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Original Research Article

Multislice CT in Maxillofacial Injuries: A Hospital-Based Study

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Abstract

Introduction: Worldwide, cranial cerebral injuries are a cause of death and disability due impairment of brain function and as such most centres will use all resources at their disposal to diagnose and treat these injuries. In recent advances of CT scan, 3D CT is one such which is advantageous because of clear preoperative localization of fracture lines involving the facial buttresses. It was found that the 3D CT images provided information regarding depth perception, contours, volumes, and extent of an abnormality.

Aim: The aim of this study was to determine the causative factors of maxillofacial injuries and as well as to assess, the number of fractures, fracture extent, and displacement of fractures by comparing axial and 3D reformatted images of the computed tomography scan of the trauma patients at Silchar Medical College and Hospital.

Methods: All the patients of age >12 years presenting to the emergency department who sustained polytrauma with facial injury on clinical examination over 1-year period of the study. Patients were checked for CT imaging contraindications. The pregnancy in female patients was ruled out. The patient's primary complaint, the location of the injury, the nature of the damage, the patient's overall state both immediately and afterward, and the period between the injury and reporting to the hospital was noted down.

Results: A total 100 of patients with faciomaxillary injuries on CT scan were studied over the one year study period. The median age of the patients with maxillofacial fractures was 30.9 years and 23-32 age group was most common at 47.5%. Road traffic accidents constituted 38% of fractures. The single most affected isolated bone was the zygomatic bone (51%) followed by maxillary bone (45%).

Conclusions: The craniofacial region is one of the most complicated parts of the human body. Clinical conditions of traumatised patients and lack of their cooperation make radiographic imaging of this area even more challenging. 3D images can provide the clinician with an overall spatial concept that allows a simpler understanding of the complexity of multiple two-dimensional axial CT images. However, 3D CT was found to be less useful in minor trauma.

Keywords: 3D CT, Maxillofacial Trauma, Fracture.

Introduction

They say "*face is the mirror of the mind*" therefore any injury to the face is responsible for tremendous physical and psychological trauma on the patient. A huge percentage of emergency department admissions are due to craniofacial trauma, which is associated with significant morbidity and mortality. Plain radiographs have been the initial modality of imaging these patients. However, they are inadequate due to the superimposition of bony structures. Multi detector computed tomography (MDCT) and 3D (three dimensional) volume rendering greatly simplifies the interpretation of complex maxillofacial injuries [1]. Clinical examination of a large facial trauma patient is challenging due to significant edema or bleeding. The clinical and radiological evaluation of facial fractures are important for the accurate diagnosis and treatment of patients [2].

Worldwide, cranial cerebral injuries are a cause of death and disability due impairment of brain function and as such most centres will use all resources at their disposal to diagnose and treat these injuries [3]. In recent advances of CT (computed tomography) scan, 3D CT is one such which is advantageous because of clear preoperative localization of fracture lines involving the facial buttresses. The degree of bone displacement was difficult to assess on the radiographs but was seen on 3D CT [4].

It was found that the 3D CT images provided information regarding depth perception, contours, volumes, and extent of an abnormality. The study concluded that 3D CT reconstructed images in conjunction with routine 2D CT should be an integral part of the examination in evaluating craniofacial abnormalities [5]. Cost de silva *et al* found in their study that Computer-generated three-dimensional CT imaging can provide superior views and spatial orientation of fragments for complex orbital and facial fractures [6].

Hence, this study aimed (i) To assess, the number of fractures, fracture extent, and displacement of fractures by comparing axial and 3D reformatted images of the computed tomography scan of the trauma patients (ii) To determine the causative factors of maxillofacial injuries.

Methods

The present study was carried out in the Department of Radiology, Silchar Medical College and Hospital, Silchar, India for one year from 01-06- 2021 to 31-05-2022. The study comprised patients referred from both OPD and Indoor sections from the Departments of otorhinolaryngology, Surgery, and other departments of Silchar Medical College, Silchar with a history of injuries in the maxillofacial region. Informed consent was obtained from the subjects or the respective attendants before the commencement of the investigations after proper explanation of the procedure. The current investigation was conducted on humans following ethical standards. The patient underwent CT as a research instrument after receiving volunteer approval from study participants [8].

The images were acquired using Phillips 128 slice ingenuity elite CT scanner (helical rotating) at a setting of 120kV, 191 mAs with beam collimation 2-3mm, pitch 0.399 and scan time 4 sec. Noncontrast axial CT sections were taken. Along with the axial images, coronal and multiplanar reformatted (MPR) images were obtained. 3D volume-rendering images were also obtained with 1mm increment. The assessment was made in the CT console using the high-definition workstation Intellispace Portal.

Study design: Cross-sectional observational study.

Sample size:100 patients.

Inclusion criteria:

1. Patients of age >12 years.
2. All patients presenting to the emergency department who sustained polytrauma with facial injury on clinical examination.
3. Incidentally discovered facial injuries on the brain scan.

Exclusion criteria:

1. Pregnant patients.
2. Pediatric patients (< 12 years).
3. Patient with general contraindication for CT scan.
4. Consents not given for the study.

Data entered in MS excel sheet and SPSS version 26.0 was used for statistical analysis. Qualitative variables were summarized using frequencies and percentages. Association among the study groups is assessed with the help of a chi-square test. 'p-value less than 0.05 is taken as statistically significant.

Results

In our study, 100 patients were studied. 80% (n=80) of the patients who reported were males, whereas the female patients accounted for just 20% (n=20). The study age group was divided into six groups. The maximum number of patients (38 patients, 38%) were in the age group of 23-32 years followed by 33–42 years (n=22, 22%). The mean age of the population was 30.3 years.

Table 1: Gender Distribution

	Frequency (n)	Percentage (%)
Male	80	80%
Female	20	20%
Total	100	100%

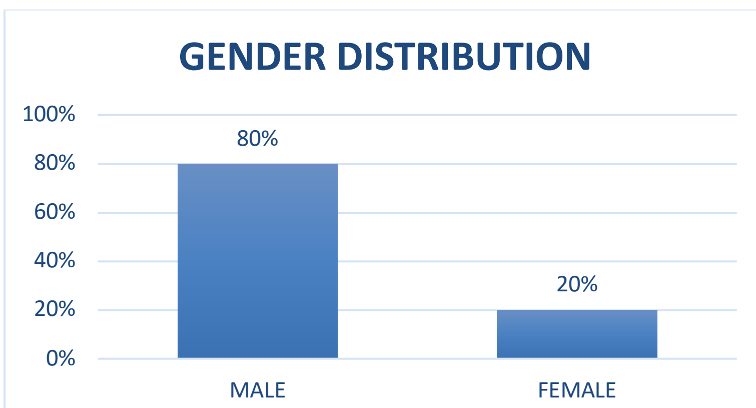

Chart 1

Table 2: Age Distribution

	Frequency (n)	Percentage (%)
12 – 22 years	18	18%
23- 32 years	38	38%
33-42 years	22	22%
43-52 years	9	9%
53– 62 years	9	9%
> 62 years	4	4%
Total	100	100%

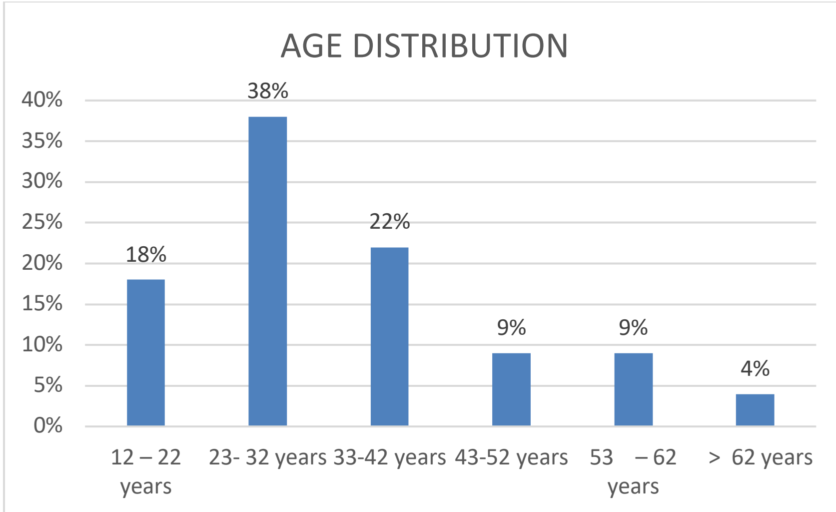

Chart 2

The most common cause of injuries was road traffic accidents (72%) followed by assault (17%) and fall from height (11%). Motorcyclists constituted the highest number of RTA cases (n=40, 55.6%)followed by other light motor vehicle (LMV) and heavy motor vehicle (HMV) (n=25, 34.7%). Pedestrians accounted for the least in RTA cases. (n=7, 9.7%). Pedestrians accounted for the least in RTA cases. (n=7, 9.7%). Most of the RTA cases were associated with alcohol intake (n=50, 69.4%). At a p-value of 0.023, a significant association between RTA and alcohol consumption was noted. Out of the 40 motorcyclists, it was found that 33 patients (82.5%) were not using helmets at the time of injury whereas only 7 motorcyclists (17.5%) were using the helmet. As the p-value is <0.001, it suggests a significant association between not wearing a helmet and 2-wheeler injury. In the study, it was noted that non-helmet-wearing motorcyclists were more prone to cerebral injury than helmet-wearing motorcyclists.

Table 3: Mode of injury

	Frequency (n)	Percentage (%)
Road Traffic Accident	72	72%
Fall	11	11%
Assault	17	17%
Total	100	100%

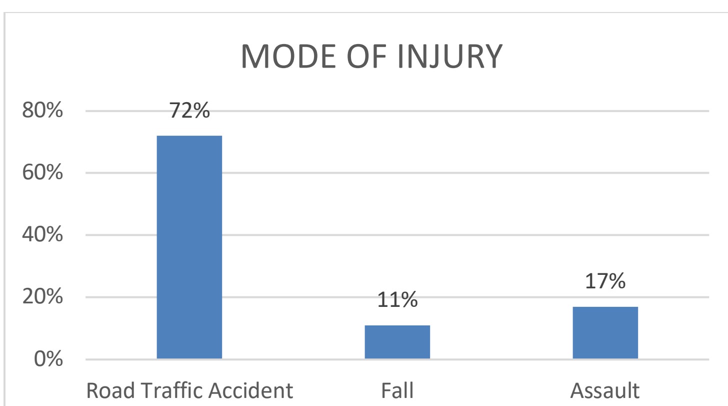

Chart 3

Table 4: Types of RTA injury

(N=72)	Motorcycle N (%)	LMV & HMV N (%)	Pedestrian N (%)
RTA	40 (55.6%)	25(34.7%)	7 (9.7%)

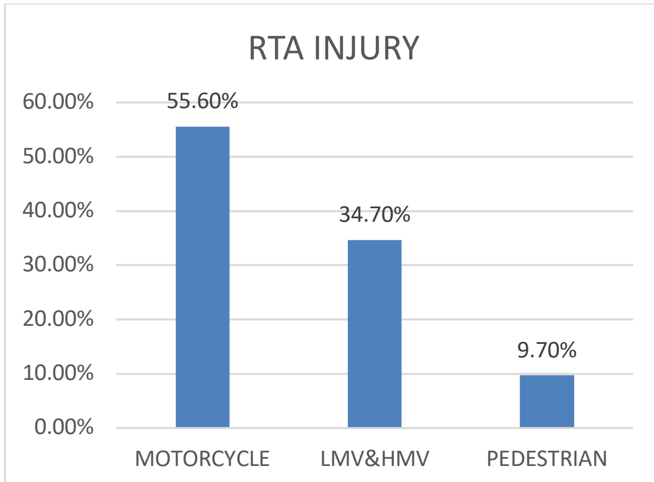

Chart 4

Table 5: Association of Road traffic accidents and alcohol

(N=72)	Alcohol N (%)	Without Alcohol N (%)
RTA	50 (69.4%)	22 (30.6%)
	Chi square test = 8.79 , p =0.023* (significant association between RTA and alcohol)	

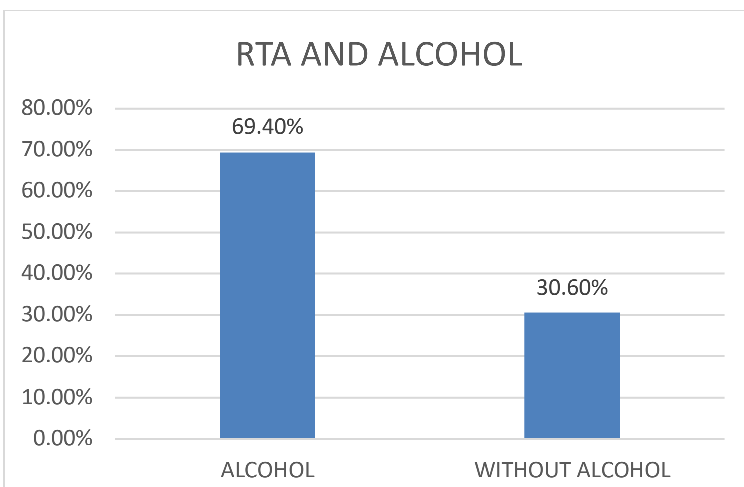

Chart 5

Table 6: RTA under the influence of alcohol

	Alcohol (n=50)	Non -Alcohol (n=22)	P value
2 wheeler (n=40)	30 (75%)	10 (25%)	p<0.001**
4 wheeler (n=25)	18 (72%)	7 (28%)	p< 0.001**
Pedestrian (n=7)	2 (28.5%)	5(71.5%)	p<0.001**

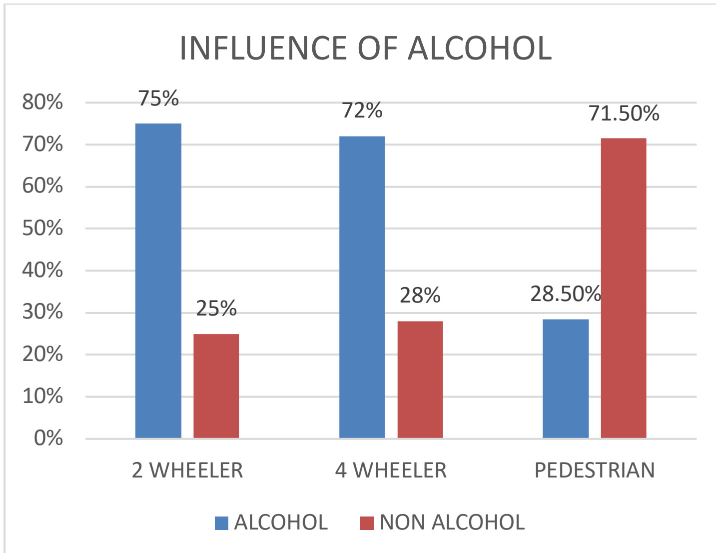

Chart 6

Table 7: Association of wearing a helmet with 2-wheeler injury

	Helmet wear N (%)	Non-helmet wear N (%)
RTA	7 (17.5%)	33 (82.5%)
	Chi square test = 21.8 , p < 0.001** (highly significant association between non-helmet wear and 2-wheeler injury)	

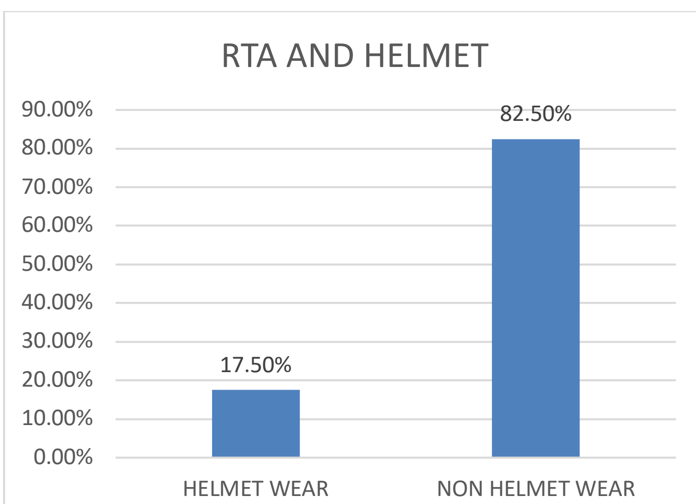

Chart 7

Hemosinus was an associated finding in 90% of non-helmet-wearing motorcyclists, and cerebral injury was noted in 22 non-helmet-wearing motorcyclists and 3 helmet-wearing motorcyclists. 3

cases of pneumocephalus were also associated with non-helmet-wearing motorcyclists. The study suggested a significant association between craniocerebral injury and not wearing a helmet (p value= 0.004). Out of 72 RTA cases, 24 patients presented with abrasion followed by laceration in 13 patients, contusion in 10 patients, and RTA-associated penetrating wound in 1 patient. Similarly in the patients with a history of fall and physical assault, the most common soft tissue injury was abrasion (n=10 and n=12 respectively). As the p-value reported <0.05, there was a statistically significant relation between soft tissue injury and maxillofacial trauma.

Table 8: Association of helmet wear and craniocerebral injury

(N=40)	Helmet wear (N=7) N (%)	Non-helmet wear (N=33) N (%)
Hemosinus	3 (42.8%)	30 (90.9%)
cerebral injury	3 (42.8%)	22 (66.6%)
Pneumocephalus	1 (14.4%)	3 (9.5%)
	Chi square test = 31.97, p=0.004* (Significant association)	

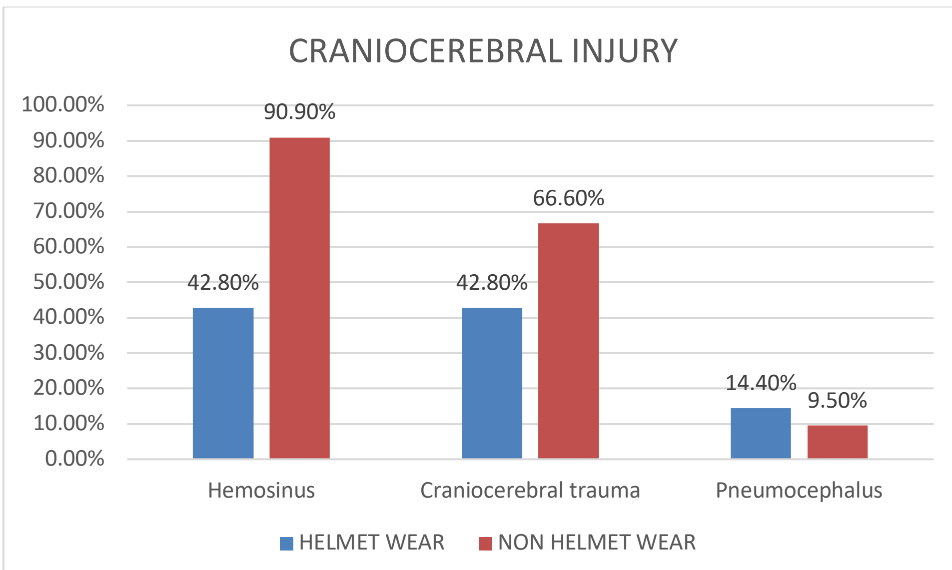

Chart 8

Table 9: Distribution of soft tissue injuries

	Frequency (n)	Percentage (%)
Abrasion	46	46%
Laceration	32	32%
Contusion	23	23%
Penetrating wound	8	8%

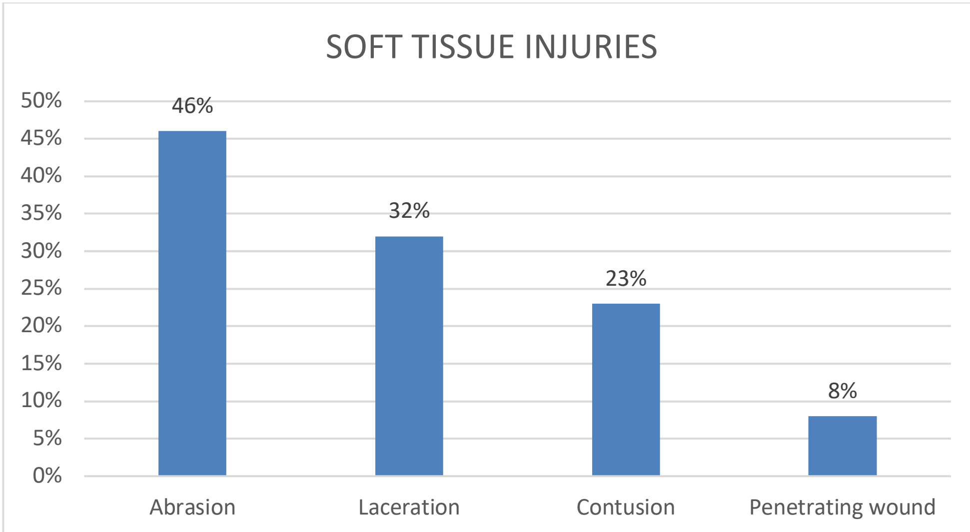

Chart 9

The most commonly involved bone fracture was zygomatic bone (51%) followed by maxillary bone (45%), nasal bone (32%) orbital bone (30%) frontal bone (15%), and mandible (9%). In tables 12 and 13, we noted that fracture displacement less than 2mm was less detected in 3D images. In the imaging of mandible fractures, it was noted that both axial and 3-D images were equally efficient in detecting fractures. It was also noted that complex fractures like Le Fort and Naso orbito ethmoid (NOE) fractures were equally detected in both axial and 3D images, however, their extent was better visualized in 3D images due to their complexity in axial images.

Table 10: Distribution of subjects based on the skeletal bone involved

	Frequency (n)	Percentage (%)
Nasal Bone	32	32%
Zygomatic	51	51%
Mandible	9	9%
Orbital	30	30%
Frontal Bone	15	15%
Maxillary Bone	45	45%

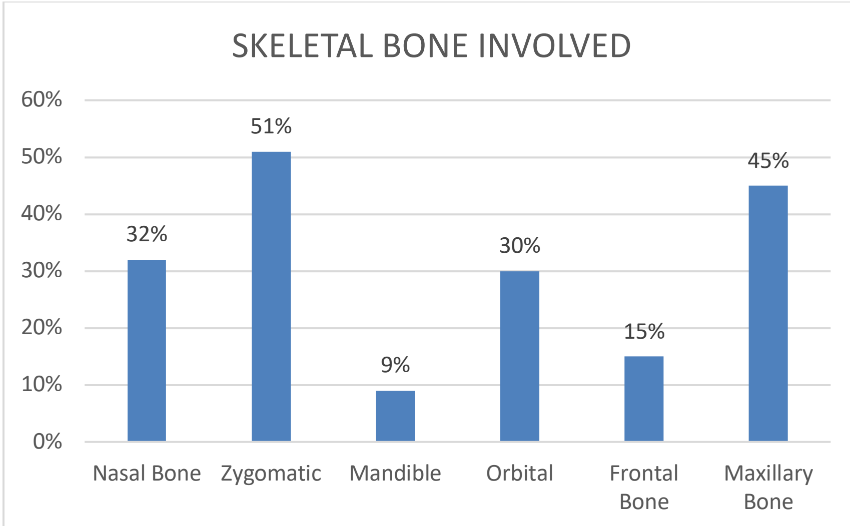

Chart 10

Table 11: Comparison of type of complex bone fracture in axial images with 3D images

LeFort	**Axial N (%)**	**3D N (%)**
Lefort I	4 (25%)	4 (25%)
Lefort II	7 (43.7%)	7 (43.7%)
Lefort III	5 (31.3%)	5 (31.3%)
Total	16 (100%)	16 (100%)
	Chi square test = 0.0, p =1.00 (No statistically significant difference)	
	Axial N (%)	**3D N (%)**
Naso-orbital ethmoid	22 (100%)	22 (100%)
	Chi square test = 0.0, p =1.00 (No statistically significant difference)	

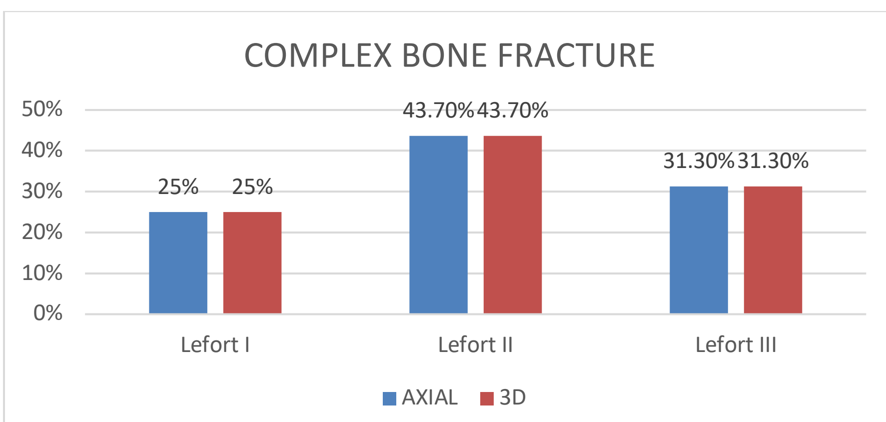

Chart 11

Table 12: Maximum displacement of fracture unit as visualized in the axial image

	Axial image	
	≤ 2 mm	>2 mm
Nasal Bone (n=32)	16 (50%)	16 (50%)
Zygomatic (n=51)	10 (19.6%)	41(80.4%)
Mandible (n=9)	5 (55.5%)	4(44.5%)
Orbital (n=30)	14 (46.6%)	16 (53.6%)
Frontal Bone (n=15)	9 (60%)	6 (40%)
Maxillary Sinus (n=45)	8 (17.8%)	37 (82.2%)

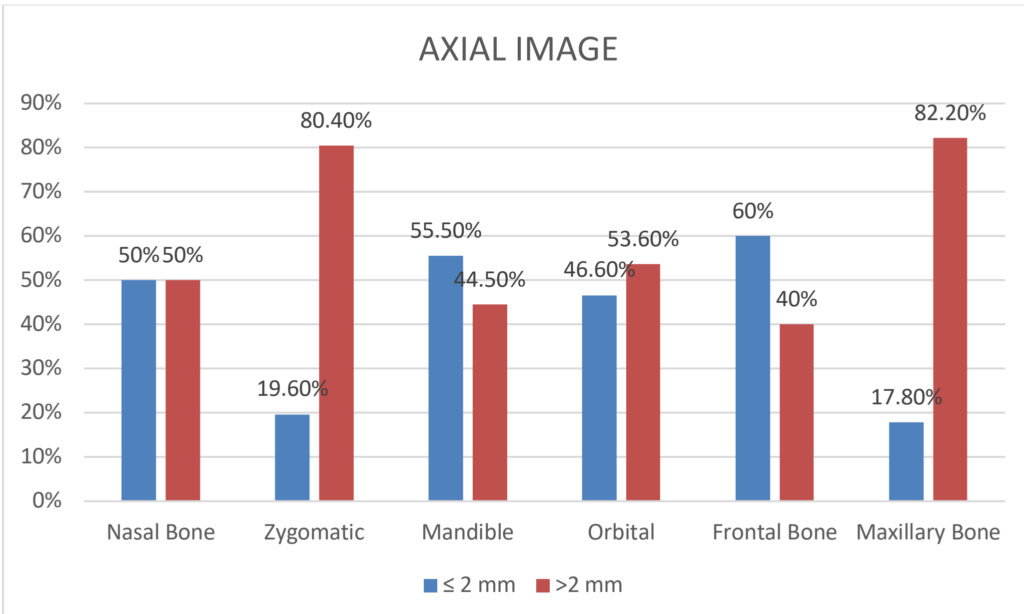

Chart 12

Table 13: Maximum displacement of fracture unit as visualized in 3D image

	3D image	
	≤ 2 mm	>2 mm
Nasal Bone (n=29)	13 (44.9%)	16 (55.1%)
Zygomatic (n=48)	7 (14.6%)	41 (85.4%)
Mandible (n=9)	5 (55.5%)	4(44.5%)
Orbital (n=28)	12 (42.8%)	16 (57.2%)
Frontal Bone (n=14)	8 (57.2%)	6 (42.8%)
Maxillary (n=42)	5 (11.9%)	37 (88.1%)

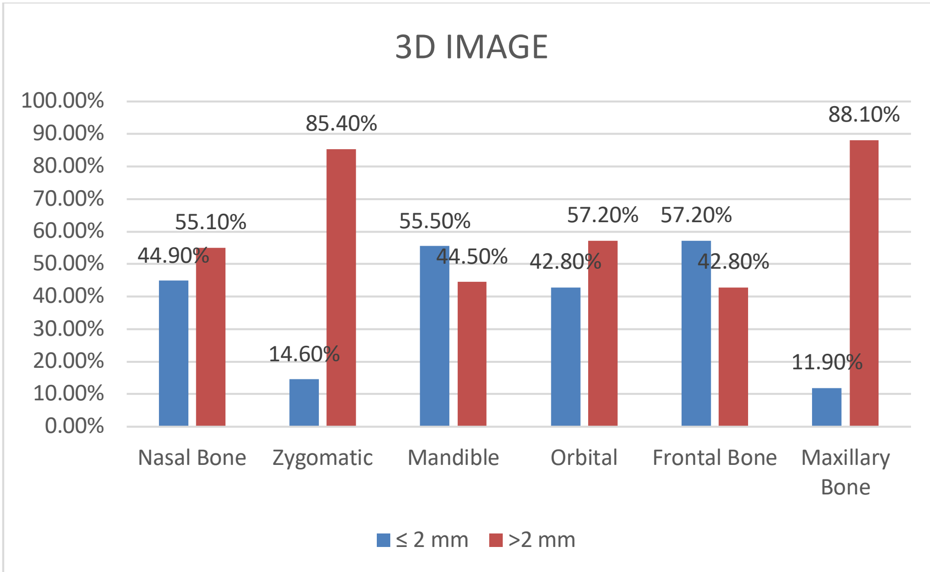

Chart 13

Discussion

CT scan imaging has become the mainstay of investigation in faciomaxillary trauma due to its sensitivity and ability to pick up life-threatening or permanently disabling injuries.

In our study 80 (80 %) were male and 20 (20%) were female. The differences can be attributed to the fact that men are more likely to work in dangerous jobs or play bold sports or outdoor activities as well as involving in physical assault. Cultural differences between men and women are also responsible. In our study maximum number of patients (38%) belonged to the age group of 22-32 years followed by 33-42 years (22%) and the minimum number of patients (4%) belonged to the age group of >62 years. Young and middle-aged adults are more prone to such injuries because they are the breadwinner of the family and are mostly involved in various outdoor work and commuting. The most common mode of injury was road traffic accidents (72%) followed by assault (17%). In developing countries like India poor roadways infrastructure, lack of enforcement of traffic laws, lack of use of safety measures and drunk driving cause most of the RTAs. In our study, most numbers of RTA cases were seen in the age group of 23-32 years (n= 32) followed by 33-42 years (n=19) as these groups of young people are mostly involved in commuting for daily work. Lack of driving experience together with risk-taking behaviour is another important factor.

Amongst RTA cases, motorcyclists (n=40, 55.6%) were the maximum in numbers whereas pedestrians contributed for only 7 cases (9.7%). The smaller size, lesser stability of the motorcycle as well as speeding and reckless riding by the motorcyclists are the common causes of motorcycle accidents.

Studies	RTA	Fall	Assault
Sivalingam J *et al*(9)	81%	13%	6%
N Sreenivasa Raju *et al*(10)	80%	13%	7%
Adekeye EO (11)	75.6%	7.9%	12.7%
Present study	72%	11%	17%

In our study, we found that 50 RTA cases (69.4%) were associated with alcohol consumption with a significant association between RTA and alcohol consumption (p=0.023, Chi-square test = 8.79). Drinking alcohol deteriorates abilities, skills, and inhibition which increases risk-taking behaviour resulting in the likelihood of injuries. The study by Sathanaselis *et al* on 856 cases shows a significant percentage of 41% (n=352) of the drivers that were involved in traffic accidents during the years 1995 to 1997 in Greece had consumed some alcoholic beverage shortly before the accident [10].

In our study, it was found that more numbers of RTA-associated maxillofacial injuries were noted amongst the non-helmet-wearing motorcyclist (n=33, 82.5%) with Chi-square test = 21.8 and p value<0.001. During a fall or collision, most of the impact energy is absorbed by the helmet, rather than the head and brain. Sisimwo *et al* found that only 94 (28%) motorcyclists wore helmets at the time of crashes. 143 (42%), of the respondents without helmets at the time of the motorcycle crash sustained head injuries. The use of a helmet was protective against head injury during a motorcycle crash and was statistically significant ($\chi2=55.78$, $p<0.001$) [12]. Liu BC *et al* in a retrospective study concluded that motorcycle helmets were found to reduce the risk of death and head injury in motorcyclists who crashed. It is also estimated that helmets reduce the risk of death by 42 % and reduce the risk of head injury by 69% [13].

It was observed in the study that 3D images alone were inferior in detecting fractures with displacement ≤ 2mm in all the facial bones except mandibular fractures. Alone 3D images could detect 13 nasal bone fractures instead of 16, 7 zygomatic bone fractures instead of 10, 12 orbital bone fractures instead of 14, 8 frontal bone fractures instead of 9, and 5 maxillary fractures instead of 8

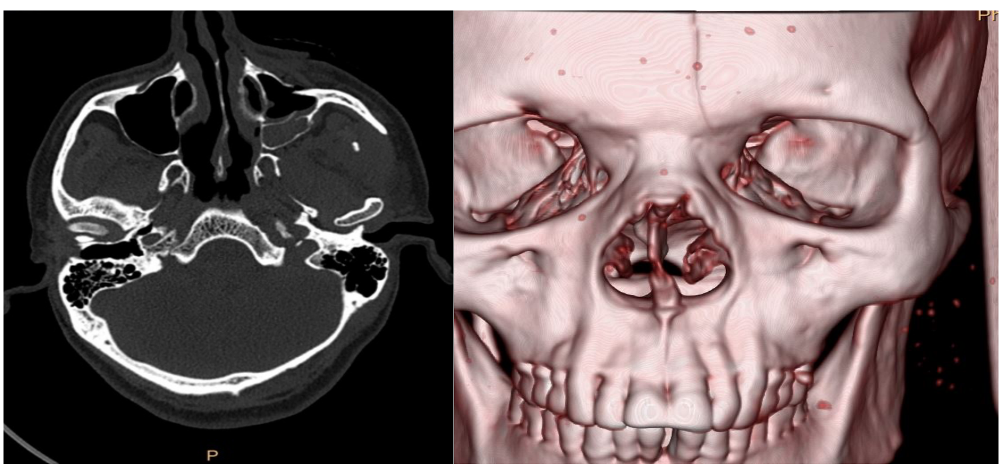

Figure 1: (a) linear displaced fracture noted involving the anterior wall of left maxillary sinus. (b) 3D VR shows no fracture in the maxillary sinus however, a fracture line is noted involving the frontal bone.

It was observed that 3D images alone never showed any more fractures than those seen on axial and multiplanar images, they were still found to be particularly helpful to the surgeon because they allow for the panoramic depiction of the complex fracture, which makes treatment planning easier (Fig 1a, 1b). For higher diagnostic yield, the radiologist can employ 3D reconstructions to direct the acquisition of focused multiplanar reconstructions. The study concluded that the evaluation of craniofacial anomalies should include both routine 2D CT and 3D CT reconstructed images. Complex fractures like Le Fort and NOE fractures displacements are equally detected in both axial and 3D CT images (Fig 2a, 2b). The study by Mayer JS *et al* found that 3D CT provided the superior definition of fracture lines (especially horizontal) and the extent of comminution was better appreciated. Both conventional and 3D CT methods can be used to diagnose the majority of mandibular fractures (Fig 3a, 3b). The use of 3D CT enables better detection of fracture lines and the distinctive patterns of comminution in midface fractures [11].

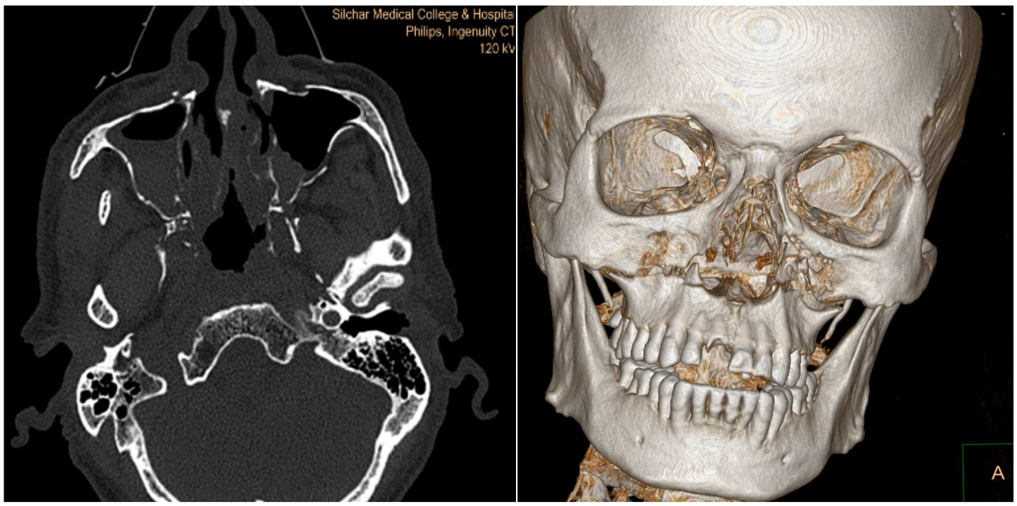

Figure 2: (a) NCCT image shows comminuted fractures noted involving all the walls of the bilateral maxillary sinus with associated hemosinus. A comminuted fracture is also noted involving the bilateral medial and lateral pterygoid plates. (b) 3D VR image shows the Le Fort I fracture line extending from the right zygomatic bone to the left zygomatic bone involving the bilateral maxillary sinus.

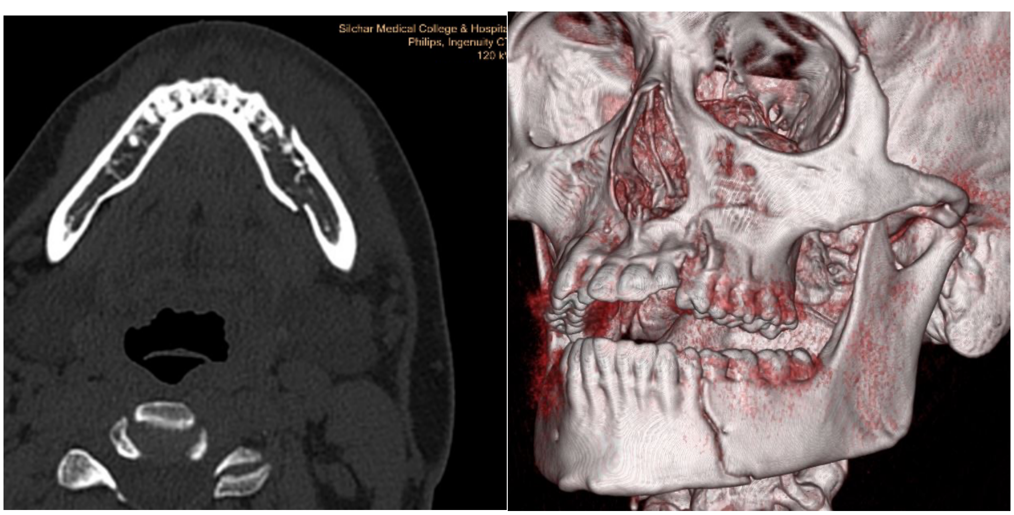

Figure 3: (a) Axial CT image in the patient showing displaced fracture of the body of left hemi mandible with surrounding soft tissue swelling. (b) 3D VR image shows a linear displaced fracture in the left hemi mandible with its extent superiorly up to the alveolar ridge and inferiorly up to the base of the mandible.

In our study, we found that haemosinus (64%) (Fig 2a) was the most common associated finding of maxillofacial trauma followed by craniocerebral trauma (34%) and orthopedic injury (23%). N Sreenivasa Raju *et al* found the most frequent concomitant finding in individuals who had facial injuries was haemosinus.

In 45 (72.6%) cases, haemosinus was noted followed by brain contusion in 12 (19.4%) individuals. [14]. In the study by Salonen *et al* brain contusion or intracranial hemorrhage (ICH) is found in 47 cases, pneumocephalus in 6 cases, subarachnoid hemorrhage (SAH) or intraventricular hemorrhage (IVH) in 26 cases [15].

Conclusion

After spectacular advancements in health system, unfortunately we have put RTAs among the top 10 global killers. Road traffic accidents are the most frequent cause of injury in developing nations. Extensive maxillofacial fractures are likely caused by poor road maintenance, insufficient driving abilities, and lack of enforcement of traffic laws and ordinances, such as the usage of seat belts and helmets. Road design, speed limit enforcement, routine awareness programs, various community participation measures, use of safety measures, and strict vigilance against drink and driving are some examples of corrective solutions.

MDCT is an accurate, non-invasive, and fast technique which plays a valuable role in the evaluation and management of maxillofacial fractures. 3D CT images help to interpret a difficult set of cross-sectional CT images more simply and quickly. In addition, 3D images can provide the clinician with an overall spatial concept that allows a simpler understanding of the complexity of multiple two-dimensional axial CT images. However, 3D CT was found to be less useful in minor trauma. Thus it enables better preoperative analysis and surgical planning as compared to conventional CT images.

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