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Analysis of Patterns of Zygomaticomaxillary Complex Fractures: A Retrospective CT scan based study

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ABSTRACT

Aim: The purpose of this study was to analyse retrospectively the Zygomaticomaxillary complex fracture patterns using Computed tomography scans with three-dimensional reconstruction.

Methods: A radiographic retrospective study was carried out on CT scans of patients diagnosed with isolated ZMC fractures.Fracture images were studied and the patterns of fractures were documented. Other variables assessed include, distribution of types of fractures, presence or absence of orbital floor fractures and the relation of fracture line to the infra orbital foramen. Various demographic data like age and gender of thepatients and the mode of injurywas documented from patient records and correlated with the CT scan data.

Results: A total of 198 scans were analysed, of which, records of only 163 patients was available and were included in this study. Majority of cases belonged to the age group of 21-30 years with a definite male predilection (88.3%).The most common mode of injury was motor vehicle accidents. The etiologywas found to be significantly associated with side of fracture (p 0.00).Majority of the fracture patterns were of the atypical type (65.6%) and fracture pattern and etiologywas found to have a statistically significant correlation.Type IVwas found to be the most common type of fracture was statistically significant with the mode of injury (p 0.00).Orbital floor and medial wall fractures were present in 64.4% were mostly present in patients with MVA type of etiology and has minimal significance (0.053).The anteromedial fracture line over the anterior surface of maxilla was most commonly seen to pass through the IOF. This was found to be statistically significant in relation to the mode of injury (p value 0.03) of the fracture.

Conclusion: Successful management of ZMC fractures greatly depends on the detailed study of the fracture patterns. The aetiology of fractures as proposed in literature has changed over the years and this has brought about a change in the fracture patterns that are encountered.

Keywords: ZMC fractures, fracture patterns, orbital fractures, infraorbital foramen, Knight and North classification

INTRODUCTION

The Zygomaticomaxillary complex (ZMC) forms the most crucial part of the facial skeleton by providing both vertical and horizontal pillars to the facial framework. Zygoma is a strong buttress that forms the malar prominence

and is the principle structure of the lateral portion of midface(1,2). Its prominent position, makes it is vulnerable to traumatic forces and hence it is prone to fractures either alone or in combination with other structures of midface(3). The severity and pattern of the fracture is determined by the magnitude of the etiologic force, duration of impact, energy imparted by it to the part of the body struck, and the change in rate of acceleration(4,5)

A ZMC fracture can be anatomically designated as a "tetrapod" due to its four articulations that include the frontozygomatico (FZ) suture, zygomaticotemporal suture (ZT), zygomaticomaxillary buttress suture (ZMB) and zygomaticosphenoid suture s (ZS) respectively(6). These fractures involve disruption at four sites that include the frontozygomatic region, the infraorbital rim, the ZMB and the zygomatic arch(7). The typical lines of a ZMC fracture are the three lines that extend from the inferior orbital fissure in an **anteromedial, superolateral, and inferior** direction(8,9).

The use of three-dimensional evaluation is known to have many potential applications that include diagnosis and surgical planning and may also be used for postoperative comparisons. The CT evaluation is vital because of the complex nature of these fractures and the daunting task of their repair(7). The purpose of this study was to analyse ZMC fracture patterns using CT scans with three-dimensional (3D) reconstruction in relation to its etiology and to determine the incidence, cause, age, and gender predilection of ZMC fractures.

MATERIALS AND METHODS

After obtaining ethical clearance from the institutional ethical committee, the records and CT scans of 163 patients who reported to the Department of Oral and Maxillofacial Surgery Goa Dental College and Hospital, Bambolim – Goa from January 2016 to December 2020 were retrieved. A radiographic retrospective study of CT scans of patients diagnosed with ZMC fractures was conducted using 1-1.6 mm axial, sagittal, coronal sections and their 3D reconstruction. Demographical data was recorded in terms of age, gender, etiologyand correlated with the fracture type and patterns.

The inclusion criteria were CT scans of patients with isolated ZMC fractures with or without orbital fractures belonging to the age group of 18- 70 years and availability of complete CT scan of midface with history and demographic data. The exclusion criteria were scans with isolated zygomatic arch fracture and malunited fractures.
The CT scans with 3D reconstruction of the ZMC fracture were studied using the RadiAnt DICOM Viewer software and were divided into two groups: Typical fracture lines and atypical fracture lines.

Typical Fracture Group
Zygomaticomaxillary complex fractures without any deviations from the previously mentioned typical fracture lines with or without orbital floor and medial wall fractures were included in the typical fracture group. (Fig 1)

Fig 1: Typical ZMC fracture pattern

Atypical Fracture Group
Fracture patterns that were incomplete or not constituting the three fracture lines, deviations from typical lines, severely comminute fractures, fracture lines characteristically involving the body of zygoma but not the processeswere included in atypical group.(Fig 2)

Fig 2: Atypical ZMC fracture pattern

Other variables noted include:

- Distribution of types of fractures classified according to the Knight and North classification (1961)(10)
- Presence or absence of orbital floor fractures
- Relation of fracture line to the infra orbital foramen

Statistical Analysis

Statistical analysis was done using Chi-square tests and software SPSS version 20. A p value of <0.05 was accepted to confirm statistical significance.

RESULTS

A total of 198 scans were analysed, of which, records of only 163 patients was available and were included in this study. On demographic analysis, it was noted that majority of cases belonged to the age group of 21-30 years. A major proportion of the study sample consisted of male patients (88.3%). (Figure 3 and Table 1)

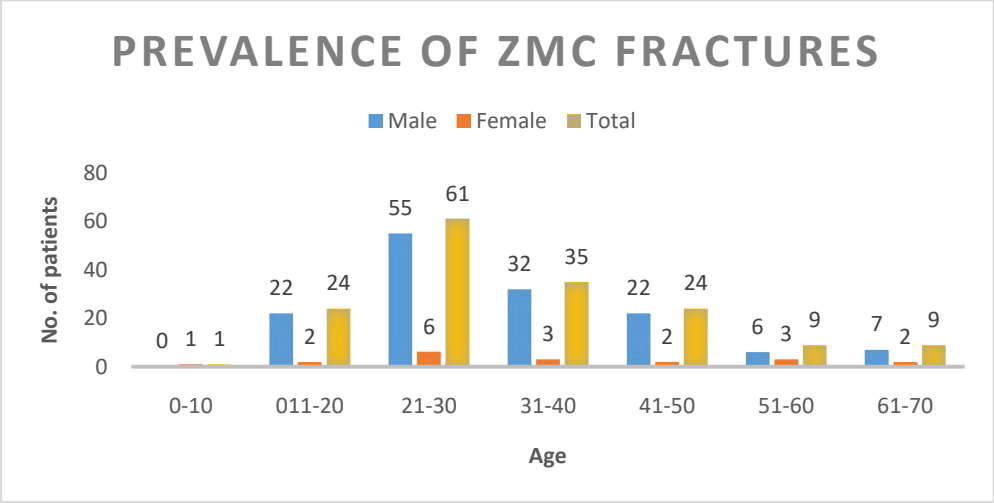

Fig 3: Prevalence of ZMC fractures

Table 1 Gender Distribution

Gender	Number of Patients
Male	144 (88.3%)
Female	19 (11.7%)
Total	163 (100%)

Mode of Injury

Motor vehicular accidents contributed to a majority of ZMC fractures (69.9%), followed by assaults (17.8%) and falls (9.8%). The mode of injury is summarised in table 2.

Table 2 Mode of Injury

Mode of Injury	Number of cases
MVA	114 (69.9%)
Fall	16 (9.8%)
Assault	29 (17.8%)
FFH	1 (0.6%)
Sports	3 (1.8%)
Total	163 (100%)

Location of fracture

Left sided fractures (50.3%) were found to be more common than the right sided (48.5%) while bilateral fractures were seen in 1.2% (fig 4). The etiologywas found to be significantly associated with side of fracture (p 0.00). Left zygoma was most commonly afflicted in altercations while fractures caused by MVAs showed no such predilection.

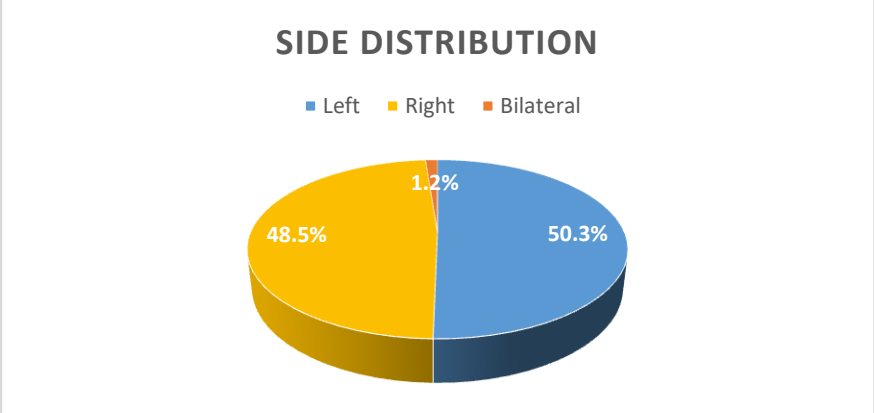

Fig 4 Side distribution

Pattern of fracture

Majority of the fracture patterns were of the atypical type (65.6%). The fracture pattern and etiology was found to have a statistically significant correlation. (table 3)

Table 3 Distribution of fracture pattern

Pattern	No. of cases
Typical fracture lines	56 (34.4%)
Atypical fracture lines	107 (65.6%)
Total	163 (100%)

Types of fractures classified according to the Knight and North classification

The medially rotated body of zygoma type of fracture (type IV) was found to be the most common type in this study as depicted in table no 4. The fracture types were statistically significant with the mode of injury (p 0.00).

Table 4 Distribution of fracture type

Type	Description	No. of patients
I	Un-displaced fractures	26 (16%)
III	Depressed body without rotation	50 (30.7%)
IV	Medially rotated fractures	56 (34.4%)
V	Laterally rotated fractures	21 (12.9%)
VI	Complex fractures	10 (6.1%)
Total		163 (100%)

Presence or absence of orbital floor fractures

Orbital floor and medial wall fractures were present in 64.4% were mostly present in patients with MVA type of etiology (Table 4). This was found to have mild statistical significance with etiology (0.053).

Table 5 Distribution of orbital floor and/or medial wall fractures

Orbital floor and/or medial wall fracture	No. of patients
Present	105 (64.4%)
Absent	58 (35.6%)
Total	163 (100%)

Relation of fracture line to the infra orbital foramen

The anteromedial fracture line over the anterior surface of maxillawas seen to have a varied relation to the infraorbital foramen as depicted in table 6. It was most commonly seen to pass through the IOF. This was found to be statistically significant in relation to the mode of injury (p value 0.03) of the fracture. (Fig 5)

Table 6 Distribution of relation of fracture line to Infra orbital foramen

Relation to Infra orbital foramen	No of cases
Not applicable	11 (6.7%)
Medial to IOF	13 (8%)
Through IOF	77 (47.2%)
Lateral to IOF	44 (27%)
Two lines Medial and lateral to IOF	18 (11%)
Total	163 (100%)

*not applicable represents cases with incomplete lines

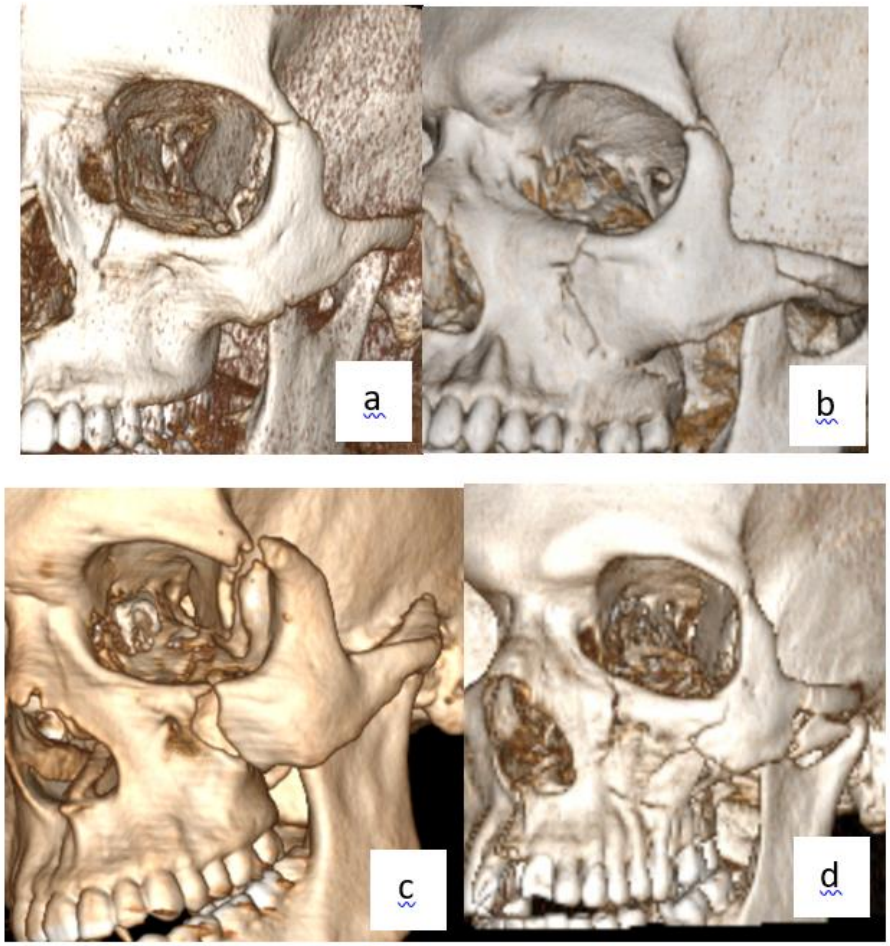

Fig 5 CT scan 3D images
a Fracture line medial to IOF b Fracture line through IOF
c Lateral to IOF d medial and lateral to IOF

DISCUSSION

The Zygomatic bone is a quadrangular bone that forms the prominence of the lateral midface hence ZMC fractures are the second most common fractures after nasal bone fractures.These fractures may result in severe aesthetic and functional sequelae due to its prominent position and proximity to vital structures. Thorough CT evaluation is crucial for surgical planning and precise reduction and fixation of these complex fractures.

In this study, the age group most commonly involved belonged to the 3rd decade.This was similar to findings of studies reported by Chowdhury et al(11), Ozemene et al(12), Fasola et al(13)(14). Our study recorded that ZMC fractures occurred more commonly in males than in females. Similar findings were found in other studies byOzemene et al(12), Chowdhury(11), Kovacs FA et al(15). In the present study the most common mode of injury was found to be road traffic accident Similar high incidence of road traffic accidents were reported by Yamsani et al(3), Fasola et al, (13)Ozemene(12). However, Kovacs et al(15), Zingg et al(16)reported interpersonal violence as the leading cause of ZMC fractures. In the present study the etiology was found to be significantly associated with the side of fracture and is in congruence with various studies reported in literature(9).The etiology of facial fractures has changed over decades and it continues to do so(14).

In this study, the cases were dividedinto typical and atypical types as mentioned previously. On statistical analysis,we noted that there was significant difference betweenthe two groups with regards to their etiology. Number of MVAs was considerably higher in the atypical group ascompared to the typical group. These findings suggested that MVA will most likely result in atypical fractures which require greater amount of fixation due to the complex nature of injury. Similar findings were noted by Dikhit et al(2).

We then classified the cases based on the Knight and North classification(10) and noted that medially rotated body of zygoma type of fracture was found to be the most common type of fracture and showed a positive correlation to the etiology. According to the original study by Knight et al the most common type of fracture was type III fracture. They also noted that the type IV fracturesare most likely caused by a blow on the malar prominence, from above the horizontal axis of the bone and this drives the bone backwards, inwards, and downwards but with a medial rotation(10).

In this study, orbital floor and medial wall fractures were present in majority of the cases 64.4%with MVA type of etiology. E Ellis et al(17)showed that ZMCfractures are mostly associated with fractures of the internalorbit. A fracture line extends from the inferior orbitalfissure anteromedially along the orbital floor toward the infraorbital rim and may be associated with comminution of the floor of the orbit. Hence, diagnosis of an associated orbital fracture is critical for adequate correction of the orbital volume. It is therefore an important component in the overall management of ZMC fractures.

The fracture line over the infraorbital rim and anterior wall of maxilla was seen to have a varied relation to the infraorbital foramen. In this study we noted that the fracture line passed through the IOF in a majority of the cases. This was in congruence with the finding in a study by El-Anwar et al(18) which stated that the IOF was a weak point over the midface and showed a higher incidence of involvement by the fracture line. The location of the IOF also plays an important role in treatment planning. Literature suggests the strong need for exploration of orbital floor when the fracture line passes medial to the IOF(19).

CONCLUSION

The aetiology of fractures as proposed in literature has changed over the years with rising technology and this has brought about a change in the fracture patterns that are encountered. Trauma inflicted in MVAs was found to be more severe as compared to other modes of injury. Successful management of ZMC fractures greatly depends on the detailed study of the fracture patterns by thorough CT evaluation and its correlation with etiology.

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Compliance with Ethical Standards
Conflict of interest: The authors declare that they have no conflict ofinterest.

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