

ORIGINAL ARTICLE

## Assessment of changing patterns of Le fort fracture lines using computed tomography scan: an observational study

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### Abstract

**Objectives.** To assess the changing mid-face fracture patterns using a computed tomography scan. **Methodology:** Fifty patients with mid-face trauma requiring open reduction and fixation were studied using 1.6 mm axial, sagittal, coronal and 3D images. Images were evaluated clinically, intra-operatively and finally were compared with standard Le Fort lines. **Results.** The male population dominated the female at a ratio of 11.5:1. The majority of the mid-face fractures were seen in the age group of 21–30 years. Road traffic accident (78%) was the major etiological factor followed by work-related accidents (12%) and assaults (10%). The CT scan analysis included categorizing the patients into three groups: (1) Fracture patterns resembling Le Fort lines (24%); (2) Fracture patterns partially resembling Le Fort lines (56%); and (3) Fracture patterns that do not resemble Le Fort lines (20%). **Conclusion.** With the change in the velocity of wounding object, there is a change in the mid-face fracture patterns. The majority of the cases present as a variant of classical Le Fort fractures. Computed tomography is a valuable diagnostic tool in assessing the fractures of the mid-face. 2D images are more sensitive than 3D images. However, both the images are required in delivery of an optimal treatment plan.

**Key Words:** axial, coronal images, 3D reconstruction images, Le Fort fracture, mid-face fractures, sagittal

### Introduction

In 1901, Rene Le Fort conducted three experimental studies on 35 cadavers and proposed the three great lines of weaknesses, popularly known as Le Fort fracture lines. Although the etiology for mid-face trauma remains the same as proposed by Rene Le Fort, what has changed over the years is the velocity of the wounding objects. The mass and the velocity of the wounding object dictate the type of fracture. The majority of the mid-face trauma occurs due to road traffic accidents; thus, today we more often are encountering a variation of Le Fort fractures. Most of the cases present as permutations and combinations of Le Fort fractures [1,2].

Hence, we aimed at studying the varying fracture patterns of mid-face using 1.6 mm axial, sagittal and coronal slices along with 3D images.

### Methodology

The study comprised of analyzing 50 cases with maxillo-facial trauma reporting to K.L.E. Prabhakar Hospital, Department of Oral and Maxillo-facial Surgery, Belgaum, during the years 2010–2012. Ethical clearance was obtained by the Institutional Ethical Committee. Informed consent was taken from the patients. Patients with bony injuries to the maxillo-facial skeleton above the age of 18 years were included. Cases of pathological fractures and isolated

soft tissue injury were excluded. The fractures were evaluated using 3D images and 2D computed tomography scan primarily. Images obtained by these two techniques were evaluated clinically, intra-operatively and were finally compared with the standard Le Fort fractures lines. The data collected were age, sex and etiological factor for the maxillo-facial trauma. The analysis included categorizing the fracture pattern into three groups, namely:

- (1) Fracture patterns that resemble Le Fort classification;
- (2) Fracture patterns that partially resemble Le Fort classification; and
- (3) Fractures that did not conform to Le Fort classification.

## Results

Out of 50 cases, males accounted for 92% ( $n = 46$ ) and females accounted for 8% ( $n = 4$ ). Males dominated the mid-face fracture group with an overall ratio of 11.5:1. The highest incidence was noted in the age group of 21–30 years, followed by 31–40 years. The etiological factors were:

- (1) Road Traffic Accidents ( $n = 39$ ) in 78% of cases;
- (2) Work related ( $n = 6$ ) in 12% of cases; and
- (3) Assaults ( $n = 5$ ) in 10% of cases.

The majority of the fractures that occurred partially resembled the Le Fort lines 56% ( $n = 28$ ). Only 24% ( $n = 12$ ) of the fractures resembled the classical Le Fort lines. The fractures that were seen least commonly were the comminuted fractures and those which did not resemble the Le Fort lines ( $n = 10$ ). Partially resembling Le Fort fracture lines were associated with other mid-face fractures like dento-alveolar fractures, zygomatico-maxillary complex fractures, naso-orbito-ethmoid fractures and palatal fractures (Tables I-IV).

## Discussion

The complexity of the mid-face skeleton poses a great challenge to the operator in making an accurate assessment, diagnosis and treatment planning. Anatomically the mid-face is located between the cranium superiorly and occlusal plane inferiorly. It acts as a cushion, absorbing the forces and, thus, protecting the cranium. Mid-face is made up of wafer thin bones that

Table II. Age-wise comparison of the cases.

Age	$n$	%
2nd decade	27	54
3rd decade	12	24
4th decade	7	14
5th decade	3	6
6th decade	1	2
Total	50	100

are encased within the mucosal lining. Strength to the mid-face is provided by the vertical buttresses (nasomaxillary, pterygo-maxillary and the zygomatico-maxillary) and the horizontal buttresses (supra orbital rim, infra orbital rim and the occlusal plane) [3,4].

Today, the majority of the fractures which occur rarely correlate to the classical Le Fort fracture lines. This could be attributed to the change in the mass and the velocity of the wounding object. In motor vehicle accidents, three types of collision can occur. First when the victim is static and the wounding object is moving, second when the victim is moving and the wounding agent is static and third when both are moving at varying velocities [5]. The third type of collision leads to comminuted fractures. Airbags and seat belts play a vital role in high velocity accidents as they act as a cushion, absorbing the kinetic energy of the body. Thus, today we see more complex fracture patterns and rarely see the classical Le Fort lines [6].

In our study, males dominated the females at a ratio of 11.5:1, which was found to be slightly higher than the findings that were observed by Kadkhodaie [7] (10:1) and almost the same as observed by Hachl et al. [8] (11.8:1). The studies done by Maladiere et al. [9], Iida and Kugo [10], Ajike et al. [11] and Subhashraj et al. [12] also concluded that males dominated females. The current study results correlated with the findings observed by Iida and Kugo [10], Ajike et al. [11], Subhashraj et al. [12], Sawhney and Ahuja [13], Haug and Adams [14] and Abiodun et al. [15]. On the contrary, a study done by Olasoji et al. [16] on changing the picture of facial fractures in a selected population of Northern Nigeria found that interpersonal violence was the major etiological factor. Thus, incidence of head injuries resulting from road traffic accidents is drastically

Table I. Gender-wise comparison of the cases.

Sex	$n$	%
Male	46	92
Female	4	8
Total	50	100

Table III. Etiologic factors for the fracture.

Etiology	$n$	%
Road traffic accidents	39	78
Work-related	6	12
Assault	5	10
Total	50	100

Table IV. Fracture patterns.

Classification	<i>n</i>	%
Ideal Le Fort fractures	12	24
Partially resembling Le Fort fractures	28	56
Comminuted fractures	10	20

being taken over by interpersonal violence in a few countries. Fabio et al. [5] has reported a decrease in the mid-face fractures by 40% when airbags are used.

Although the Le Fort classification was given 100 years ago, to date it is considered as the gold standard in classifying mid-face fractures. Today, due to the change in the velocity of the vehicles being used, the classical Le Fort lines are rarely being encountered. Most of the fractures seen today are a permutation and combination of Le Fort lines. In our study, the majority of the fracture patterns partially resembled the Le Fort fractures (56%). Surprisingly, only 24% of the cases were ideal Le Fort lines and 20% of the lines did not resemble the classical lines at all. The partially resembling fracture patterns are actually a combination of Le Fort I, II or III lines or are associated with the other mid-face fractures like zygomatic complex fractures, naso-orbito-ethmoidal or dento-alveolar and palatal fractures [17]. The results of the present study are similar to the studies conducted by Dawson and Fordyce [18], Beck [19], Frank and Marentette [20] and Tong et al. [21].

The mid-face skeleton is related to the skull base through the suture lines. Due to the increase in the velocity of the wounding agent, the fractures are no more seen to be restricted to the mid-face. They are now seen to be extending to the anterior skull base. Twenty-eight per cent of the cases in our study showed involvement of the anterior skull base. Marciani [6], Maladiere et al. [9], Subhashraj et al. [12], Abiodun et al. [15] and Pappachan and Alexander [22], in their respective studies, also observed the extension of mid-face fractures into the skull base.

The short-comings of Le Fort classification are:

- (1) Unilateral, comminuted and pan-facial fractures are not described.
- (2) Other associated mid-face fractures are not considered.
- (3) The correlation between skull base and mid-face is not mentioned.
- (4) Pediatric and mixed dentition fractures are not included.

Marciani [6] re-assessed the mid-face fracture patterns to overcome the short-comings of Le Fort lines and modified the Le Fort classification system. He included nasal bone fractures, naso-orbito-ethmoidal and anterior skull base fractures. An extension of Le Fort II and III lines into the anterior skull base were

described as Le Fort IV lines. However, Marciani's modified classification also fails to accurately represent every single injury of the complex mid-face fractures. An ideal classification system must give a clear picture of soft tissue and hard tissue injuries and the operator must be able to assess the severity and the complexity of the injury. The system must provide therapeutic information and must be able to guide the surgeon in picking up an accurate treatment option.

Carlos et al. [23] proposed a new classification system on the basis of Arbeitsgemeinschaft Fur Osteosynthesefragen/Association for the Study of Internal Fixation system (AO/ASIF). This classification system precisely describes the majority of the fractures line seen to be occurring in mid-face and the skull base. The limitation with this classification system is that it fails to address the soft tissue injuries and the associated mandibular fractures. Moreover, it is mandatory to know the AO classification system, as it forms the basis of the newly proposed classification system.

Donat [24] proposed a new classification system based on the skeletal support mechanism. In this system, 11 unilateral and 22 bilateral sites are described. A total of 2047 fracture combinations have been explained. The major drawback with this system is it is difficult to apply in clinical practice. Even though the system describes 2047 fracture combinations, it still fails to include most common fractures like nasal bone fractures and the orbital floor fractures and does not describe the degree of displacement.

The computed tomography (CT) scan has been regarded as the gold standard in fracture detection. 3D images are of great value in diagnosing complex and comminuted fractures and well treatment planning becomes very easy, accurate and less time-consuming. In our study, the 3D images could be correlated accurately with the intra-operative findings. The surgeon and trainees were able to assess accurately the degree of displacement of the fractures. However, the 3D images failed to give information regarding soft tissue injuries and there could be minor artefacts while the 3D images are being formed using the 2D views. The 2D views provided excellent information on every minute fracture line. Soft tissue injuries like fat or muscle entrapment, hematoma, etc., could clearly be seen [25].

In the current study, Le Fort I fractures were best appreciated in coronal cuts, Le Fort II in axial and coronal cuts and Le Fort III in axial and sagittal cuts. The conventional radiographs failed to give details of the soft tissue injuries and also there is a lot of overlapping, especially in the mid-face region. Thus, CT is highly sensitive and accurate in detecting craniofacial fractures.

## Conclusion

With the change in lifestyle, a change in the fracture patterns is being noticed. Newer vehicles travel at a



Figure 1. Bilateral Le Fort fracture lines seen at varying levels.

higher speed. The type of fractures that occur depends upon the mass and velocity of the striking object. As the fracture patterns are changing there is a need for revising the Le Fort classification. There is a change in the treatment with the change in the fracture patterns. The classical lines were treated with open reduction and fixation. Comminuted fractures were treated using splints or suspension wiring. Although these are traditional methods of fracture fixation, the results obtained were satisfactory. The variant of Le Fort fractures required additional fixation. Thus, the treatment planning depends on how well the fractures are been classified.

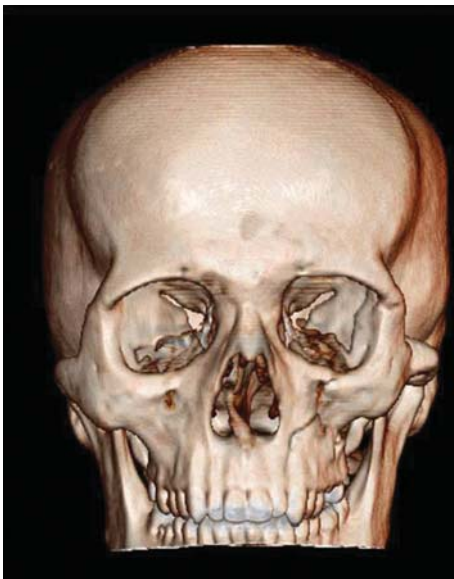


Figure 2. Intact fronto-nasal component, frontal process of maxilla and lacrimal bone.

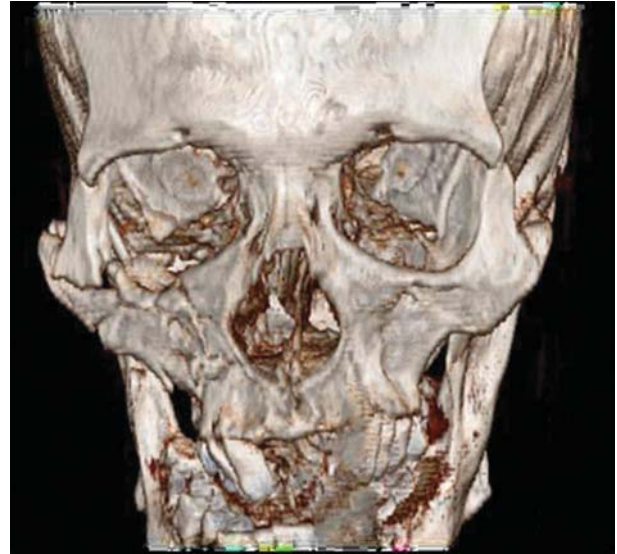


Figure 3. Right Le Fort III fracture.

### Case discussions

#### Case 1

In this case, bilateral Le Fort fracture lines are seen at varying levels (Figure 1). For this case neither Le Fort classification nor its modification holds good. It is said that the highest fracture line must be designated. Considering the highest designation it will be classified as Le Fort III.

*Query.* The question that arises here is that, if it is a Le Fort III fracture then the fractures at the lower level will not be classified, which will definitely affect the treatment plan. The naso-maxillary and zygomatico-maxillary buttresses will not be fixed if it is a Le Fort

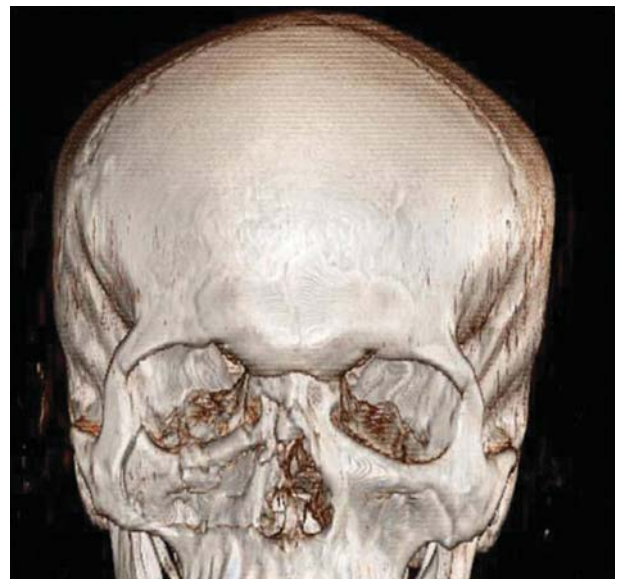


Figure 4. Right comminuted Le Fort II fracture with ZMC.

III fracture, which are a must to be stabilized in Le Fort I and II fractures.

#### Case 2

In this case, the fracture line is running from the canine fossa to the lower one third of the pterygoid plates, but the fronto-nasal component, frontal process of maxilla and lacrimal bone are intact (Figure 2).

*Query.* It cannot be called Le Fort II because the fronto-nasal component, frontal process of maxilla and lacrimal bone are intact, neither can it be called Le Fort I because the line is not involving the nasal septum and pyriform aperture. The fracture line is running from the canine fossa to the lower one third of the pterygoid plates. There exists a parasagittal split.

Will this case be regarded as a variant of Le Fort I with zygomatico-maxillary complex (ZMC)?

#### Case 3

This is a case of right Le Fort III fracture (Figure 3). The left side of the infra-orbital line extends and terminates at the dento-alveolar component without extending to involve the pterygoid plates.

*Query.* Can Le Fort fractures terminate at the alveolar segment without fracturing the pterygoid plates? Or is it a dentoalveolar fracture extending higher up?

#### Case 4

This is a case of right comminuted Le Fort II fracture with ZMC (Figure 4). The left side there is incomplete Le Fort II fracture without involving the pterygoids.

*Query.* Can comminuted Le Fort fractures occur without pterygoid plate involvement?

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