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Original Research Article

Multidetector computed tomography in evaluation of maxillofacial injuries

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A B S T R A C T

Background: Facial injuries occur in significant proportion in trauma patients requiring prompt diagnosis and management. The number of maxillofacial injuries is continuously increasing due to rise in traffic, failure to take preventive measures in the traffic leads to road traffic accidents, which is the main etiological factor in maxillofacial fractures.
Aim: To study role of multidetector tomography in evaluation of maxillofacial injuries. To describe the advantages of 3D reconstructed images over axial images in the imaging of facial fractures.
Materials and Methods: This cross-sectional study included 100 patients who underwent CT evaluation of facial bones when they presented with evidence of fracture of maxillofacial bones on a 64-slice volume scanner (SIEMENS SOMATOM definition) in Geetanjali Medical College and Hospital, Udaipur during February 2019 to July 2020.
Results: RTA comprised of 76.19% cases. Assault and fall from height were 11.42 and 12.38%. The maxilla, the walls of its sinus were the most commonly involved bone with 71.42% next was Naso-orbito-ethmoid 68.57%. Zygomatic bone and mandible fractures were 50 and 38.09%. The type 2 frontal bone fractures were commonly seen 12 (31.5%) followed by Type 3, 10 (26.02%), Type 4 & Type 1 seen in 6 (15.7%) and Type 5 was the least common injury seen 4 (10.52%). The medial wall of the orbit was most commonly involved 49 (35.76%). Le Fort fracture lines were identified in 17 occasions with Le Fort II seen 9 (52.9%).
Conclusion: The advantages of 3D images within the assessment of facial trauma might be described especially in mandible and cheekbone. 3D images were better within the identification of Le Fort fracture lines. The coronal reconstructed images are 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.

1. Introduction

In the emergency room, maxillofacial trauma frequently manifests as a single injury or as a polytrauma (Casualty). Even patients with severe injuries make it through to success in specialised trauma centres that are getting better at rescuing patients as easier emergency transportation facilities and advanced life support become more common.[1]

Trauma patients frequently have facial injuries that need quick diagnosis and treatment. Maxillofacial injuries are frequent in both times of peace and war. Due to increased traffic, the number of maxillofacial injuries is continuously rising. Inadequate traffic safety measures result in road traffic accidents, which are the primary cause of maxillofacial fractures.[2]

The nasal, orbital, zygomatic, maxillary, and mandibular regions of the face can be divided into five separate anatomical groups. Face injuries can be divided into three

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categories: those that affect a single region, different regions, and multiple contiguous regions (e.g., midface smash or panfacial fractures). These traumas have evolved into a type of social disease as a result of the increase in urban violence incidents and the frequency and severity of traffic accidents.[3] Maxillofacial injuries are more common now than ever before, and this is largely due to injuries sustained in violent crimes and car accidents.[3,4] Falls and sports injuries are two additional ways that the maxillofacial region can be hurt.

Various populations are prone to mid-face fractures.[5,6] Only about 5 to 10% of accident patients have facial fractures. Mid-face cracks appear to be most frequently caused by auto accidents worldwide.[7,8] Attacks, falls, sports injuries, and animal attacks are only a few of the eight different causes of facial fractures, including the mid-face damage mentioned in the writing.[9,10]

Mid-face importance is evident in both capacity and sensation. A functional unit for the respiratory, olfactory, visual, and stomach-related frameworks is provided by the mid-face skeleton. Vertical, level, and sagittal columns make up the mid-face.[10]

2. Maxillofacial Anatomy

For a variety of reasons, including the following, the radiographic examination of patients who present with facial trauma can occasionally be perplexing and unpleasant. The normal radiographic face anatomy is complicated. Getting the best diagnostic films is challenging because of the patient's physical state and/or unwillingness to cooperate. inadequate correlation between clinical and radiological findings.

Basic knowledge of the normal osseous facial anatomy is necessary for the radiographic evaluation of facial trauma.

It is also crucial to understand the facial skeleton's inherent biomechanical weak points. To better understand radiographic facial anatomy, it can be helpful to break the maxillofacial skeleton down into its three main parts.[11]

1. The cranium's ovoid shape.
2. The midface skeleton, which is pyramid-shaped.
3. The zygoma with three legs (shaped like a tripod).

The facial skeleton has a number of inherent structural flaws. These include the presence of numerous air-filled sinuses and passages with walls made of thin membranous bones, as well as an incomplete congruity between the base of the pyramid-shaped facial skeleton and the ovoid cranium. Additionally, the maxilla, zygomas, and skull are primarily connected by sutures that are easily separated.

3. Facial Buttresses

Numerous buttresses for the face have been described. The facial skeleton has four main vertical buttress groups: three are bilateral and peripheral, and one is positioned in the middle. The superior, middle, and inferior horizontal buttresses are also described.[12]

Vertical Buttresses: The nasofrontal buttress, zygomatic buttress, and pterygomaxillary buttress are the peripherally situated vertical buttresses.

The nasoethmoid buttress is the main vertical support. Vertical Buttresses: The orbital plates of the frontal bones, the roofs of the ethmoid air cells, and the cribriform plate of the ethmoid make up the superior horizontal buttress. The orbital surface of the maxilla, the frontal process of the maxilla, the body and temporal processes of the zygoma, the zygomatic process of the temporal bone, and the infraorbital process of the zygoma make up the middle horizontal. Alveolar ridge and hard palate make up the inferior horizontal buttress, which serves as a crucial stabilising link between the two maxillary bones.[12]

3.1. Anatomy of the normal osseous facial

The following are the facial bones:[13]

Fig.1 Diagram showing Facial bones

4. Aim and Objectives

1. Researching the function of multidetector tomography in assessing maxillofacial injuries.
2. Using MDCT to assess patients with facial fractures and injuries.
3. To discuss the benefits of using three-dimensional (3D) reconstructed images when imaging patients with facial fractures as opposed to axial images.

5. Material and Methods

In this cross-sectional study, 100 patients who presented with evidence of a maxillofacial bone fracture on a 64-slice volume scanner (SIEMENS SOMATOM definition) at Geetanjali Medical College and Hospital, Udaipur, between February 2019 and July 2020 were included. On the referral doctor's recommendation, the CT was performed (casualty medical officer, duty assistant surgeon, duty ENT surgeon).

6. Methodology

Each individual was prepared and examined in accordance with the predetermined protocol. It was noted that individuals had previously presented with face injuries. Coronal-plane multiplanar reformation (MPR) images were also reconstructed with a 0.5mm increment along with the axial images. Additionally, photos of three-dimensional volume rendering were obtained. The clinical workstation was used to review the MDCT scans. According to the region affected, the fractures seen during the CT examination were categorised. Fracture identification, fracture extent, and displacement were evaluated by comparing 3D volumetric reconstruction (VR) pictures with axial images. Axial and coronal pictures were examined to identify fractures.

6.1. Sample size

Minimum 100 patients.

6.2. Inclusion criteria

Patients with maxillofacial bone fractures as seen on a CT scan.

6.3. Exclusion criteria

1. Patients without any signs of a maxillofacial bone fracture.
2. Individuals with maxillofacial fractures in whom a CT scan is not recommended.
3. Fractures of the maxilla and mandible's dento-alveoli.
4. Bone ailments and conditions.

6.4. To be done intervention/assessment

MDCT Face: MDCT scans of the subjects' faces were taken. A 64-slice volume scanner was used to perform MDCT scans (SIEMENS SOMATOM Definition).

7. Statistical Analysis Proposed

The decision was made to include all eligible cases who presented to the department of radiodiagnosis during the study period despite the study's limited patient intake (February 2019 to June 2020).

8. Results

The distribution of data as per age of the Maxillofacial Injuries Using Multislice Computed Tomography was shown in the tables and graphs below among the 105 cases collected matching the inclusion and exclusion criteria.

8.1. Age distribution of study participants

The age range of the participants in our study was 20 to 50 years old. Table 1 and Figure 1 display the frequency distribution for each age group (16). The age at presentation in this study group, which included a total of 105 patients, ranged from 11 to 65 years. 35 and 30 patients, respectively, belonged to the age groups of 31–40 and 21–30. (Graph 1). The majority of the study population was made up of men.

8.2. Mode of injury

Road traffic accidents accounted for 76.19% of cases involving patients who had maxillofacial trauma and were treated at the Emergency Department. Other causes included

Table 1: Mode of injury of patients presenting with facial fractures

Mode of injury	No. of Fractures	%
RTA	80	76.19
Fall from Height	12	11.42
Assault	13	12.38

Table 2: Distribution of fractures detected in the Maxillofacial region

SR. No	Type of bone	Occurance of fractures	%
1.	Frontal bone fracture	38	36.19
2.	Zygomatic bone fracture	50	50
3.	Naso-Orbito Ethmoid Fracture	72	68.57
4.	Fracture in Maxilla	75	71.42
5.	Fracture in Mandible	40	38.09
6.	Pterygoid Plate	12	11.42
7.	Sphenoid wing	14	13.33
8.	Temporal bone	16	15.23
9.	Parietal Bone	4	3.80

Table 3: Frontal bone injuries (Classified according to Manolidis)

Fracture type	No. of fractures (n=38)	%
Type I	6	15.7
Type II	12	31.5
Type III	10	26.02
Type IV	6	15.7
Type V	4	10.52

Table 4: Orbital injury according to the walls involved

Orbital injury	No. of fractures (n=137)	%
Lateral wall	34	25.81
Medial wall	49	35.76
Roof	12	8.75
Floor	42	30.65

Table 5: Classification of mandible fractures according to the site of involvement

Mandible injury	No of fractures n=70	%
Condylar	20	28.57
Body	20	28.57
Sub- Condylar	6	8.57
Coronoid	6	8.57
Ramus	7	10
Angular	2	2.85
Alveolar Ridge	3	3.42
Para-Symphyseal	4	5.71
Symphyseal	2	2.85

Table 6: Le fort fracture lines identified

Le fort fracture Lines identified	No. of Fractures (n=17)	%
Le Fort I	6	35.2
Le Fort II	9	52.9
Le Fort III	2	11.7

assault and falls from height, accounting for 11.42 and 12.38% respectively. (Table 1)

The most frequently affected bone was found to be the maxilla, especially the walls of its sinus, with 71.42% of patients having a fracture in this bone. The next frequently affected area was the naso-orbito-ethmoid region, where fractures were found in 68.57% of patients. Mandibular and zygomatic bone fractures were found in 50 and 38.09% of patients, respectively. In the five regions of the face examined, fractures of the frontal bone were less frequent, accounting for 36.19% of patients. Twelve patients (11.42%) were found to have involvement of the pterygoid plates. 14 patients (13.33%) had sphenoidal wing involvement. 16 (15.23%) and 4 (3.80%) patents were found to have the parietal and temporal bones involved, respectively. (Table 2)

In this study, type 2 frontal bone fractures were more frequently observed 12 (31.5%) times. The next most prevalent type, type 3, occurs 10 (26.02%) times. Each fracture of type 4 and type 1 was observed six times (15.7%). The least frequent injury, which occurred four times (10.52%), was type 5. (Table 3)

49 (35.76%) of the total orbital injuries found involved the medial wall of the orbit the most frequently. Involvement of the orbital floor was observed 42 times (30.65%). There were 34 and 12 instances of the lateral wall and roof, respectively. (Table 4)

The condyle and the mandibular body were the most frequently injured areas. 20 fractures were found in the condyle and body of the mandible, making up a total of 70 fractures, or 28.57% of all fractures. The coronoid process, located in the subcondylar region, contained fractures in 6 of each (8.57%). Three (3.42%) fractures in the alveolar ridge and seven (10%) fractures in the ramus were discovered. Four parasymphyseal fractures (5.71%) were reported. Symphyseal and angular fractures were both noted twice (2.85%). (Table 5)

Le Fort fracture lines were discovered 17 times, as shown in the above table (8). The Le Fort II was observed nine times (52.9%), making it the most frequent Le Fort line to date. Le Fort I was noted six (35.2%) times, and LeFort III fracture lines were noted twice (11.7%) times. (Table 6)

9. Indicative Case Studies

Axial images, 3D constructed images, and coronal MPRs were analysed to evaluate all patients with maxillofacial fractures.

9.1. Case 1

AGE: 22 Gender: M RTA, Mode of Injury

1. Mandibular body fracture.
2. Right orbital medial wall fracture.
3. Frontal and sphenoid bone anterior and posterior wall fractures.
4. Hemosinus and SDH.

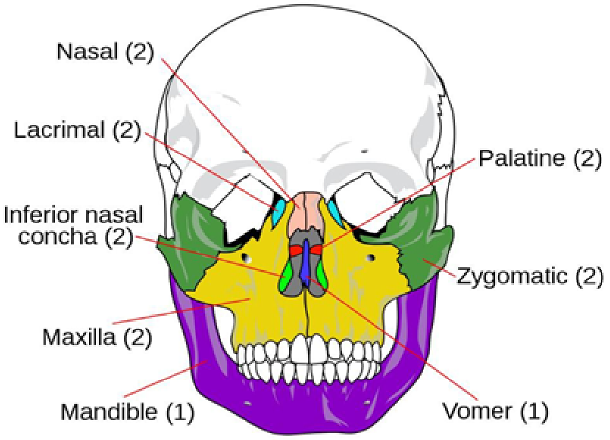


Fig. 1: Diagram showing facialbones

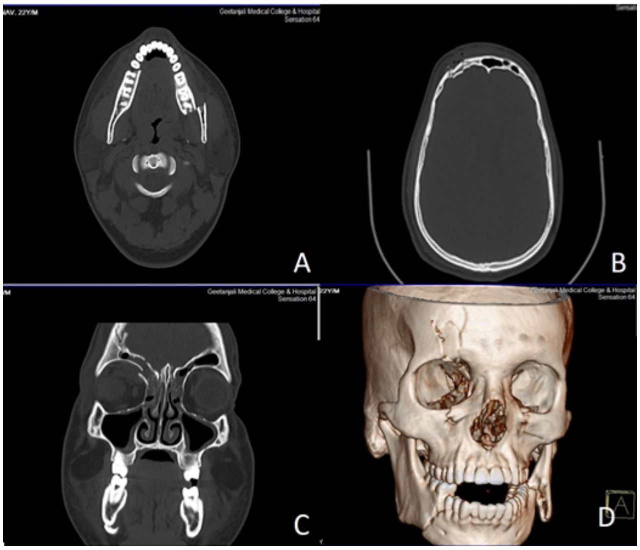


Fig. 2: A & B. Axial images demonstrate the fracture of left half of mandible and comminuted fracture of frontal bone on right side. C. Coronal image demonstrate the fractures in the medial wall of right orbit and frontal bone on right side with associated hemosinus. D. 3D images better demonstrate the frontal and mandible bone fractures.

9.2. Case 2

Gender: M Age: 60 RTA, Mode of Injury

9.3. Findings

1. Right orbital superior and lateral wall fracture.
2. Right maxillary sinus posterior wall fracture.
3. Right zygomatic arch fractured into several pieces.
4. Subcutaneous emphysema and hemosinus.

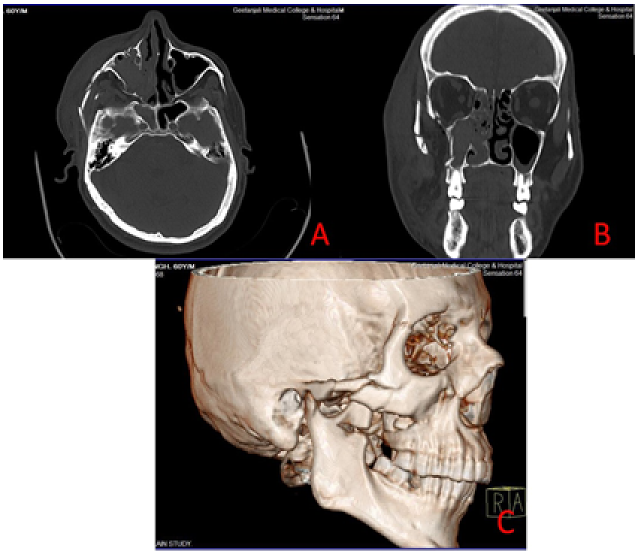


Fig. 3: A. Axial images demonstrate the fractures in the posterior wall of right maxillary sinus and comminuted fracture of right zygomatic arch with hemosinus B. Coronal image demonstrate the fractures of posterior wall of right maxillary sinus, right zygomatic arch and associated hemosinus. C. 3D image better in demonstrating the fracture of the zygomatic arch on right side and also in the assessment of its extent and displacement

9.4. Case 3

Age 32 years, gender M Mode of Damage: Attack

9.5. Findings

1. Right orbital superior and lateral wall fracture.
2. Right maxillary sinus posterior wall fracture.
3. Orbital and hemosinus emphysema.

9.6. Case 4

Age: 20 Years, M-type RTA, Mode of Injury

9.7. Findings

1. Right-side frontal bone fracture with multiple fragments.

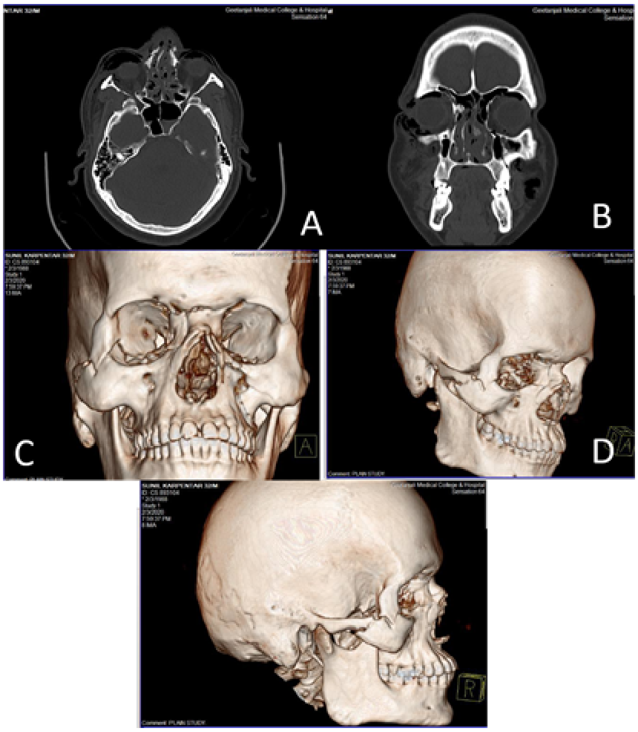


Fig. 4: A. Axial image showing the fracture of lateral wall of right orbit with associated orbital emphysema. B. Coronal image demonstrate the fractures in the superior wall, lateral of orbits and posterior wall of maxillary sinus with orbital and subcutaneous emphysema. C. 3D images provide information with respect to the extent and displacement of fragments in the right zygomatic arch.

2. Lesser and greater wing fractures of the sphenoid bone.
3. Lesser and greater wing fractures of the sphenoid bone.
4. Right maxillary sinus anterior and medial wall fracture, as well as left maxillary sinus anterior and medial wall fracture.
5. Pneumocephalus and hemosinus noted in the frontal ethmoid and maxillary sinuses.

10. Discussion

The disruption of the soft tissues and bones of the face causes facial asymmetry and disfigurement, which causes emotional and cosmetic concerns. The region is also connected to several crucial daily functions. Maxillofacial trauma can present as isolated injuries or as a component of polytrauma.

The most recent technological development in CT imaging, multislice CT, represents a significant advance in x-ray, CT, and imaging technology as a whole, providing the opportunity to significantly speed up data collection and reconstruction.[14] Multislice CT has been shown to be capable of obtaining a wider range of anatomic coverage

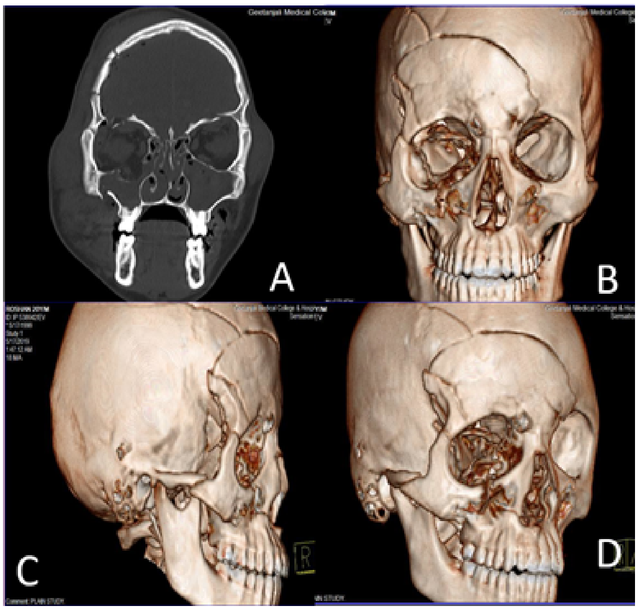
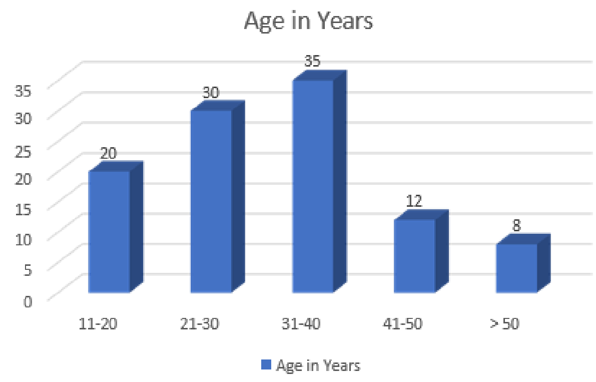


Fig. 5: A. Coronal image showing the fracture of frontal bone on right side, all walls of right orbit, anterior & medial wall right maxillary sinus. B. 3D images provide information with respect to the extent and displacement of fragments in the maxillary and zygomatic region



Graph 1: Age distribution of patients presenting with facial fractures.

during the scan.[15] As the entire volume of interest is being scanned, continuous data acquisition and archiving takes place. As a result, a large volume of interest can be quickly scanned with high image quality, thin sections, and a low artefact rating in a short amount of time, significantly reducing respiratory motion issues.[16]

According to this study, men make up 87.61% of all injuries, which is similar to Kieser et al., who found that men account for 80% of facial fractures.[17]

Road traffic accidents were the most frequent cause of injury, accounting for 76.19% of instances involving patients who had suffered craniofacial trauma. Other reasons, accounting for 12.38% and 11.42%, respectively, were assault and falls from a height. Numerous publications asserted that motor accidents were the primary cause of face fractures.[18,19]

Fox discovered that 3D reconstructed CT scans were more accurately and quickly interpreted. 3D CT was also better at assessing zygomatic fractures but less accurate than axial images at determining orbital fractures.[20] According to other studies, 3D CT is best suited for imaging comminuted fractures of the zygomatico-maxillary complex and the middle third of the face.[21] These findings suggest that 3D scans help clinicians more accurately determine where bone fragments are located and in which direction they are moving.

However, for minor fractures of the orbital floor or isolated fractures of the maxillary wall, where the fracture is restricted to a single plane, three-dimensional imaging is not advised. Here, relying solely on 3D scans can produce false-negative results.

Axial and coronal CT images are sufficient for diagnosing medial orbital wall fractures, according to Tanrikulu and Erol. They also confirmed that coronal CT is superior for diagnosing blow-out fractures and fractures of the orbital floor, particularly in patients who may experience diplopia and enophthalmos.[22]

Axial and coronal images both worked well for finding mandibular fractures. The evaluation of fracture comminution, displacement components, and complex fractures involving multiple planes has been noted in numerous studies to benefit from the use of 3D reconstructed images. The 3D-CT, which clearly reveals the size, shape, and displacement of individual fragments, is a better way to show the extent of comminuted fractures.[23,24] Several advancements in imaging interpretation were made possible by the combination of multislice CT and 3D volume rendering technology.

The 3D reconstructions were found to be useful in this study's evaluation of comminuted fractures, displacement components, and complex fractures involving multiple planes.

The most frequent concomitant finding in patients who had facial trauma was hemosinus. It was noted in 45 patients (65.71%) According to research by Lambart et al., the absence of free paranasal sinus fluid (also known as the "clear sinus sign") on a facial CT scan is a highly accurate criterion for ruling out fractures of the paranasal sinus walls.[25] Only one patient in this study had an injury to the sinus wall along with an absence of hemosinus. The following frequent finding was observed in 21 (20%) patients: brain contusions. Ten patients (9.5%) had pneumocephalus. SDH, SAH, and EDH were three additional intracranial complications that were observed in 13 (12.38%), 12 (11.42%), and 15 (14.28%) patients, respectively.

Type 2 frontal bone fractures were 12 (31.5%) more common in this study. The next frequent type is type 3, which occurs 10 (26.02%) times. Type 4 and Type 1 fractures each occurred six occasions (15.7%). The injury type 5 was the least frequent, occurring four times (10.52%). Solonen et al. reported similar findings, finding that patients who had fallen from a height had frontal bone fractures of types 3, 4, and 2.[26] Of the total number of lesions to the orbit, 49 (35.76%) impacted the medial wall. A 42-time (30.65%) observation of involvement of the orbital floor. The lateral wall appeared 34 times, and the roof appeared 12 times. Studies of orbital fractures, where the medial wall and the floor were commonly impacted, are consistent with this.[27,28]

The mandibular body and condyle suffered injuries the most frequently. 20 fractures, or 28.57% of all fractures, were discovered in the condyle and body of the mandible, totaling 70 fractures. The condylar-subcondylar region (25–40%) is the most common site for all mandibular fractures, according to numerous studies, especially the one by Hall RK et al. (if single and multiple fracture cases are included).[29] If there is only one fracture, the angle is more likely to experience it.[30] Patients involved in auto accidents have the highest incidence of body fractures, which account for 16–36% of mandibular fractures, according to Kruger GO.[31]

On 17 occasions, Le Fort fracture lines were located. The Le Fort II was observed nine times (52.9%), making it the most frequent Le Fort line to date. Le Fort I and III fracture lines were discovered on six and two separate occasions, respectively. This is in line with research by Duval AJ et al., which revealed that Le Fort III fractures were the most severe and Le Fort II fractures were the most prevalent.[32]

11. Conclusion

Due to the exquisite sensitivity of this imaging technique for fracture, MDCT with MPR and 3D images has become a standard component of the assessment of maxillofacial injury. Maxillofacial injuries are frequent emergencies that require prompt diagnosis and treatment. The advantage of MDCT in the case of acute trauma is that it is becoming more widely accessible and has a shorter scan time. The primary goal of diagnostic imaging is to identify and pinpoint the precise number, location, and nature of soft tissue injuries and facial fractures. Excellent spatial resolution provided by MDCT paves the way for exquisite multiplanar reformations, exquisite 3D reconstructions, and improved diagnostic accuracy as well as a surgical planning road map. The usefulness of MDCT in the assessment of maxillofacial fractures is demonstrated by this study. The benefits of 3D images for assessing facial trauma can be described, particularly for the mandible and cheekbone. In patients with complex midfacial fractures, the easier detection of frontal and maxillary bone fractures as well as their displacement could be described. Le Fort fracture lines could be identified more accurately using 3D images. The orbital and maxillary fractures can be more easily found on the coronal reconstructed images. When there is little fracture displacement and when there are fractures involving the naso-orbito-ethmoid region, 3D images are only marginally useful.

12. Source of Funding

None.

13. Conflict of Interest

None.

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