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Evaluation Of Facial Asymmetry Following Zygomaticomaxillary Complex Fracture Reduction Using Two-Point Versus Three Point Fixation

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ZMC fracture, Facial symmetry, Two point fixation, Three point fixation

Abstract

Background
Was to evaluate the degree of facial asymmetry after ZMC fracture reduction with two point fixation in comparison to three point fixation.

Methods: Retrospective study was done on patients reported to the Department of Oral & Maxillofacial Surgery Cairo University. for evaluation and management of ZMC fracture from 2021 to 2023. 24 eligible patients were included: Twelve patients received 2-point fixation at zygomaticofronal and zygomaticomaxillary buttress region. (Group A). Twelve patients received 3-point fixation at zygomaticofronal, zygomaticomaxillary buttress and additional fixation was done in the infraorbital region. (Group B)
Facial asymmetry was evaluated using zygomatic complex projection (ZCP) comparison on both sides & comparison between the location of the most prominent point of the zygoma, malar eminence (ME) to establish mid-facial symmetry, before and after surgery in both groups.

Results: For facial asymmetry index measurements in Group (A) the Mean value was 5.63±1.365 preoperatively then reduced to 2.28±0.432 postoperatively showing highly statistical significant decrease ($P \leq 0.05$).For facial asymmetry index measurements in Group (B), the Mean value was 4.68±1.102 preoperatively then reduced to 2.36±0.498 postoperatively showing highly statistical significant decrease ($P \leq 0.05$). When the two groups were compared to each other's, the variations between them regarding mean of ZCP and facial asymmetry were statistically non-significant ($P \leq 0.05$) pre & post operatively.

Conclusion: Fractured ZMC can be managed successfully using 2 or 3 point fixation with improved postoperative facial symmetry results. Both surgical techniques showed similar results yet with fewer surgical incisions in 2 points fixation group.

1. Introduction

The zygomaticomaxillary complex (ZMC) is one of the main buttresses in the mid-facial area. It has an integral functional, structural, & aesthetical role in the mid-face contour along with protection of the orbital contents [1 2]. Owing to prominence of the zygomatic bone, ZMC fractures are among the most common injuries of craniofacial fractures [3]. With an incidence range of 13%–40% of all facial fractures, ZMC fractures are the second most common after nasal bone fractures [4].

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The zygomatic bone has a tetrapod- like shape articulation with the frontal, temporal, sphenoid, and maxillary bones creating the cheek prominence as well as the horizontal buttress of the face [3]. This articulation forms lateral part of the face along with the inferior wall of the orbit contributing to the malar projection and the width of the face. Integrity of the ZMC is essential for the function of the eye globe, facial symmetry and it gives path for infraorbital nerves & vessels that innervates the mid-face [5]. The articulating points of the zygomatic bone with the adjacent bones make suture lines: the zygomaticofrontal (ZF) suture line, zygomaticotemporal (ZT) suture line, zygomaticomaxillary buttress (ZMB) & zygomaticosphenoid (ZS) suture line. These lines are integral fixation points to preserve the malar projection and reduce the fracture fragment. Inadequate reduction or fixation of ZMC fracture may lead to variety of complications including: functional (visual impairment, diplopia, malocclusion, and hypoesthesia of the infraorbital nerve) & aesthetic deformities (malar asymmetry, mid-facial widening, and enophthalmos) [6 7 8 9].

The main goal of ZMC fractures treatment is achievement of adequate three-dimensional anatomical reduction & stable rigid fixation in order to ensure the optimal postoperative functional and aesthetical results [2 6 10 11]. Treatment modalities for management of ZMC fractures varies according to the severity of deformity and the surgeon's considerations ranging from simple observation to open reduction with internal fixation [12 13]. Conservative treatment is indicated for minimally displaced ZMC fractures, while surgery is the treatment of choice for displaced, unstable & comminuted zygomatic complex fractures [14 15]. Open reduction & internal fixation (ORIF) has been described to be the most effective method for the surgical repair of ZMC fractures [16 17 18].

Several algorithms were described in the literature for reduction & fixation of ZMC fractures including one, two, and three-point fixation according to severity & extent of the fracture [16 19 19 20]. Although some authors reported that one- point fixation provides enough stability [10 21], others argue that multiple fixations are critical to prevent inferior displacement, which results in facial asymmetry [10 21 22]. However, it remains unclear if increasing the number of fixation points will provide more predictable & successful outcomes with accurate anatomical reduction & improved stability [1]. With numerous studies implemented to evaluate diagnosis, surgical management & postoperative complications of ZMC fractures [23 24 25 26], fewer were performed to evaluate postoperative symmetry after ZMC fracture reduction [2728]. Hence, aim of this study was to evaluate the degree of facial asymmetry after ZMC fracture reduction with two-point fixation in comparison to three point fixation.

2. Patients and Methods

2.1 Sample size:

The sample of this study was calculated based on the previous study by Degala et al [29], comparing two-point & three-point fixation in fracture zygoma. A sample size of 12 patients for each group was calculated with 95% statistical power, an α of 0.05. Sample size was calculated using G*Power program (University of Düsseldorf, Düsseldorf, Germany).

2.2 Patient selection and study design:

Retrospective study was done on patients reported to the Department of Oral and Maxillofacial Surgery Cairo University. Cairo, Egypt for evaluation and management of ZMC fracture from 2021 to 2023.

In accordance with the principles of Declaration of Helsinki on medical protocol & ethics, this study achieved the approval of the Ethical Review Board of MSA University (No: 383).

Verbal consent was obtained either directly from the patients or their legal representatives. The concept of the experiment was explained to patients, mentioning the social, personnel benefits as well as the expected risks and complications. Patients were informed that they are free to continue the experiment and follow up.

Inclusion Criteria:

- Unilateral ZMC fracture with preoperative radiological evaluation
- ORIF within two weeks after injury
- Medically fit patients without any contraindication to the surgery.
- Patients agreed to be enrolled in the study
- Postoperative evaluation including clinical outcomes and radiological examination within three months postoperative.

Exclusion Criteria:

- Nondisplaced ZMC fracture
- Bilateral ZMC fractures,
- comminuted ZMC fractures
- History of craniofacial surgery
- ZMC fractures with other facial fractures
- History of congenital facial asymmetry
- Inadequate treatment or follow-up information

2.3 Patients grouping:

Twenty four eligible patients were included in the present retrospective study:

- Twelve patients received 2-point fixation at zygomaticofronal and zygomaticomaxillary buttress region. (**Group A**)
- Twelve patients received 3-point fixation at zygomaticofronal, zygomaticomaxillary buttress and additional fixation was done in the infraorbital region. (**Group B**)

2.4 Surgical technique:

Surgeries were performed under general anaesthesia & aseptic conditions. Patient scrubbing & draping was completed in standard fashion. Frontozygomatic suture was approached via lateral eyebrow incision or pre-existing lacerations. Intraoral buccal sulcus incision was addressed to expose zygomatico maxillary buttress. In patients receiving three point fixation, the infraorbital rim was approached through subciliary incision. After adequate exposure, the zygomatic complex was reduced & aligned to satisfactory anatomic position. This was confirmed through palpating the infraorbital margin & the frontozygomatic suture. Titanium mini plates (1.5 mm) were used for fixation. (Figure 1) After fixation, facial sling suture was utilized to suspend soft tissue in the midface to lateral orbital rim periosteum or infraorbital rim plate. Forced duction test was performed at the end to check ocular motility & ensure the absence of entrapped intraocular contents. Wound closure was performed in standard manner using Vicryl 4-0 and Prolene 5-0 sutures.

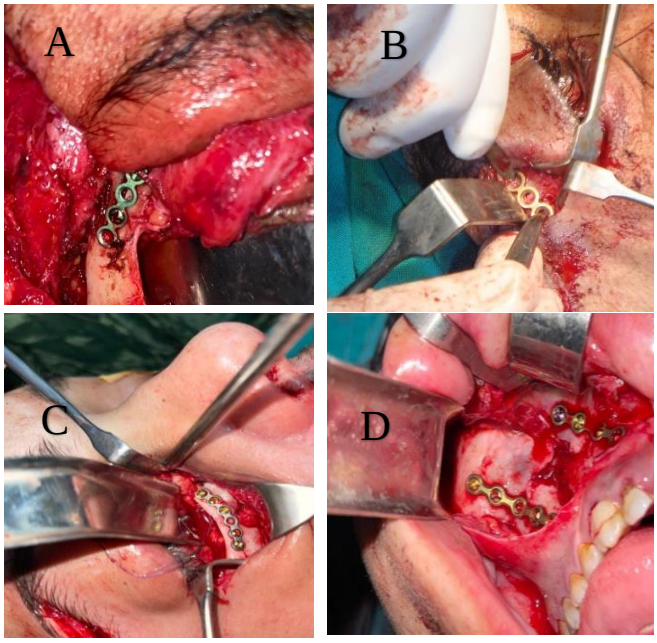

Figure 1. Fixation of ZMC fracture A,B,C,D (A, B: Fixation at the zygomatico frontal suture)(C: Fixation at the infraorbital rim)(D:Fixation at the zygomaticomaxillary buttress)

2.5 Radiographic evaluation:

Full facial CT scan were made for both groups before and after surgery. Zygomatic complex projection (ZCP) comparison on both sides and comparison between the locations of the most prominent point of the zygoma, malar eminence (ME) to establish mid-facial symmetry. These measurements were made on both the normal and fractured sides in order to determine the ZCP of the fractured side in relation to the normal side and the ME symmetrical projection from CT scans and with the aid of fusion of both images.

CT scans of the facial bones' axial sections were used to assess the ZCP comparison. The widths of the anterior and posterior zygomatic complexes were represented by horizontal lines, and the separation between them was measured. The contralateral normal side was likewise subjected to this procedure, and the difference was measured and recorded [30].

The ME position defined as the most prominent point of the zygomatic bone on the zygomatic complex on a CT scan determined by the final cephalo-facial midsagittal plane. The mid-facial asymmetry was characterized by the bilateral difference in the position of the ME. Measurements were made to compare the bilateral 3-dimensional position of the ME on both sides (Right & Left), defined as the linear distance between the ME point and the reference planes. Reference planes were the midsagittal plane (mediolateral distance) RM & LM, a coronal plane passing through the anterior border of the foramen magnum (antro-posterior distance) RA & LA, and a transverse plane passing through the superior orbital rims (superio-inferior distance) RS & LS. The CT scan's axial cut were used for the first two measures. For the third measurement, the ME point was performed on the coronal cut [31].

All measurements were carried out twice by the same researcher, with at least 1 week between sessions, for internal validation. For lack of agreement between the two calculations, when a case was categorized into two different groups, a third calculation was performed.

The collected data were processed and analysed. First, the difference between the ZCP of the left and right was calculated and compared with before and after treatment. Second, the difference between the positions of the left and right ME points was calculated in all three dimensions and calculation of the asymmetry index using the following formula was used to determine the difference, before and after treatment:

$$\sqrt{(RM - LM)^2 + (RA - LA)^2 + (RS - LS)^2}$$

Where RM is the distance between the ME and the midsagittal plane on the right side and LM is the same distance on the left side. This was performed in all three dimensions. (figure 2: A, B, C, D,E, F)

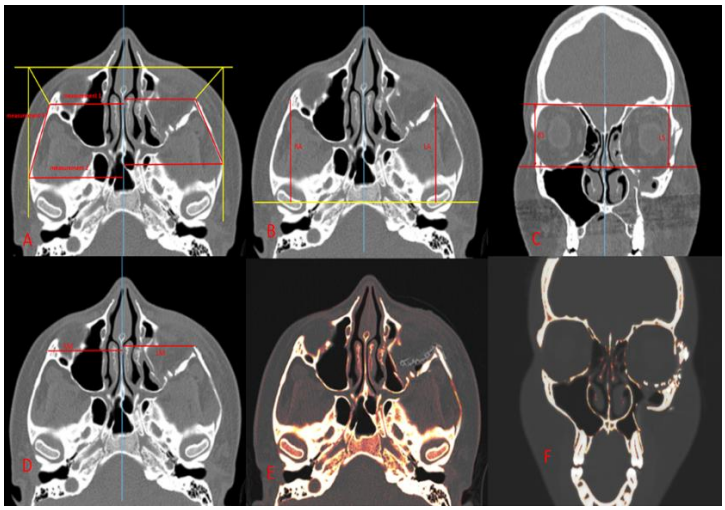

Figure 2.
A- Zygomatic projection measurements
B- Anteroposterior distance
C- Superoinferior distance
D- Mediolateral distance
E- Axial Fusion over view
F- Coronal Fusion over view

2.6 Statistical analysis:

The collected data were statistically analysed. The significance of the difference between the preoperative and postoperative data regarding zygomatic complex projection and facial asymmetry index at the same group was assessed using the Student T test (paired and unpaired). The two groups were compared to each other using also the Student T test (paired and unpaired). The statistical analysis was carried out using SPSS ver. 22 software (statistical package for social science on windows 2013). A probability value p≤ 0.05.

3. Results

The present study involved 24 eligible patients (20 males& 4 females) with ZMC fracture, the male to female ratio was 5:1. Patients mean age was 31.4 years.

The current study was conducted to evaluate the degree of facial asymmetry after ZMC fracture reduction with two-point fixation in comparison to three point fixation. All were assessed clinically & radiographically before and after fixations. Neither complications nor clinical side effects were reported. All participants showed uneventful healing of hard & soft tissues throughout the study intervals.

For Group (A), Mean zygomatic complex projection for 2 point fixation before reduction & fixation was 2.54 ±0.765 while after reduction & fixation the mean value for 2 point fixation was 1.12±0.261.There was a highly statistical significant decrease ($P \leq 0.05$) in ZCP mean in that group comparing it's before and after 2 point fixation technique (Figure 3) (Table 1).

As for facial asymmetry index measurements in Group (A), for 2 point fixation the Mean was 5.63±1.365 before reduction& fixation while after reduction & fixation the mean value for 2 point fixation was 2.28±0.432. There was a highly statistical significant decrease ($P \leq 0.05$) in facial asymmetry index mean in that group comparing it's before and after 2 point fixation technique (Figure 3) (Table 1).

Table 1. Showing means of zygomatic complex projection& facial asymmetry of the Study group (A) (2 points of fixation)

Group (A) 2 points of fixation			
	(Before)	**(After)**	**P value**
Zygomatic Complex Projection	**2.54 ± 0.765 (1.65 – 3.63)**	**1.12 ± 0.261 (0.8 – 1.5)**	**0.0001**
Facial Asymmetry Index	**5.63 ± 1.365 (3.58 – 7.62)**	**2.28 ± 0.432 (1.6 – 2.92)**	**0.00001**

For Group (B), Mean zygomatic complex projection for 3 point fixation before reduction & fixation was 2.53±0.617 while after reduction & fixation the mean value for 3 point fixation was 1.22±0.165. There was a highly statistical significant decrease ($P \leq 0.05$) in ZCP mean in that group comparing it's before and after 3 point fixation technique (Figure 3) (Table 2).

As for Facial asymmetry index measurements in Group (B), for 3 point fixation the Mean was 4.68±1.102 before reduction & fixation while after reduction & fixation the mean value for 3 point fixation was 2.36±0.498. There was a highly statistical significant decrease ($P \leq 0.05$) in facial asymmetry index mean in that group comparing it's before and after 3 point fixation technique (Figure 3) (Table 2).

Table 2. Showing means of zygomatic complex projection & facial asymmetry of the Study group (B) (3 points of fixation)

Group (B) 3 points of fixation			
	(Before)	**(After)**	**P value**
Zygomatic Complex Projection	**2.53 ± 0.617 (1.76 – 3.27)**	**1.22 ± 0.165 (1.03 – 1.46)**	**0.00001**
Facial Asymmetry Index	**4.68 ± 1.102 (3.16 – 6.37)**	**2.36 ± 0.498 (1.68 – 3.01)**	**0.00001**

When the two groups were compared to each other's, the variations between them regarding mean of ZCP and facial asymmetry were statistically non-significant ($P \leq 0.05$) pre operatively (before) and post operatively (after) (Figure 3) (Table 3).

Table 3. Showing comparison of means of zygomatic complex projection& facial asymmetry of the two groups.

Comparison between the two groups		2 points of fixation Group (A)		3 points of fixation Group (B)		P value
		Mean	SD	Mean	SD	
Zygomatic Complex Projection	Before	2.54	0.765	2.53	0.617	0.977
	(After)	1.12	0.261	1.22	0.165	0.300
Facial Asymmetry Index	Before	5.63	1.365	4.68	1.102	0.074
	(After)	2.28	0.432	2.36	0.498	0.666

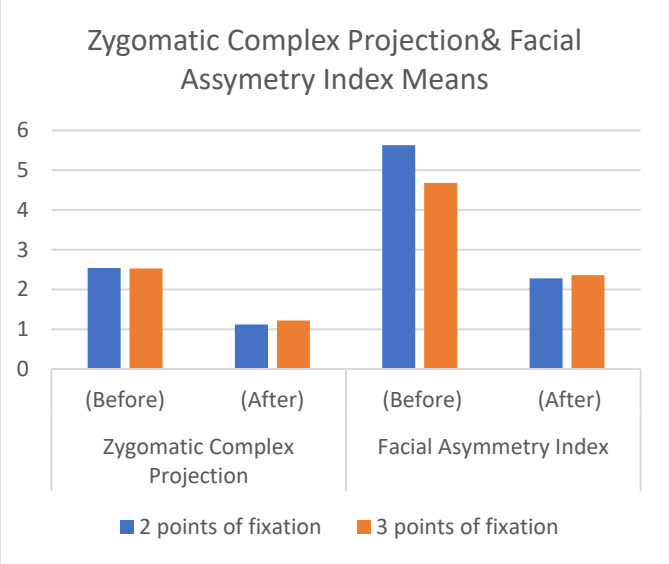

Figure 3. Showing means of the zygomatic complex projection & facial asymmetry index measurements of the two groups before and after fixations.

4. Discussion

The present study included 24 eligible patients with fracture zygomaticomaxillary complex. The mean age was 31.4 with the third decade constituting the majority of them. These data are comparable to other studies [20] [29] [42] [43]. a study by Adekey [44] justified that adult group are more vulnerable to injuries due to increased outdoor activities at that age range.

Among the included patients in the current study males predilection was noticed with ration of 5:1male to female. This incidence is in agreement with other studies showing that males are involved more than females in ZMC fractures [20] [45]. It was explained that higher male incidence is correlated to their involvement to outdoor activities while females are mostly confined to indoor environment [20].

The zygomatic bone is one of the major midface buttresses that has a great impact on facial width symmetry [12]. Fracture of zygomaticomaxillary complex will disturb normal stress distribution & facial aesthetics [29]. Failure of restoring the malar segment to its normal anatomic position will result in facial asymmetry [32]. Therefore the treatment of this fracture represents a challenging procedure to restore normal function & aesthetics [33]. Many surgical approaches were advocated in the literature to achieve adequate anatomic alignment with successful treatment outcome [34] [35] [36]. However, the number of fixation points to achieve adequate reduction & fixation remains controversial. Moreover, there is tendency in the literature to minimize the amount of soft tissue exposures to decrease soft tissue disruption & postoperative complication. Therefore, the aim of this study was to evaluate the degree of facial asymmetry after ZMC fracture reduction with two-point fixation in comparison to three point fixation.

Rudderman and Mullen investigated biomechanics of the facial skeleton, and reported that fractured zygomatic segment has rotational & translational motion along x-, y-, and z-axes [37]. They recommended adequate plating & stabilization of the fractured zygoma to prevent translational and rotational forces. To accomplish a predictable fixation & stabilization the literature advocate more than one fixation point [29]. Rana et al. reported that post-reduction displacement of the fractured segment will result in the development of malar asymmetry & vertical dystopia [20].

In the present study 2-point fixation was performed at zygomaticofronal & zygomaticomaxillary buttress in (Group A), while 3-point fixation added another fixation point at the infraorbital rim in (Group B). It is believed that single plate fixation at the ZF suture will resist translation & rotation forces acting in two axis perpendicular to the plane of the plate. Although the bony buttress may neutralize the remaining motion, in most cases a second plate properly positioned at the zygomaticomaxillary buttress perpendicular to the axis of the zygomaticofronal buttress is required to compensate for these forces. The addition of third plate at the infraorbital rim when performed will provide more stable reduction & stabilization of the fractured zygoma [37].

Investigations of different modalities of ZMC fractures, evaluated several radiographic parameters to assess the treatment outcome in terms of reduction, fixation & stabilization. CT scans were used for three-dimensional imaging of the ZMC fractures & were considered as the

golden standard for treatment planning of fractured zygoma. In CT scans coronal and axial cuts evaluated sphenozygomatic suture alignment, zygomatic arch alignment & symmetry of malar prominence were compared with the opposite side [24 34] This is in consistent with our study, as we implicated CT scans (axial & coronal cuts) for diagnosis, treatment planning & assessment of the outcome of the fixation techniques in ZMC fractures.

In the current study facial asymmetry was recognized by the bilateral difference in the position of the malar eminence (ME) in three dimensions. Facial asymmetry index implicated in the present study was consistent with other studies evaluating facial symmetry [31 38 39].

The present study utilized the use of asymmetry index for evaluation of facial asymmetry between affected and unaffected side. This matches the study presented by Khaqani et al.[7] Our results showed that values of facial asymmetry indexes decreased postoperatively following reduction & fixation which demonstrate adequate reduction & fixation to proper anatomic location of the zygoma in both groups.

The results of our study revealed that both surgical techniques (two-point fixation & three point fixation) proved to achieve statistically significant improvement of facial asymmetry postoperatively. However, the variation between the two groups was statistically non-significant. These results are in agreement with those reported by Naser et al.[3] who reported non-significant difference between two-point fixation and three-point fixation for facial asymmetry.

In similar manner the results of the current study showed that three point fixation provided better results of zygomatic complex projection & maintaining postoperative stability. This is in accordance to results reported by Rana et al [20] & Parashar et al.[40] & who stated that three point fixation provided better postoperative fracture stability than two point fixation.

However, 3-point fixation is not always necessary to achieve 3 dimensional biomechanical stability of the fractured segment as reported by *Zingg M, LaedrachK et al.*[41] in their study on 813 patient with zygomatico-maxillary complex fracture, they suggested that adequate alignment & adaptation of the fractured segment to proper anatomy as the determining factor dictating the need for further fixation points. Another study by *Chakranarayan et al.*[12] evaluating the efficiency of 2 point fixation in zygomatic fractures clarified that a minimum of 2-point fixation is required in treatment of tripod ZMC fractures. The results of the current study proved that 2 point fixation succeeded to achieve adequate postoperative stability & facial symmetry.

On the other hand, despite of the benefits of three point fixation, it is still associated with a variety of limitations including the need for extensive periosteal stripping, the requirement of expert assistance during miniplate application, longer operative procedure & increased expanses of surgery [20 39 40]. Therefore, this study hypothesized that two point fixation would provide comparable results to three point fixation in terms of adequate reduction & stabilization of ZMC fracture expressed by reestablishment of the facial symmetry postoperatively. It was shown in the current study that two point fixation had successful outcomes in terms of: fracture reduction & stabilization with adequate facial symmetry and also decreased operation time, cost & hardware.

Conclusion

Fractured ZMC can be managed successfully using 2 or 3 point fixation with improved postoperative facial symmetry results. Both surgical techniques showed similar results yet with fewer surgical incisions in 2 points fixation group.

Authors' Contributions

All authors have read and approved the manuscript.

Informed Consent

The patient accepted and signed a written informed consent to allow this case report and associated photographs to be published.

Conflict of interest

The authors declare that they hold no competing interests.

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