in the zygomatic region (209, 36.4%), followed by orbital (102, 17.8%) and others [20].

In the assessment of frontal bone fracture, detection and displacements were seen well on 3D images in more percentage of patients. 3D images were found to be similar for the detection and description of extent in most patients with zygomatic bone fractures. In the assessment of displacement, it was found to be superior to axial images in most patients. Nisha *et al*. evaluated mid facial fractures in 100 patients using 3D CT [21]. It was shown that 3D reconstruction helped in preoperative analysis and surgical planning. It was valuable in case of severe facial injury enabling a clear perception of extent of major fracture lines and resulting displacement of fragments [22].

Whereas, frontal bone fracture was least in our study. The most commonly affected Frontal sinus involvement (37.5%) followed by frontal sinus collection and comminuted was (25%). Least commonly affected was depressed (12.5%). Linear and displaced were not affected region. These results support with the studies conducted by salonen *et al*, the identification of frontal bone fractures by helical computed tomography [23].

In zygomatic bone fracture, the most common site of fracture in decreasing order were that of the zygomatic arch, diastasis of adjacent suture and displaced were 20%, followed by bilateral, segmental, tripod, body were less commonly affected region 10%. Verma *et al*. found that road traffic accidents was responsible for most zygomatic complex fractures [24].

In present study, NOE bone fracture was present in 23.3% of cases. RTA was the mode of injury. Medial wall was the most common fracture (28%) followed by Lateral wall (24%). Floor, roof, lamina papyrecea accounted for 12%. This occurs due to force of impact transmitted by the orbital rim to the orbital floor causing it to shatter usually in the middle third portion. The inferior orbital and eyeball usually remains undamaged. The presence of an air-fluid level or the fracture of the maxillary sinus is common. According to TANRIKULU and EROL, axial and coronal CT images are adequate for diagnosis of medial orbital wall fractures, and they confirmed the superiority of coronal CT in the diagnosis of fractures of the orbital floor and blow-out fractures, especially in those patients who may develop diplopia or exophthalmos [25].

Maxillary fractures were seen in 7 patients with the most commonly affected region being lateral wall of the maxilla (20%). Anterior wall and hemosinus was the next common affected region (16%) followed by Posterior wall in the region of maxilla (12%). Whereas, bilateral maxilla fracture, medial wall, herniation of orbital fat was 8%. Hard palate and roof were least commonly affected sites (4%). In the assessment of the detection, extent, and the displacement of the maxillary bone fractures, 3D rendered images were found to be superior to the axial images. In the detection of maxillary bone fractures, coronal images provided similar information as the axial images in of most patients.

Mandibular fractures were classified into body, condyle, ramus, coronoid process, alveolar ridge, parasymphyseal, symphyseal. The percentage of multiple mandibular fractures of condyle, alveolar ridge, parasymphyseal (25%), Symphyseal and body least affected (12.5%). Ogura *et al*. characterized the locations of different mandibular fractures using MDCT. The percentage of multiple mandibular fractures was 80.9% median type, 74.3% paramedian type, 52.9% angle type and 60.9% condylar type. The data showed a significant relationship between multiple fractures and the median type, paramedian type and condylar type in decreasing order [26].

Many studies have noted that 3D reconstructed images are helpful in the evaluation of fracture comminution, displaced components, and complex fractures involving multiple planes. The extent of comminuted fractures is better demonstrated on the 3D-CT, where the size, shape, and displacement of individual fragments are clearly revealed [27]. The combination of multislice CT and 3D volume rendering technique allowed several improvements in imaging interpretation. Absence of free paranasal sinus fluid (clear sinus sign) in facial CT is a highly reliable criterion for excluding fractures involving the paranasal sinus walls. [28]

CONCLUSION

This study demonstrated the valuable role of 3D CT in the evaluation of maxillofacial fractures. The advantages of CT and 3D images include assessment of accuracy and extension of fracture in the maxillofacial

region. The easier detection of frontal and maxillary bones as well as their displacement in patients with complex midface fractures could be described. The coronal reconstructed images are superior in the detection of fractures in the orbit and maxilla. 3D images have a limited role in fracture involving the naso-orbital, naso-ethamoid region and also when there is minimal fracture displacement. We can appreciate soft tissue injuries in provided soft tissue window in CT scan. Though CT is time consuming technique, it become superior or higher radiological investigation for better treatment outcome, as we can't justify the accuracy and extensions, of fractures in midface region using conventional radiography technique.

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