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Multi detector computed tomography in maxillofacial injuries

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Abstract
Background: Imaging is an important step after the clinical evaluation in the workup of patients with facial trauma .It helps to define the extent of injury and to plan the surgical, interventional, or conservative therapy. Multidetector computed tomography (MDCT) is the imaging technique of choice to detect and characterize the number of fractures, fragments, the degree of dislocation, and the involvement of anatomical structures. It provides a three-dimensional (3D) mapping of the smallest fractures and abnormalities in a short period of time in trauma and emergency setting.
Results: The study included 30 patients with mean age of 41.07± 13.92 years with age range of 21 – 68 years. In most of the cases the mode of injury was road traffic accidents among 23(76.7%). Fracture maxilla in 63.3% followed by mandible in 56.7% was the most common bone involved in facial fractures. Hemosinus (56.7%) was the most common associated finding in the patients who presented with facial trauma. Brain contusions were the next common finding seen in 30% patients. Medial wall of the orbit was the most common wall involved in orbital fractures. The mandibular injuries were most common in the condyle and the body of the mandible. Le Fort fracture lines were identified in 17 patients with the most common Le Fort line being the Le Fort II & Le Fort III which was seen 7 patients (23.3%) each.
Conclusion: The complex anatomy of the facial bones requires multiplanar imaging techniques for a proper evaluation. The main purpose of diagnostic imaging is to detect and localize the exact number, site of facial fractures and soft tissue injuries. 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. MDCT offers excellent spatial resolution, which in turn enables exquisite multiplanar reformations, and 3-D reconstructions, allowing enhanced diagnostic accuracy and surgical planning.

Keywords: MDCT, 3D images, facial fractures

1. Introduction

Injuries of facial bones and soft tissues are a very common pathology. The incidence ranges from 20% to over 50% of cases admitted to Traumatic Emergency Room. An increasing number of traumas caused by traffic accidents, sports, leisure activities, and interpersonal aggressive conflicts as well as an aging population associated with a higher tendency to tumble due to various reasons [1].

Increase the quantity of midrace fractures which represent roughly 50% of facial fractures today [2]. Imaging is an important step after the clinical evaluation in the workup of patients with facial trauma in trauma or emergency room. It helps to define the extent of injury and to plan the surgical, interventional, or conservative therapy [3].

Multidetector computed tomography (MDCT) is the imaging technique of choice to detect and characterize the number of fractures, fragments, the degree of dislocation, and the involvement of anatomical structures. It provides a three-dimensional (3D) mapping of the smallest fractures and abnormalities in a short period of time in trauma and emergency setting. For this reason MDCT is superior to conventional imaging such as X-ray imaging [4].

Microplates with exact stereoscopic reconstruction are the best surgical treatment of facial fractures, and presurgical 3D planning based on MDCT data alleviates the surgical process by giving a better spatial understanding for surgeons of, e.g., dislocated fragments.

Heavy soft tissue edema without life-threatening bleeding or airway obstruction necessitates postponing of final surgery until resolution of edema [5].

1.1 Aim and objectives
1. To classify the fractures according to the bones involved in the patients evaluated.
2. To evaluate the advantages of 3D and Coronal reformatted images over axial images in various facial fractures.

2. Material and methods
This is a hospital based Cross-Sectional study carried out over a period of 24 months from November 2017 to October 2019. The present study was conducted at Department of Radiology, Dr. Pinnameneni Siddhartha Institute of Medical Sciences & Research Foundation, Gannavaram. Institutional ethical committee clearance was obtained from ethical committee of prior to the start of study. A written and informed consent was taken from patients who were participated in the present study. This study includes all the patients with clinical evidence of maxillofacial injuries who underwent multidetector CT examination and are shown to be positive for fractures.

2.1 Exclusion criteria
1. Patients with maxillofacial injuries in whom a CT examination is contraindicated E.G: Pregnancy.
2. Previous history of maxillofacial injuries.
3. Patient refusal.

2.2 Method of collection of data
All the images was acquired using Siemens 16 slice CT scanner in department of Radio diagnosis, PSIMS & RF.

2.3 Statistical analysis
Data collected was entered into MS-Excel 2013 spreadsheet. The collected data was analyzed using IBM statistical package for social sciences (IBM SPSS) version 23 software (trail version) Continuous variables was reported as mean ± standard deviation (SD) while categorical variables was expressed as absolute values and percentages.

3. Results
The study included 30 patients among which 8(26.7%) were ≤30 years, 6(20%) were 31-40 years, 8(26.7%) were 41-50 years, 6(20%) were 51-60 years and 2(6.7%) were >60 years. The mean age of the study population was 41.07±13.92 years with age range of 21-68 years.

Among 50 patients in the present study 21(70%) were male and 9(30%) were females. The gender ratio of male: female in the present study was 2.3:1.

In most of the cases the mode of injury was road traffic accidents among 23(76.7%). In the rest 4(13.3%) were due to fall and 3(10%) were due to assault.

Table 1: Distribution of patients according to physical examination findings

Physical Examination	Number	Percentage (%)
Suspected #	25	83.3%
Suspected Inrtra Cranial Bleeding	4	13.3%
Visual Defects	4	13.3%
Focal Swelling	15	50%
Soft Tissue Injury	10	33.3%
Others	18	60%

On physical examination 83.3% cases were suspected to have fractures. Focal swelling was seen in 50% of cases. 33.3% had soft tissue injury, 13.3% had suspected intra cranial bleeding and visual defects.

Among 30 patients, GCS score was poor (3-8) in 10% cases.

Table 2: distribution of fractures in different bones

	Number	Percentage (%)
Frontal	14	46.7%
Zygomatic	10	33.3%
Nasoorbital	13	43.3%
Maxilla	19	63.3%
Mandible	17	56.7%

Fracture maxilla 63.3% followed by mandible 56.7% was the most common bone involved in facial fractures. Other facial bones involved were frontal 46.7%, Nasoorbital 43.3% and zygomatic in 33.3% cases.

Table 3: Distribution of patients according to associated findings

	Number	Percentage (%)
Hemosinus	17	56.7%
Sdh	5	16.7%
Edh	3	10%
Sah	2	6.7%
Contusions	9	30%
Tmj	4	13.3%
Pneumocephalus	3	10%
Skull base	1	3.3%
Others	8	26.7%

Hemosinus (56.7%) was the most common associated finding in the patients who presented with facial trauma. Brain contusions were the next common finding seen in 30% patients. Pneumocephalus was seen in 10% patients. Other intra cranial complications like SDH, SAH and EDH were noted in 16.7%, 6.7% and 10% patients respectively. Skull base involvement was noted in 3.3% patients.

Table 4: Orbital Injury According To Wall Involved (N = 13)

Fracture Type	Number	Percentage (%)
Lateral wall	3	23.1%
Medial wall	5	38.5%
Roof	1	7.7%
Floor	4	30.7%

Medial wall of the orbit was the most common wall involved in orbital fractures.

Table 5: Classification of mandible bone # according to site of involvement (N = 17)

Mandible Injury	Number	Percentage (%)
Condylar	5	29.4%
Body	5	29.4%
Subcondylar	1	5.9%
Coronoid	2	11.8%
Ramus	1	5.9%
Angular	1	5.9%
Alveolar ridge	2	11.8%

The mandibular injuries were most common in the condyle and the body of the mandible of the 17 fractures that were detected in the mandible, 5 each were noted in the condyle and body constituting 29.4% each of the total fractures.

Table 6: Le forts fracture lines identified

	Number	Percentage (%)
Le Fort I	3	10%
Le Fort II	7	23.3%
Le Fort III	7	23.3%

Le Fort fracture lines were identified in 17 patients. The most common Le Fort line identified was the Le Fort II & Le Fort III which was seen 7 patients (23.3%) each. Le Fort I fracture lines were identified in 3 (10%) cases.

Frontal bone fractures: Frontal bone fracture detection and displacements were seen better on 3D images in more percentage of patients. However its extension, especially into 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 extend 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.

Naso-orbito-ethmoid bone 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 majority of 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.

4. Discussion

Maxillofacial trauma presents as isolated injuries or part of polytrauma and is clinically significant as the disruption of soft tissues and bones of the face cause facial asymmetry and disfigurement which causes emotional and cosmetic concerns and the region is also associated with several vital functions of daily living.

CT is the imaging modality of choice to display the multiplicity of fragments, the degree of rotation and displacement or any skull base involvement [5]. It has been demonstrated that multiline CT can obtain a greater range of anatomic coverage during the scan [6]. 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 [7].

As a result, computed tomography is often relied on to increase diagnostic certainty and to direct management [8]. For the evaluation of the facial skeleton and for surgical planning computed tomography is the preferred modality and can be easily integrated into the conventional trauma scanning protocol.

The present study was a hospital based descriptive study which was done among patients with clinical evidence of maxillofacial injuries who underwent multidetector CT examination referred to the Radiology department of Dr. PSIMS hospital, Gannavaram.

The study was conducted among 30 patients who underwent multidetector CT examination for a period of two years from Oct 2017 to Sep 2019 with an aim to classify the fractures according to the bones involved in the patients evaluated.

Among 30 patients in the present study 26.7% were ≤ 30 years and the mean age was 41.07±13.92 years with age range of 21 – 68 years.

Among 50 patients in the present study 70% were male and 30% were females. The gender ratio of male: female in the present study was 2.3:1. Similar male predominance 64% was also reported in the study conducted by Sohns JM *et al.*, [9] which was similar to the present study.

In most of the cases the mode of injury was road traffic accidents comprising 76.7% cases. Assault and fall from height were the other causes, comprising 13.3% and 10% respectively. The location of the hospital midway along the national highway which could explain for increased number of RTA cases presenting to the hospital.

On physical examination 83.3% cases were suspected to have fractures. Focal swelling was seen in 50% of cases. 33.3% had soft tissue injury, 13.3% had suspected intra cranial bleeding and visual defects.

Among 30 patients, GCS score ≤ 8 (severely depressed) in 10% cases.

Fracture maxilla 63.3% followed by mandible 56.7% was the most common bone involved in facial fractures. Other facial bones involved were frontal 46.7%, Nasoorbital 43.3% and zygomatic in 33.3% cases.

Sohns JM *et al.*, [9] Study had reported that maxilla and Nasoorbital bones were the common sites involved which was similar to the present study.

Hemosinus (56.7%) was the most common associated finding in the patients who presented with facial trauma. Brain contusions were the next common finding seen in 30% patients. Pneumocephalus was seen in 10% patients. Other intra cranial complications like SDH, SAH and EDH were noted in 16.7%, 6.7% and 10% patients respectively. (Fig 5, Fig 6). Skull base involvement was noted in 3.3% patients. Medial wall of the orbit was the most common wall involved in orbital fractures.

Wahab MAKA *et al.*, [10] had reported that the most frequently fractured orbital wall is the medial wall seen in 63.6%, followed by the lateral and orbital floor and the least orbital boundary to be fractured was the orbital roof which was similar to the present study.

The mandibular injuries were most common in the condyle and the body of the mandible of the 17 fractures that were detected in the mandible, 5 each were noted in the condyle and body constituting 29.4% each of the total fractures (Fig 1). Le Fort fracture lines were identified in 17 (56.7%) patients. The most common Le Fort line identified was the Le Fort II & Le Fort III which was seen 7 patients (23.3%) each. Le Fort I fracture lines were identified in 3 (10%) cases (Fig 2, Fig 3, Fig 4).

In the assessment of frontal bone fracture, detection, and displacements were seen well on 3D images in more percentage of patients. However, on 3D images, its extension, especially into the posterior wall of the sinus or roof of the orbit, was not adequately visualized. This may be due to the overlap of the bony anterior wall of the sinus restricting visualization.

Coronal images were found to be similar to axial images in the detection of fractures in frontal bones. For the description and detection of extent in most patients with zygomatic bone, 3D images were found to be similar or better for 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.

The 3D images were found to be inferior in the assessment of detection, extent, and displacement of fractures in the nasoorbitoethmoid 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 the orbit.

3D images were superior in the detection of fractures in the maxilla, especially with the involvement of the 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 the maxilla of most patients.

Other studies have also described 3D CT as being most useful for imaging comminuted fractures of the middle third of the face and the zygomaticomaxillary complex [11, 12].

Three dimensional imaging is not indicated, however, for small fractures of the orbital floor or isolated fractures of the maxillary wall, in which the fracture is limited to one plane. Here, examining 3D scans alone can give false-negative results [13].

According to Tanrikulu and Erol, [14] axial and coronal CT images are adequate for the 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 enophth almost.

These findings were consistent with the findings in this study with Nasoorbitoethmoid fractures, where 3D images were found to be inferior to axial images in detect of fractures, their extent and in assessing displacement. The thin bones in these regions causing partial volume averaging resulting in ‘pseudoforamina’ and considerable bony overlap could explain this findings.

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

Many studies have noted that 3D reconstructed images are helpful in the evaluation of fracture comminution, displacement components, and complex fractures involving multiple planes [15]. The extent of comminuted fractures is better demonstrated on the 3D-CT, where the size, shape, and displacement of individual fragments are clearly revealed [16, 17]. The combination of multiline CT and 3D volume rendering technique allowed several improvements in imaging interpretation.

In the present study, as well it was seen that the 3D reconstructions were helpful in the evaluation of comminuted fractures, displacement components, and complex fractures involving multiple planes.

5. Figures

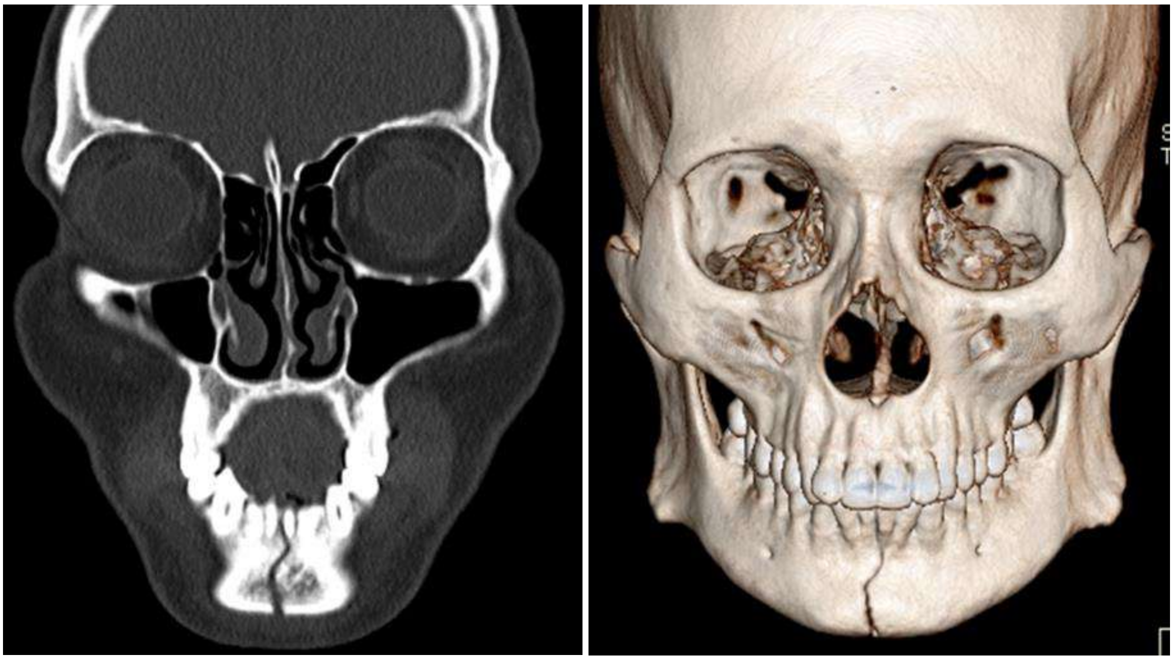

Fig 1: Coronal and 3Dimages better demonstrates linear fracture along mandibular symphysis

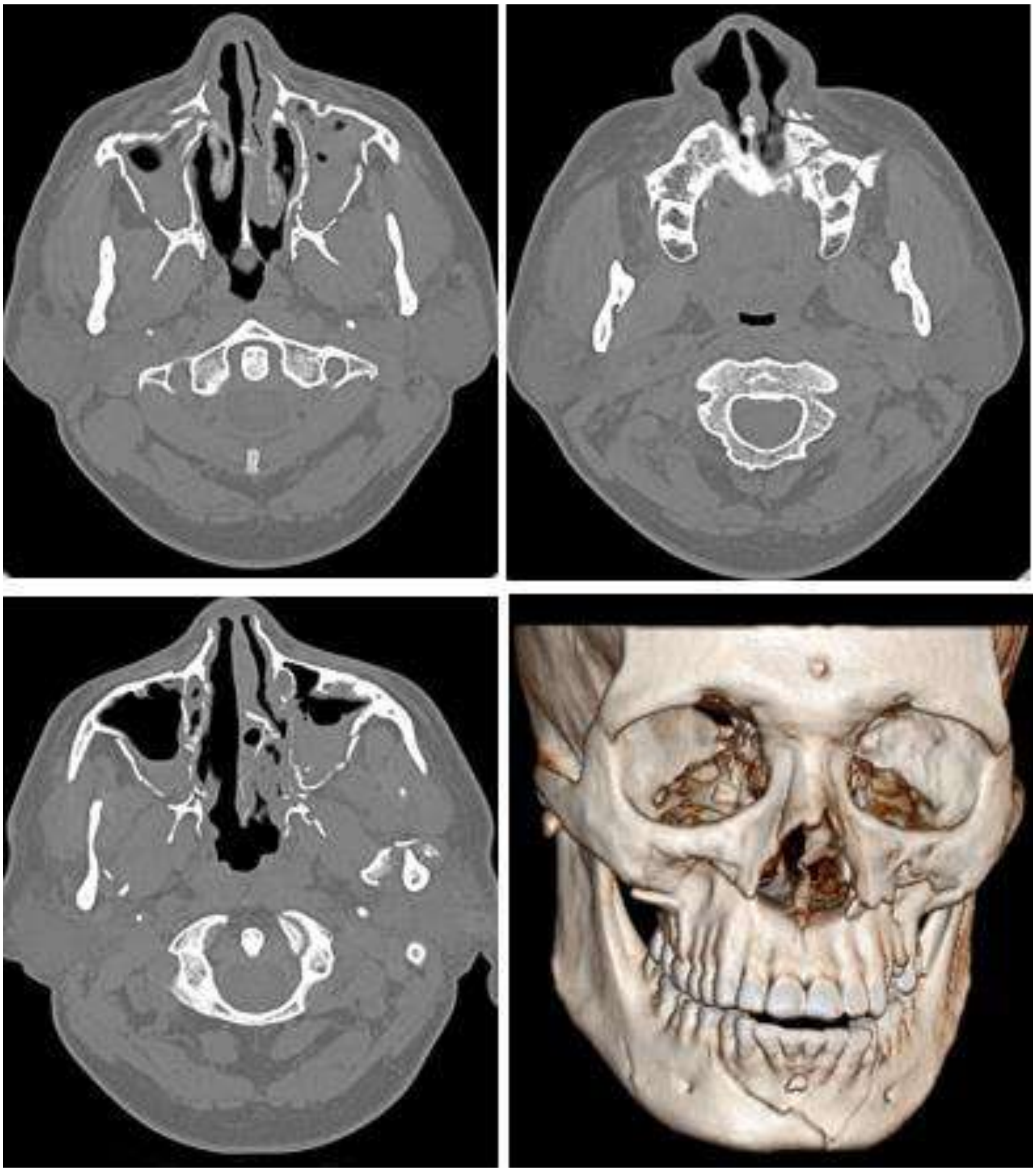

Fig 2: Axial & 3D images better demonstrate the fractures of bilateral maxillary sinuses, bilateral hem sinuses, bilateral pterygiod plates, body of maxillae and hard palate represents Ledford I fracture

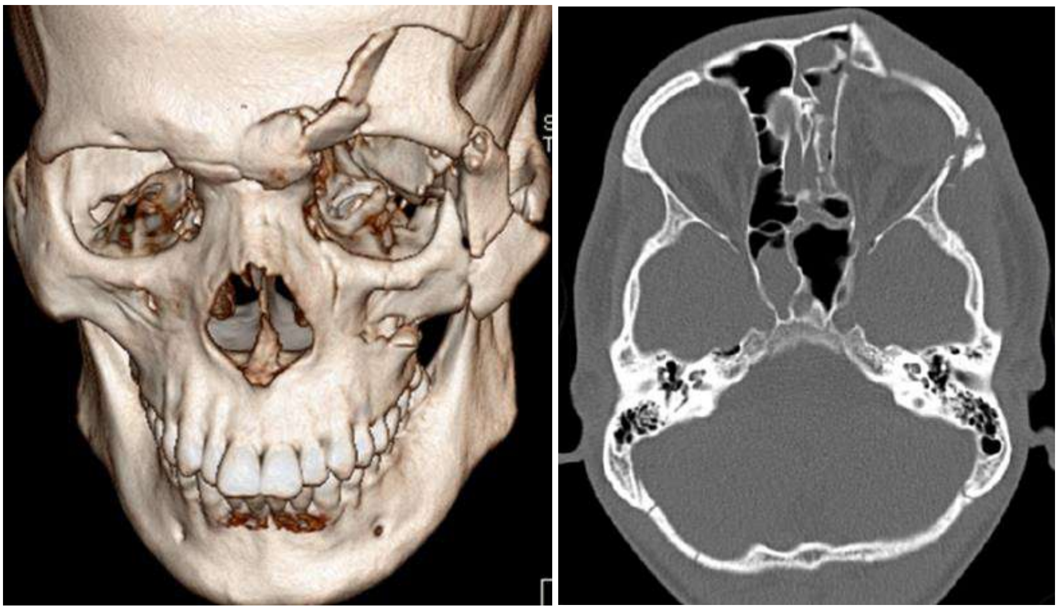

Fig 3: Axial & 3D images better demonstrate the fractures of maxillary sinuses, bilateral hem sinuses, superior walls of left orbit bilateral pterygiod plates, & frontal bone represents Ledford II fracture

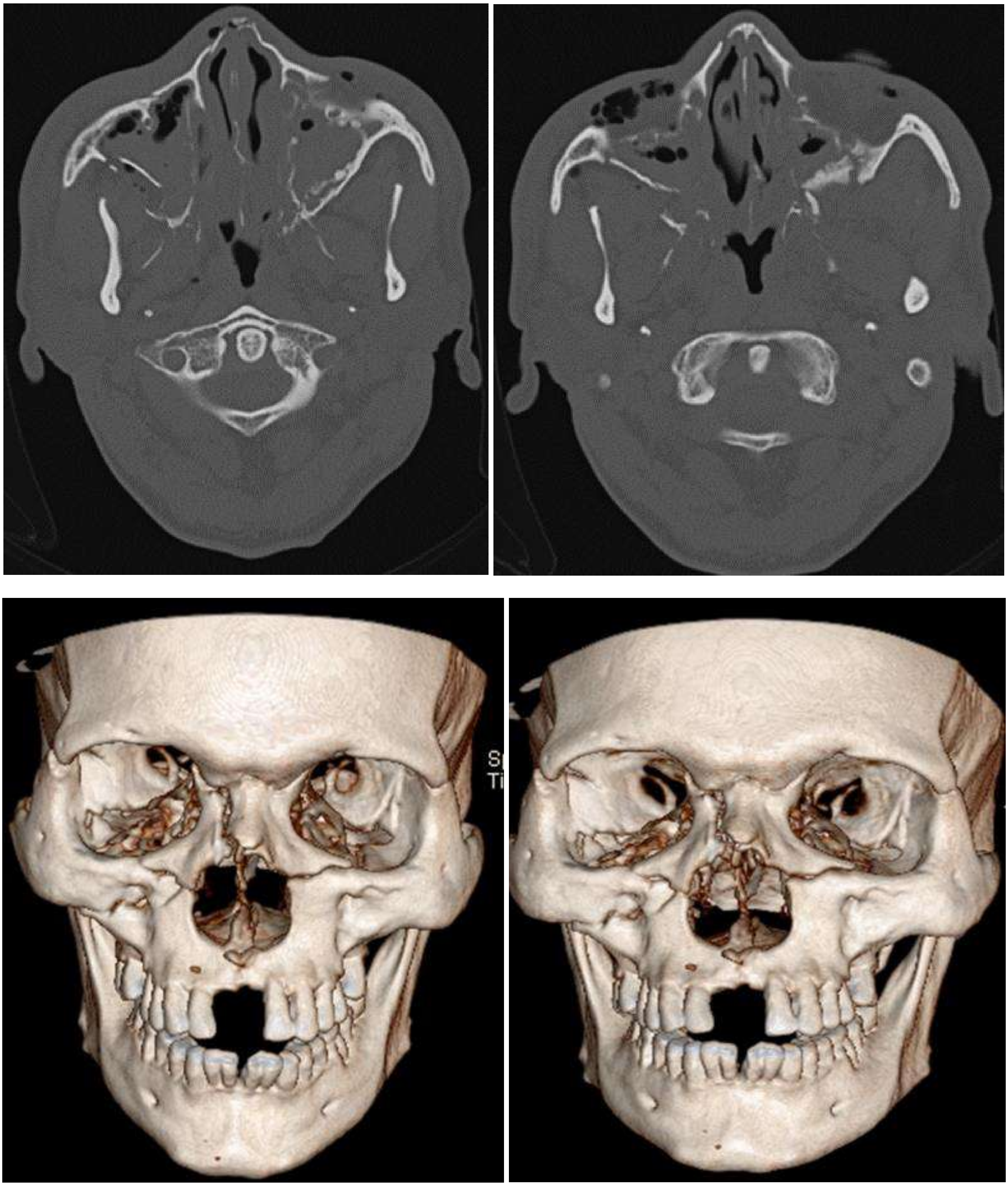

Fig 4: Axial and 3D images demonstrates fractures of bilateral maxillary sinuses, nasal bones along with septum, lateral walls of orbit with hem sinus and gas pockets in subcutaneous & right orbit represents the Ledford III fracture lines

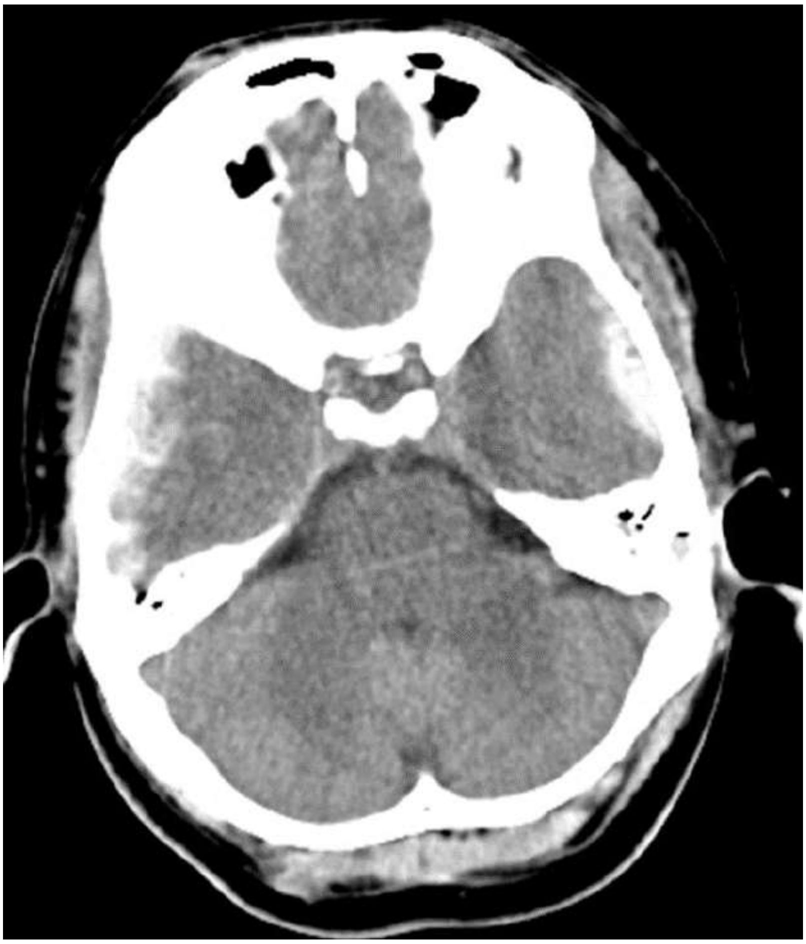

Fig 5: Axial images showing Extra Dural Hematoma (EDH)

Fig 6: Axial images showing Sub Dural Hematoma (SDH) with Sub Arachniod Hemorrhage (SAH)

6. Conclusion
The complex anatomy of the facial bones requires multiplanar imaging techniques for a proper evaluation. The main purpose of diagnostic imaging is to detect and localize the exact number, site of facial fractures and soft tissue injuries. 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. MDCT offers excellent spatial resolution, which in turn enables exquisite multiplanar reformations, and 3-D reconstructions, allowing enhanced diagnostic accuracy and surgical planning.

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