ORIGINAL RESEARCH ARTICLE

Role of MDCT with Multiplanar and 3-D Reconstruction in Evaluation of Maxillofacial Fractures

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ABSTRACT

Introduction: Maxillofacial injuries are one of the most frequently encountered cases in the Emergency Department as isolated injury or as part of polytrauma. The face area is one of the anatomically complex regions of the human body. So fracture morphology is usually complex. CT is the imaging modality of choice for the presentation of the multiplicity of fragments, the degree of dislocation. The study was aimed to describe and classify the maxillofacial fractures, compare the maxillofacial fractures using multi planar reconstruction and to describe the advantages of using 3D reconstructed images over 2D images in patients with facial fractures.

Material and methods: A descriptive, cross sectional hospital-based study of 500 patients who had positive MDCT findings of maxillo facial fractures, was done at department of Radiology in the tertiary care hospital attached to Mysore Medical College and Research Institute, Mysore, India for duration of 1 year from May 2019 to May 2020. The results were tabulated and presented in figures, tables, frequency graphs and pie charts.

Results: Of the 500 cases, males constituted 398 cases and the rest were females. Most common age group was between 21-40 years. Nasal bone fractures were most prevalent followed by naso-orbito-ethmoid and maxillary sinus wall fractures. In detecting fractures, 3-dimensional and multiplanar reconstructed CT scan images provide questionable merit.

Conclusion: MDCT is the investigation of choice in the evaluation of patients with maxillofacial trauma. 3D and multiplanar images are useful, although variable for different bones, in the assessment of complex fractures involving the face.

Keywords: Post Processing Techniques; Multiplanar Images; Volume Rendered Images (VRT); Le Fort Fractures

INTRODUCTION

Maxillofacial injuries are one of the most frequently encountered cases in the Emergency Department as isolated injury or as part of polytrauma. Owing to the increase in road traffic injuries, a significant uptick in the occurrence of facial fractures has been reported.[1] Maxillofacial injuries occur quite commonly following trauma and these injuries if not properly managed can negatively influence aesthetic, functional and psychosocial activities of the patient.[2] Due to the evolution of more effective transportation and advanced life support, even more severely injured patients survive to reach specialized trauma clinics which are increasingly successful in rescuing patients.

The face area is one of the anatomically complex regions of the human body. So fracture morphology is often complex. Five distinct anatomic regions can be organized in the face: nasal, orbital, zygomatic, maxillary and mandibular. Face injuries may be classified as those associated with a single region; different regions; or several contiguous regions.[3]

Various radiographic methods have been used for diagnosing maxillofacial trauma. Panoramic tomography is widely used for the screening of orofacial trauma as well as other diseases.[4] However, despite a higher radiation dosage compared to radiography, in craniomaxillofacial injuries, CT is the imaging choice to display the multiplicity of technique of fragments, the rotation and dislocation degree, or any skull base involvement.[5] 3-D reconstruction and multiplanar reformation in coronal and sagittal planes are the added benefit of MDCT, which are extremely helpful in evaluating the bony architecture in large comminuted, displaced and complex fractures involving multiple planes, allowing the surgeons to plan and treat appropriately.[6]

Study objectives were to describe and classify the maxillofacial fractures, to describe the importance of multiplanar reconstruction in the accuracy of detection of maxillofacial fractures and to describe the advantages of using 3D reconstructed images over 2D images in patients with facial fractures.

MATERIAL AND METHODS

This is a descriptive, cross sectional hospital-based study conducted from May 2019 to May 2020 in the department of Radiology, Krishna Rajendra Hospital, Mysore. Total 620 patients who had history of trauma and suspected maxillofacial injury, were referred to our department in this study period, but among them only 500 patients had positive MDCT findings of maxilla facial fracture and rest 120 patients had no fracture. The study was done using 128 SLICE DUAL ENERGY SEIMENS SOMATOM DEFENITION EDGE helical CT scanner.

Institute Ethics Committee approval was obtained (EC REG: ECR/134/Inst/KA/2013/RR-19).

Inclusion criteria

1. Patients with clinical confirmation of maxillofacial injuries who undergo multislice CT examination and are shown to be positive for fractures.
2. Patients of all age group and both sexes.

Exclusion criteria

1. Unstable patients who need emergency management.
2. Pregnant patients with maxillofacial injuries.
3. Patients having past history of surgical interventions in maxillofacial region.

Patients who met the criteria for inclusion were subjected to MDCT evaluation and the Face protocol was selected. With the patient in supine position, scan was performed and axial slices were taken at 0.625 mm collimation with field of view extending from the top of the frontal sinuses to the chin. The supine axial slices were taken for fast acquisition and comfort to the patient in standard bone window 1500/450 (WW/WL) and soft tissue window 130/70 (WW/WL). Intravenous iodinated contrast media was not used in our study.

The axial 1-mm reconstructed images were transferred to syngovia workstation where it was analysed using various post processing techniques:

1. Axial Multiplanar reconstruction (MPR) in coronal and sagittal plane for examination.
2. Volume-rendering technique (VRT).

The images were reviewed for the following items: (1) Presence of facial fractures (2) the extent of fractures and (3) evaluation of the related soft tissues.

In our study, facial fractures were categorized as follows: frontal bone fractures, nasal bone fractures, orbital fractures, naso-orbito-ethmoid fractures (NOE), isolated zygomatic arch fractures, zygomatio-malar complex (ZMC) fractures, maxillary sinus wall fractures, LeFort I (LF I), LeFort II (LF II) and LeFort III (LF III) fractures, mandibular fractures, skull base fractures, and other fractures.

The frontal bone fractures were classified into five subgroups according to Manolidis[7]: type 1 (anterior wall fracture, minimal comminution), type 2 (anterior wall fracture, comminution), type 3 (anterior and posterior wall fracture), type 4 (anterior and posterior wall with dural injury and cerebrospinal fluid leak), and type 5 (as type 4 with additional soft tissue or bone loss or severe disruption of the anterior cranial fossa).

The mandibular fractures were classified based on AOCMF Classification System as fractures involving symphysis, parasymphysis, body, angle, ramus, coronoid process and condylar process.[8]

STATISTICAL ANALYSIS

The results of the study were tabulated and evaluated descriptively by Microsoft excel 2016. Also the results were presented in figures, tables, frequency graphs and pie charts.

RESULTS

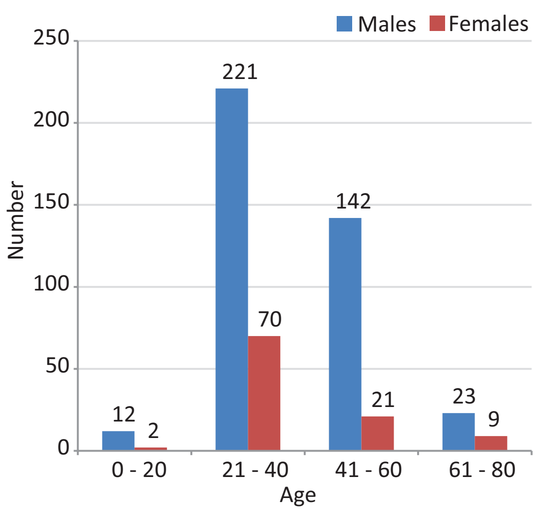
A total of 500 subjects of maxillofacial trauma patients were included in the present study. The maximum number of trauma patients fall into 21-40 years age group whereas minimal number were from below 20 years age group as shown in table/Figure 1.

Multiple fractures were commonly seen [Table/Figure 2-4]. Nasal bone fractures (13.76%) were most prevalent followed by naso-orbito-ethmoid (12.49%) and maxillary sinus wall fractures (11.61%). The least affected bone was mandible in our study accounting for 2.71%.

A total of 20 percent of the Le- Fort fractures (I, II & III) are found in our study in which most common was Lefort I. 98 patients had mandibular fractures, among them most common was condylar (fig 1) which constitute 39% followed by body fractures. Isolated symphyseal fracture was seen in 6 patients among the total (Table/figure 5).

Out of 194 patients having frontal bone fractures, 50% was type 2. Type 3 fracture was seen in 53 patients amounting for 27%. Least common type of frontal fracture was type 5 which was seen in only 2 patients. (Table /Figure 6).

With every patient in this study having MDCT examination of the face we have axial and multiplanar reconstructed images as well as 3-D images.We found that for every type of complex fractures there was a specific scan that was the clue of the case. The importance of each plane in the accuracy of detection of maxillo-facial fractures is tabulated in table/figure 7.

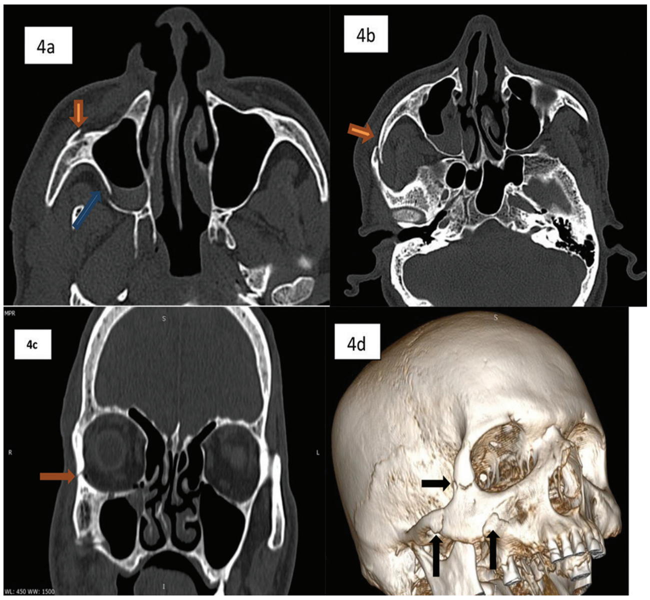


Table/Figure-1: Age distribution of patients.

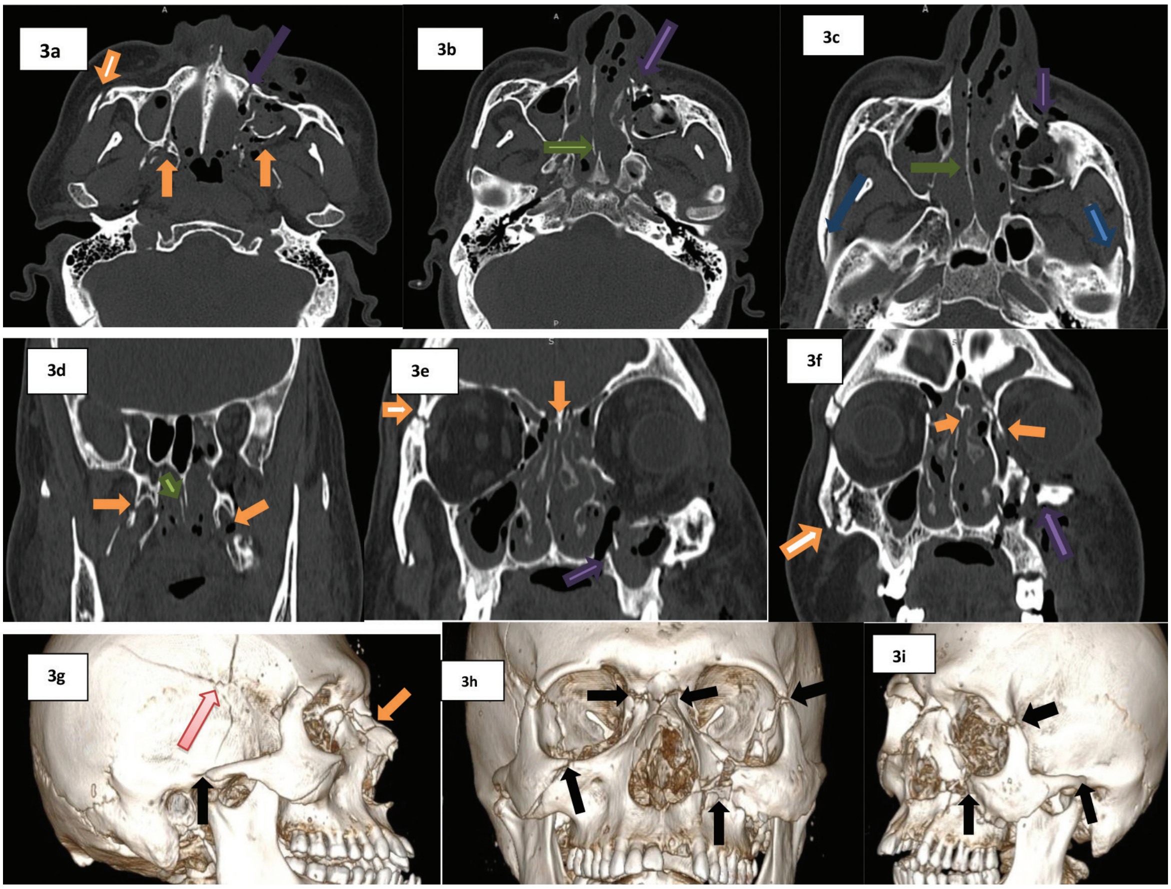
3-D reconstructed CT scan images are having questionable value in detecting fractures when compared with 2-dimensional (2D) images.3D images of frontal, naso-orbito-ethmoidal complex, zygomalar complex, maxillary and mandibular fractures were assessed to describe the

	Number	Percentage
Nasal	498	13.76
Orbital	300	8.29
Skull base	178	4.93
Maxillary sinus wall fractures	420	11.61
Mandible	98	2.71
Zygo - malar complex	356	9.84
Le Fort I	330	9.12
Le Fort II	220	6.09
Le Fort III	165	4.56
Fontal Bone	194	5.36
Naso-orbito-ethmoid	452	12.49
Zygomatic arch	340	9.42
Other fractures	66	1.82
Total	3617	100

Table/Figure2: Frequency wise distribution of maxillofacial fractures.



Table/Figure-4: Zygomatico maxillary complex fracture - Right Tripod fracture: Axial (a & b) and coronal (c) images show fracture of anterior wall of right maxillary sinus (a), right zygomatic arch (b) and right lateral orbital wall (c). Associated posterolateral wall of right maxillary sinus (a) is seen. VRT (d) image shows right tripod fracture



Table/Figure-3: Bilateral Le Fort III and left Le Fort I fracture: Axial (a - c) and coronal (d - f)images showing left pterygomaxillary disjunction/ Le Fort I fracture (violet arrows), fronto-nasal disjunction (e & f), bilateral zygomatic arch fracture (a & c), bilateral lateral wall of orbit fracture (e & i), bilateral lamina papyracea fracture (e & f) and nasal septal fracture (green arrow). VRT images show bilateral Le Fort III fracture (h) and left Le Fort I fracture (h & i), bilateral Le Fort III fracture. Associated comminuted fracture of right temporal bone with extension of fracture line into parietal bones can be seen in VRT image (g)

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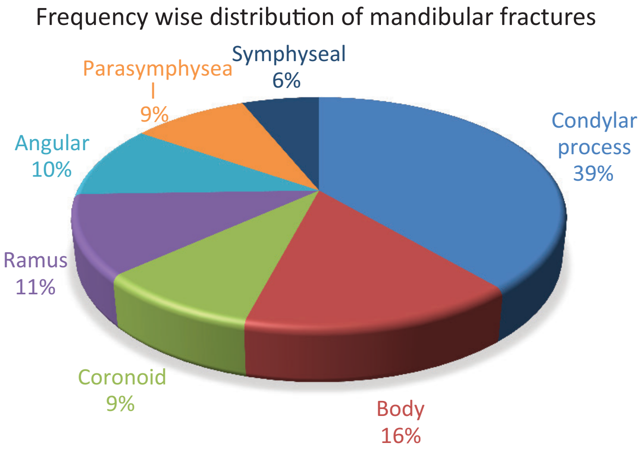
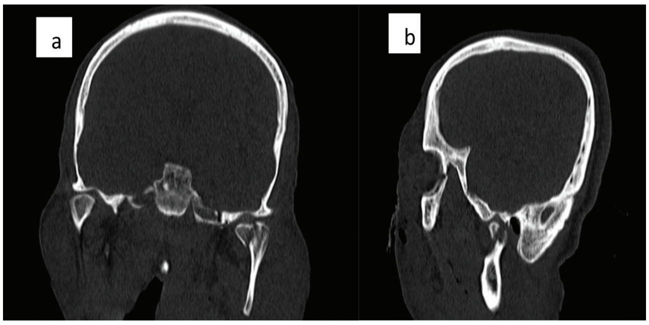




Table/Figure-5: Coronal (a) and sagittal (b) reformatted images showing condylar fracture of mandible on left side

Fracture type	Number of fractures(n=194)	%
Type 1	29	14.94
Type 2	98	50.52
Type 3	53	27.32
Type 4	12	6.18
Type 5	2	1.04

Table/Figure 6: Frequency wise distribution of frontal bone fractures

advantages in detection, extent and displacement of fractures. We found that 3D reconstructed CT scans were interpreted more rapidly and more accurately by clinicians. All except in assessment of nasoorbitoethmoid fractures 3D images were superior to 2D images. (Table/figure 8)

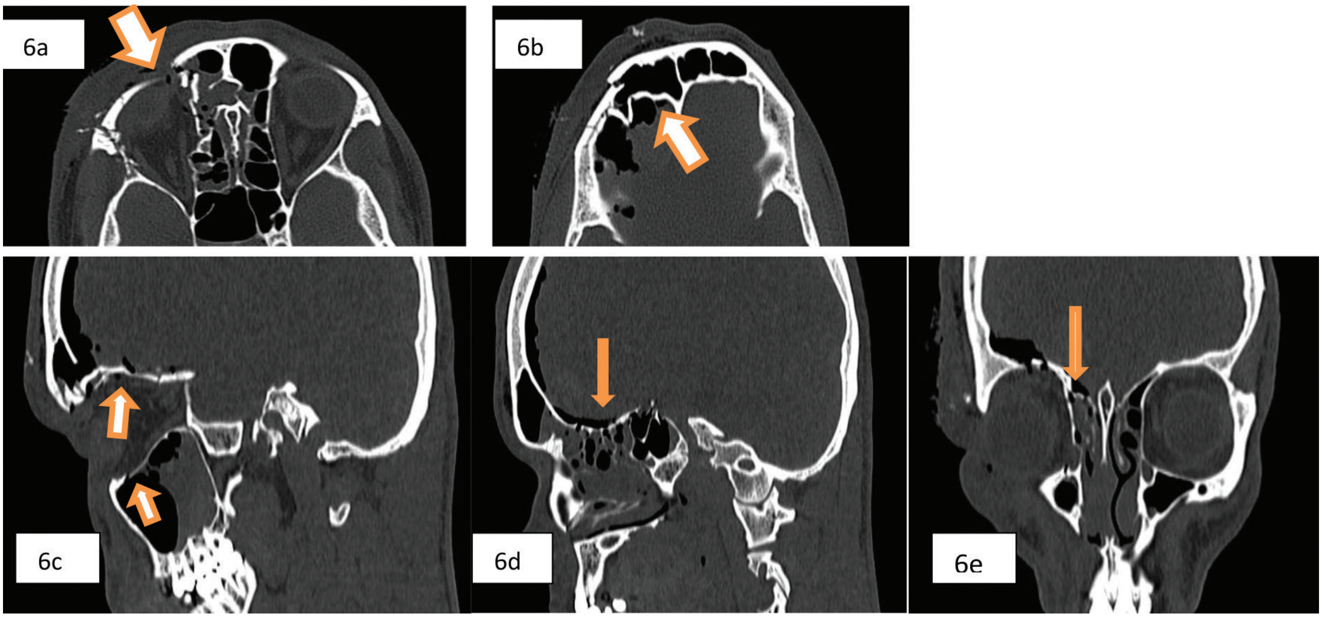
DISCUSSION

Maxillofacial trauma can occur as isolated injuries or part of polytrauma. These are clinically important as the disruption of soft tissues and bones of the face cause facial disfigurement which causes emotional and cosmetic concerns. The facial region is also associated with several important functions of daily living.[8]

Multi slice CT is a significant advance in the technology of X ray CT, and the latest technological advance in CT imaging, resulting in the opportunity to greatly increase the speed of the data acquisition and reconstruction.[9] It has been demonstrated that multi slice CT can obtain a greater range of anatomic coverage during the scan.[10,11] The continuous data acquisition and archiving occurs as the entire volume of interest is scanned. Consequently, it is possible to scan rapidly a large volume of interest with high image quality, thin sections, and a low artifact rating in short time, thereby dramatically reducing respiratory motion problems.[12,13]

This study included 500 patients who had a history of maxillofacial injury and was found to have fractures involving the facial bones. A study conducted by Flohr et al[14] had mentioned that facial injuries are predominantly an affliction of young men.[14] Similarly, in our study 79.6% of all patients were males and among them 58.5% of them were less than 40 years. This high incidence rates in young males can be attributed to their deliberate risk taking and carelessness.[15]

The most common isolated bone fracture was found to be the nasal bone fracture in our study. The same result was found in



Table/Figure-6: Type 4 frontal fracture: Axial images (a& b) showing type 4 frontal bone fracture on right side and right orbital wall fractures. Sagittal images (c & d) clearly depicts base of skull and floor of orbit fractures. Coronal image (e) depicts right cribriform plate fracture.

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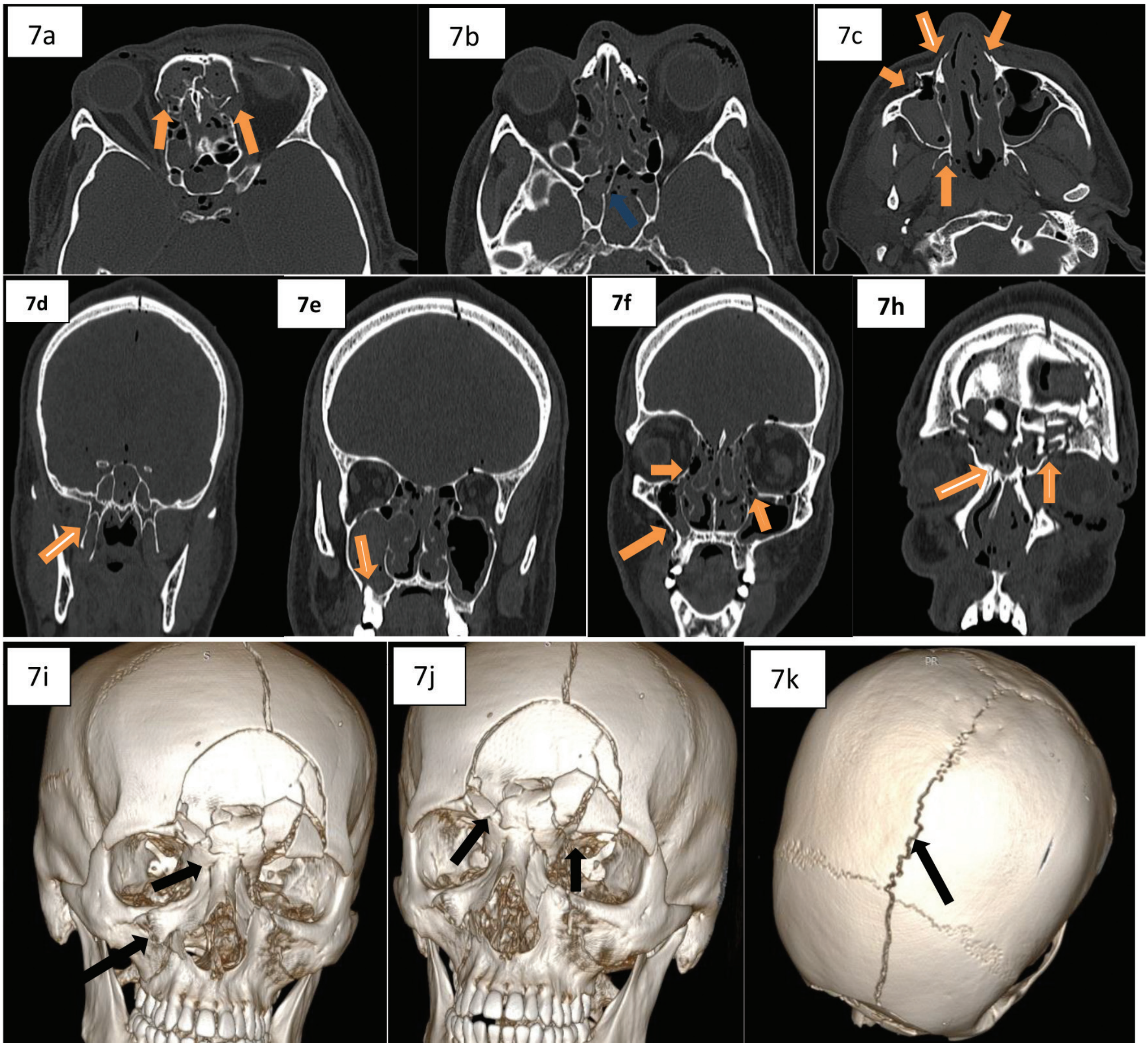
Axial section	Coronal section	Sagittal section	VRT images
-Body of mandible -Postero-lateral wall of maxillary sinus -Pterygoid plates -Dento-alveolar segments -Zygomatic arch -Lateral wall of the orbit -Anterior and posterior walls of the frontal sinus (Fig 6b)	-Le Fort fractures (fig 7d – 7h & fig 63e - 3h) -Cribriform plate (Fig 6e) Infra orbital rim (Fig 8d) -Naso-frontal recess -Lamina papyracea -Medial wall of maxillary sinus -Ramus and body of mandible -Tripod fractures	-Base of skull -The roof and floor of the orbits (Fig 6c & 6d) -Assessment of nasal fractures & degree of displacement	For accurate detection of extension of fractures.

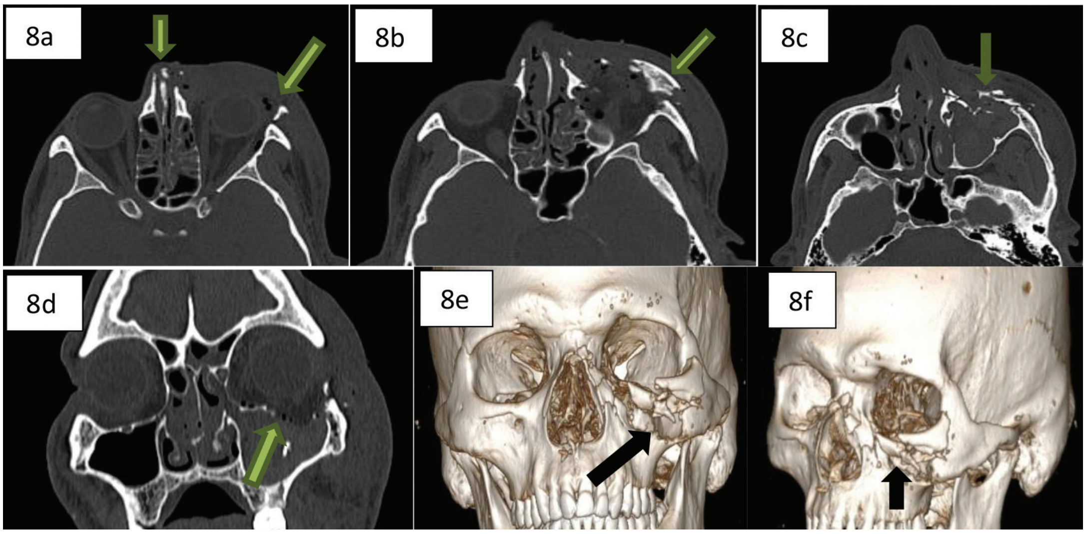
Table/Figure-7: The importance of each plane in the accuracy of detection of maxillo-facial fractures



Table/Figure-7: Right Le Fort I and II fracture, Comminuted fontal bone fracture:Axial (a - e) and coronal (d- h) images shows rightpterygomaxillary disjunction/ Le Fort I fracture (e & f), right (f & h)and fronto-nasal disjunction/ Le Fort II fracture. Associated bilateral nasal bones fractures (c & e), leftorbital wallfractures (a, f & h) and septal fracture of sphenoid sinus (b) are also seen.VRT- image (i) shows right Le Fort I and II fracture. Coronal (h) image shows comminuted depressed fracture of frontal bone. Displacement of fracture segments and extend of fracture line can better visualised in VRT images (j & k)

Fractures	Total fractures	Comparison of 2D and 3D images					
		Superior to 2D		Similar to 2D		Inferior to 2D	
		Number of fractures	%	Number of fractures	%	Number of fractures	%
Frontal bone fractures	194	86	44	58	30	50	26
Zygomalar complex fractures	356	189	53	139	39	28	8
Nasoorbito ethmoid fractures	452	113	25	122	27	217	48
Maxillary fractures	420	193	46	168	40	59	14
Mandibular fractures	98	48	49	40	41	10	10

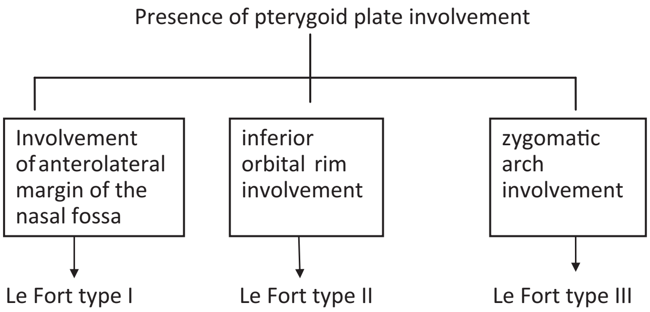
Table/Figure-8: Assessment of 3D images to describe the advantages in detection, extent and displacement of fractures compared to 2D images



Table/Figure-8: Axial (a, b &c) and coronal (d) images showing fracture of bilateral nasal bones, walls of left orbit and left maxillary sinus. Orbital floor fracture with herniation of infraorbital fat is clearly seen in coronal image (d). VRT images (e & f) showing displacement of fracture fragments and extend of fractures. However medial and inferior orbital wall fractures are difficult to identify in 3D images.

the study conducted by Hwang and You.[16]

Le Fort fractures were the predominant among complex fractures. The diagnosis of the Le Fort fractures can be done as follows:



The mandibular injuries were most common in the condyle and the body of the mandible. Many studies especially the one by HALL RK et al, have noted that most common site for all mandibular fractures is the condylar- subcondylar region.[17]

Frontal bone fractures are also commonly encountered during maxillofacial injuries, however this is not the part of maxillofacial region which results from direct trauma or extension of skull fracture.[18] Most of the fractures were Type 2 in our study. Similar result was seen in study conducted by Solonenet al[19]

Multiplanar reconstructed images were found to be beneficial in localizing and identifying maxillofacial fractures in detail. Qais H Muassaet al.[20] in their literature revealed that 46.7% fractures were detected by coronal scans while 30.4% fractures were detected by axial scans. The rest were detected from combined axial and coronal sections.

Many studies have noted that 3D reconstructed images are helpful in the evaluation of fracture comminution, displacement components, and complex fractures involving multiple planes.[21] The extent of comminutive fractures is better demonstrated on the 3D-CT, where the size, shape, and displacement of individual fragments are clearlyrevealed.[22,23,24]

The combination of multiplanar reconstructed images and 3D volume rendering technique allowed several improvements in imaging interpretation. The 3D reconstructions were also found to be helpful in determining comminutive fractures, displaced components, and complex fractures involving multiple planes in this research.

MDCT is the best imaging modality available for evaluation of maxillo facial injuries and our study was done on the same modality; hence no significant limitations are noted. The sample size and study design are adequate and satisfactory.

CONCLUSION

MDCT is the investigation of choice in the evaluation of patients with maxillofacial trauma. 3D images are useful, although variable for different bones, in the assessment of complex fractures involving the face. Coronal images are useful adjunct in detection of facial fractures. As there is no additional scanning or radiation involved in the reconstruction of images, 3D VR images and MPR is a valuable tool for the radiologist interpreting maxillofacial fractures. Continued advances in computer software algorithms and enhanced accuracy in radiographic data acquisition would allow 3D reformatted CT imaging a necessary complement to conventional 2D CT imaging in complex facial trauma management.

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