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Original Research Article

Radiological assessment of two-point versus three-point fixation in unilateral zygomatic tripod fractures: a comparative study

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ABSTRACT

Background: Zygomaticomaxillary complex (ZMC) fractures, common in craniofacial trauma, require precise surgical management to restore function and aesthetics. This prospective randomized interventional study compared outcomes of two-point versus three-point fixation in 160 patients with unilateral ZMC tripod fractures at Shija Hospitals, Imphal, from December 2019 to December 2024.
Methods: Patients aged 14–60 years presenting within 3 days of injury were randomized into two groups (n=80 each): Group A (two-point fixation at frontozygomatic and infraorbital rim) and Group B (three-point fixation, adding zygomaticomaxillary buttress). Radiological outcomes, including zygomatic projection, height and vertical dystopia, were assessed via CT scans at 6 weeks post-surgery using GE Healthcare's Media Viewer
Results: Three-point fixation demonstrated significantly better improvement in zygomatic projection (3.37±0.74 mm vs. 2.9±0.52 mm, p=0.002), height (2.81±0.42 mm vs. 2.57±0.46 mm, p=0.015) and vertical dystopia (2.43±0.56 mm vs. 2.12±0.53 mm, p=0.01) compared to two-point fixation. No postoperative complications (e.g., infection, plate exposure or enophthalmos) or loss to follow-up were reported. Males (76.25%) and the 20–35 age group were predominantly affected, with road traffic accidents as the leading cause.
Conclusions: Despite advantages, three-point fixation involves longer operative time and higher costs. This study concludes that three-point fixation offers superior radiological outcomes for ZMC fracture reduction, supporting its use despite increased resource demands.

Keywords: Open reduction internal fixation, Tripod fracture, Two-point fixation, Three-point fixation, Zygomaticomaxillary complex

INTRODUCTION

Since the face is the most visible part of the body, injuries to it are relatively frequent. The prominence of the zygomatic area makes it more vulnerable to facial injuries overall.[1] Due to its position, zygoma is the second most frequently fractured bone in the craniofacial region, behind nasal bones.[2] Males are shown to be more susceptible to zygoma fractures and the primary cause is traffic accidents, but frequency and aetiology vary from region to area. Road traffic accidents (RTA), falls, sports and auto accidents are the main causative causes for zygomatic bone fractures.[3,4] The term tripod fracture is because of the disruption of the three commonly recognized articulations. Fronto-zygomatic, zygomatico-temporal, zygomaticomaxillary buttress.[5]

The fourth buttress is also present named zygomatico sphenoid buttress. As it is deep cannot be easily plated and its significance lies in reduction of fracture. Diplopia, enophthalmos, subconjunctival ecchymosis and extra ocular muscle entrapment due to orbital content herniation to the maxillary sinus may be associated with orbito-zygomatic complex fractures.[6] The diagnosis and

reconstruction of zygomatico-maxillary complex (ZMC) fractures is challenging task for the surgeon. Surgery is not typically indicated, however, pursued until there is a functional or cosmetic issue, such as decreased mouth opening, sensory disturbance or depression of the cheek prominence.[7] Despite the fact that a variety of surgical treatment options have already been described, each method can have certain drawbacks. Zygomatic fractures are typically fixed at two or three superficial locations, including the fronto-zygomatic, infra-orbital rim and zygomatico-maxillary buttress.

Zygomatic position disruption has serious physiological, cosmetic and functional consequences that affect ocular and mandibular function. Therefore, it is essential that zygomatic bone injury be correctly diagnosed and effectively treated.[8] To achieve positive outcomes in the restoration of the midface, it is essential to achieve normal anatomical contour and position of the malar eminence and zygomatic body. So that the complicated multidimensional interaction of the zygoma to surrounding tissues can be restored, the treatment must achieve adequate and stable reduction at the fracture site.[9]

Numerous surgical approaches have been suggested for the reduction of zygomatic complex fractures in the literature and in actual practice. Surgery has been performed using the Keen's approach, the Gillies' approach, the bicoronal scalp flap strategy or the more well-known Dingman's approach.[10,11]

One form of treatment that works well is open reduction and internal fixation (ORIF). There are numerous clinical and experimental research that demonstrate how much better and longer-lasting rigid plating is owing to the paucity of clinical studies, the precise stability of the zygoma with reference to the fixation sites and number of points to be fixed remains a topic of debate.[12,13] This makes this study vital. The main aim of this study is to prospectively compare three-point fixation and two-point fixation in terms of fracture reduction for better clinical results. The objectives of this study are to compare and evaluate. Aetiology and gender distribution in unilateral zmc fractures, improvement in malar projection, improvement in malar height and improvement in vertical dystopia.

METHODS

The study was conducted at Shija Hospitals and Research Institute, Langol, Imphal which is a 350 bedded teaching hospital and is one of the largest referral hospitals of Manipur. Both In-Patient department as well as Out-Patient department patients were recruited who presented with unilateral zygomatic tripod fractures. It was designed as a Prospective Randomized Interventional Study. Study duration was 5 years (December 2019 to December 2024). Inclusion criteria was patients presenting to emergency department and OPD after injury within 3 days, patients who were willing to give consent for study, patients with displaced zygomatic complex fractures with definite indication for ORIF and age 14-60 years. Exclusion creteria was patients who were diagnosed with communited fractures, multiple fractures, pan facial fractures, blow out fractures, bilateral zygoma fractures, patients with maxillofacial fractures who were not ready to give consent due to various reasons and patients who are not ready for follow up, age below 14 years and patients who are unfit for surgery during pre-anaesthetic check-up due to systemic illness. 160 patients were recruited for the study in 5 years period who fulfilled inclusion and exclusion criteria and were divided into two groups consisting of 80 in each group, group a-two-point fixation and Group B-three-point fixation after getting approval of Institutional Ethical Committee. Patients were allocated to groups by using computer generated randomizer. Surgical fitness is obtained after getting necessary investigations done.

After evaluation and confirmation of fitness for general anaesthesia, patients underwent endotracheal intubation under aseptic conditions. Standard incisions-Dingman's lateral brow, subciliary and intraoral Keen's—were used to access the frontozygomatic region, infraorbital rim and zygomaticomaxillary buttress, respectively. Internal fixation was performed using a micro drill and titanium miniplates. Group A received two-point fixation (frontozygomatic and infraorbital rim), while Group B received an additional third point of fixation at the zygomaticomaxillary buttress. Postoperative follow-up was conducted on days 3 and 7 and at 2, 4 and 6 weeks, with final assessment at 6 weeks.

Following parameters were considered pre-op and post-op

Radiological evaluation

Post reduction displacement of zygoma will be assessed by performing CT scan of midface after 6 weeks of fixation. The parameters to be recorded are Zygomatic complex projection and height. All the CT scans are imported in to media viewer, ge health care application and measurements done.

Zygomatic complex projection

It will be recorded using axial section of computed tomography. This entails marking of line corresponding to anterior and posterior Zygomatic complex width. The distance between two lines is measured and compared with opposite side so as to document any difference if present.

Axial midline

It is drawn from the vertical plate of the Ethmoid bone extending posteriorly up to the midline of the clivus on the skull base or the midline of the foramen magnum (whichever is most easily identified).

Marking 1 or A (posterior zygomatic complex width)

It is drawn from the midline to the most lateral aspect of the curve of the zygomatic arch.

Marking 2 or B (anterior zygomatic complex width)

A point is marked on the most anterolateral aspect of the Zygomatic complex. This point is established by the intersection of a line perpendicular to the axial midline extending laterally and through the depth of the concavity of the frontal process of the maxilla and a line parallel to the axial midline extending anterior from the most lateral aspect of the zygomatic arch. A bisecting line from the intersection of these 2 lines is drawn to the outer surface of the zygomatic arch.

Marking 3 or C (zygomatic complex projection)

The distance between the 2 points established on the Zygomatic arch i.e. between marking 1 and 2 or A and B will be measured which reflects the Zygomatic complex projection. The value of one side is compared to another normal side and any deficit if present will be noted (Figure 1).[14]

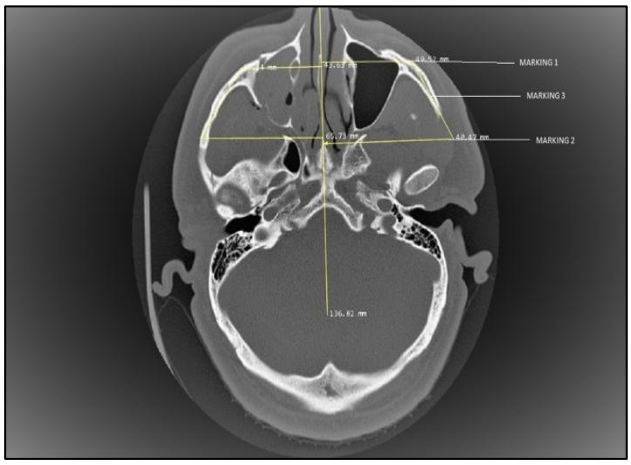

Figure 1: Zygomatic projection calculation.

Zygomatic complex height

Zygomatic complex height measurement requires coronal section of computed tomography. The horizontal reference line and a line extended from the most lateral aspect of curved surface of Zygomatic complex will be drawn and compared with opposite normal side.

Coronal midline and reference line

The midline was drawn through the most superior aspect of the suture joining the nasal bones and the midline crest of the maxilla. A second line, perpendicular to the first, is aligned through the most superior aspect of the superior orbital rims. This is referred to as the horizontal reference line.

Marking A or A' (zygomatic complex height)

The most lateral aspect of the curved surface of the Zygomatic complex is identified. Measurement A or A' is the distance between the horizontal reference line and the point present on most lateral aspect of the Zygomatic complex. This measurement was compared with normal side and any deficit if present is recorded (Figure 2).[15]

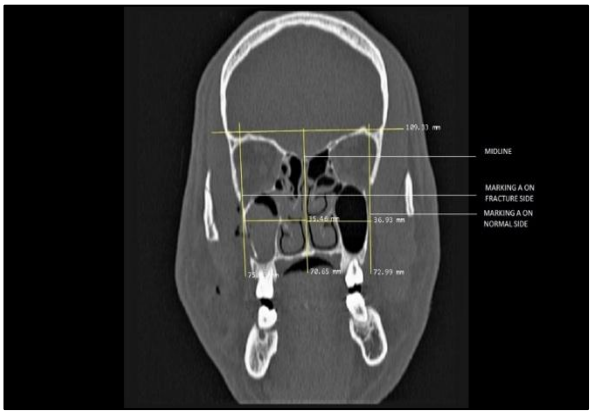

Figure 2: Zygomatic height calculation.

Vertical dystopia–3D view

Vertical change of inferior orbital rim (vertical step)

The distance between two parallel lines drawn over inferior orbital rim on both sides will be measured. Difference of more than 2 mm is considered abnormal (Figure 3).[16]

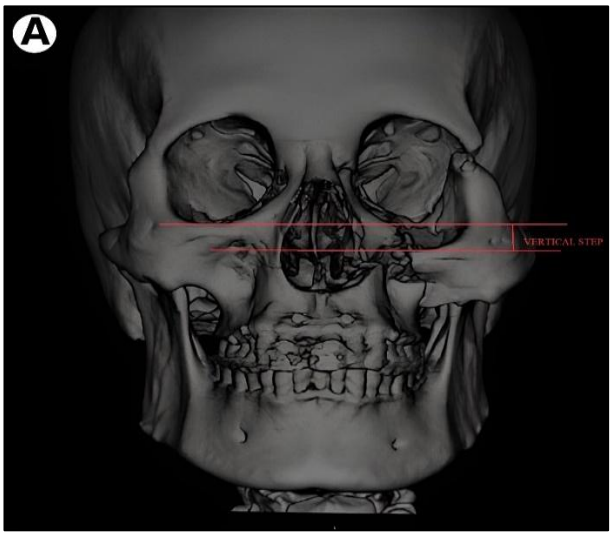

Figure 3: Vertical dystopia calculation.

Statistical analysis

The presentation of the Categorical variables was done in the form of number and percentage (%). On the other hand, the quantitative data were presented as the

means±SD and as median with 25th and 75th percentiles (interquartile range). The following statistical tests were applied for the results. The comparison of the variables which were quantitative in nature were analyzed using independent t test. Paired t test was used for comparison across follow up. The comparison of the variables which were qualitative in nature were analyzed using Chi-Square test. If any cell had an expected value of less than 5 then Fisher's exact test was used. The data entry was done in the Microsoft EXCEL spreadsheet and the final analysis was done with the use of Statistical Package for Social Sciences (SPSS) software, IBM manufacturer, Chicago, USA, version 25.0.

RESULTS

ZMC fractures are more common in age group of 21-40 with a mean age group of 31.5 years (Table 1). ZMC fractures are more common in males than in females (Table 2). RTA stands as main cause of ZMC fractures with 62% of cases (Figure 4).

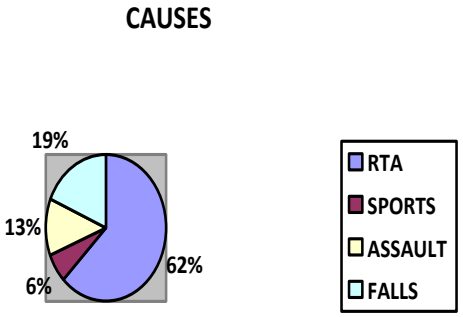

Figure 4: Causes of ZMC fracture.

Improvement in zygomatic projection was better in three-point fixation with significant p value of 0.002 (Table 3).

Zygomatic height improvement in post-operative period was better with three-point fixation with a significant p value of 0.015 (Table 4).

Table 1: Comparison of age (years) between two-point and three-point fixation.

Age (in years)	Two-point fixation (n=80)	Three-point fixation (n=80)	Total	P value
18-20	6 (7.50%)	6 (7.50%)	12 (7.50%)	0.977*
21-30	32 (40%)	26 (32.50%)	58 (36.25%)	
31-40	14 (17.50%)	18 (22.50%)	32 (20%)	
41-50	14 (17.50%)	16 (20%)	30 (18.75%)	
51-60	14 (17.50%)	14 (17.50%)	28 (17.50%)	
Mean±SD	34.92±12.21	36.02 ± 11.68	35.48±11.88	0.682‡
Median (25th-75th percentile)	31(26-42.25)	35.5 (26.75-44.5)	31.5 (26-43.25)	
Range	19-60	18-60	18-60	

‡Independent t test, *Fisher's exact test.

Table 2: Comparison of gender between two-point and three-point fixation.

Gender	Two-point fixation (n=80)	Three-point fixation (n=80)	Total	P value
Female	20 (25%)	18 (22.50%)	38 (23.75%)	0.793†
Male	60 (75%)	62 (77.50%)	122 (76.25%)	
Total	80 (100%)	80 (100%)	160 (100%)	

†Chi square test.

Table 3: Comparison of improvement in projection deficit (mm) between two-point and three-point fixation.

Improvement in projection deficit (mm)	Two-point fixation (n=80)	Three-point fixation (n=80)	Total	P value
Mean±SD	2.9±0.52	3.37±0.74	3.13±0.68	0.002‡
Median (25th-75th percentile)	2.95 (2.455-3.252)	3.36 (2.85-3.892)	3.03 (2.755-3.562)	
Range	1.99-4.3	1.32-5.18	1.32-5.18	

‡Independent t test.

Table 4: Comparison of improvement in height deficit (mm) between two-point and three-point fixation.

Improvement in height deficit (mm)	Two-point fixation (n=80)	Three-point fixation (n=80)	Total	P value
Mean±SD	2.57±0.46	2.81±0.42	2.69±0.45	0.015‡
Median (25th-75th percentile)	2.54 (2.2-2.858)	2.82 (2.498-3.055)	2.68 (2.338-2.95)	
Range	1.74-3.91	2.04-3.96	1.74-3.96	

‡Independent t test.

Table 5: Comparison of improvement in vertical dystopia (mm) between two-point and three-point fixation.

Improvement in vertical dystopia (mm)	Two-point fixation (n=80)	Three-point fixation (n=80)	Total	P value
Mean±SD	2.12±0.53	2.43±0.56	2.28±0.56	0.01‡
Median (25th-75th percentile)	2.14 (1.76-2.562)	2.38 (1.96-2.925)	2.21 (1.825-2.8)	
Range	1.08-3.01	1.44-3.48	1.08-3.48	

‡Independent t test.

Figure 5: Post op 3D CT.

Vertical dystopia was better corrected with three-point fixation during post-operative period with a significant p value of 0.01 (Table 5).

DISCUSSION

There isn't a single definitive method that is considered as the gold standard to treat zygomaticomaxillary complex fractures, despite the fact that there are several scholarly disagreements over how to treat ZMC fractures in the literature. In order to evaluate malar asymmetry postoperatively utilizing two-point vs. three-point fixation procedures, we have done this study. Figure 5 for post op 3D CT for three-point fixation.

In this study we included 160 individuals who attended to ER and OPD of our department and categorized them in to two groups for two-point fixation and three-point fixation, 80 in each group. We have observed that males are more commonly involved in ZMC fractures than females due to RTA and physical assaults. 20-35 years age groups are more commonly involved with zygoma fractures with a mean age group of 35.47 years. It is more common in this age group due to involvement in bike accidents without helmets, rash driving and fights. When we observed these patients in post-operative period of 6 weeks, patients who underwent three-point fixation had significant outcome in terms of zygomatic projection, zygomatic height and vertical dystopia than two-point fixation.

There were no complications observed in any of patients and no loss of follow up noted. The management of zygomatic complex fractures remains a topic of debate. While closed reduction was traditionally favored, the use of miniplates has become standard in craniomaxillofacial surgery due to their small size, flexibility, ease of use and hidden intraoral application. The choice of fixation points depends on the fracture's displacement and anatomy. Some studies suggest that two-point fixation offers comparable stability to three-point methods, regardless of plate location. Manson et al, emphasized the zygomaticomaxillary buttress (ZMB) as an ideal site due to its resistance to masseter muscle pull and deep placement, which minimizes palpability.[7] Although the frontozygomatic (ZF) region provides strong bone, it is a poor guide for alignment and is best used as a secondary reference, along with the infraorbital rim. In this study we noted that majority of patients are males with 76.25%. Most other studies similarly indicate male prediction with more than 60%. Our percentage compares favorably with that of Singh et al, Latif et al, Zaman G et al, Begum et al and Jolly et al.[17-21] The sex distribution is more in males due to the high-speed road traffic accidents and more exposure to external environment and involvement in physical assaults.

In this study improvement in malar projection post operatively in two-point fixation is 2.9±0.52 mm

whereas, in three-point fixation is 3.37±0.74 mm, showing dominance of three-point fixation with a strong p value of 0.002. It is consistent with that of the studies of Nasar et al, Parashar A et al, in which malar projection in three-point fixation is superior to two-point fixation with a significant p value.[15,22] But in studies conducted by Arora I et al, Jolly S et al and Begum S et al, the p value is not significant showing that there is no significant difference in improvement of malar projection by both two-point and three-point fixation method.[20,21,23] In this study improvement in malar height post operatively at 6 weeks was 2.57±0.46 mm in two-point fixation and 2.81±0.42 mm in three- point fixation showing a significant improvement by three-point fixation with a p value of 0.015. This data was consistent with the studies of various studies done by Nasar et al, Parashar et al, Mahmood et al, Zaman et al, with significant p values less than 0.05.[15,19,22,25] Hence it proves that three-point fixation is superior to two-point fixation in terms of malar projection and malar height radiographically. These results are similar to that of Pearl et al, who reported in his study that it is essential in tripod fractures to reposition zygoma at three points to achieve a three-dimensional reduction of fracture.[24]

In this study vertical dystopia was measured by 3D reconstruction of CT scan of facial bones after 6 weeks of surgery and found an improvement of 2.12±0.53 mm by two-point fixation and 2.43±0.56 mm by three-point fixation showing a significant p value of 0.01 indication superiority of three-point fixation in terms of vertical dystopia correction in tripod fractures.

Despite of all the above advantages three-point fixation has disadvantages of extensive periosteal stripping, more operative time, extra hardware and increase in cost of surgery. However, we didn't encounter any extra complications due to three-point fixation. My study didn't show any post-operative complications like infection, plate exposure, paraesthesia, asymmetry, enophthalmos in both two-point and three-point fixation techniques.

CONCLUSION

Three-point fixation gives a better fracture reduction and malar symmetry than two-point fixation. Age groups of 21-40 are commonly encountered with zygoma fractures and males are frequently affected than females. RTA is the leading cause of zygoma fractures. There is no difference in terms of complications between both groups.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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