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Facial Asymmetry After Management of Unilateral Zygomaticomaxillary Complex Fractures Using Two-Point Fixation Technique

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ABSTRACT

Background: It is crucial to correctly identify and treat zygomatic bone injuries because of the zygoma's functional and aesthetic importance in the face contour. Zygomatic fractures can cause disfigurement, which necessitates operation to restore face symmetry.

Objective: To evaluate the facial asymmetry after management of unilateral zygomaticomaxillary complex fracture using a two-point fixation technique.

Patients and Methods: This study was conducted on 20 patients with unilateral zygomaticomaxillary complex (ZMC) fractures managed by a two-point fixation technique. The zygomaticomaxillary (ZM) buttress was used as a key point of fixation through an intra-oral approach for all patients and either the infraorbital rim (IOR) or the frontozygomatic (FZ) suture area was used as a second point of fixation. Radiographic assessment of the computed tomography (CT) scans was done by measuring the malar width, malar projection, and malar height on the fracture side and the normal side both preoperatively and postoperatively after 1 week and after 1 month. The asymmetry index comparing the normal side with the fracture side was measured both preoperatively and postoperatively.

Results: The difference between preoperative and 1-week, 1-month postoperative malar width and malar projection was highly significant, while the malar height difference wasn't significant. The asymmetry index decreased significantly postoperatively by 1 week and 1 month by using the 2-point fixation technique.

Conclusions: Stable fixation results and adequate aesthetic outcomes can be obtained by using the 2-point fixation technique in the management of ZMC fractures.

Keywords: Zygomaticomaxillary complex fracture, Zygomatic buttress, Two-point fixation, Maxillofacial trauma, Facial asymmetry, Malar projection.

INTRODUCTION

A sturdy cheekbone with four joints is called a zygoma. Rather than a zygoma fracture, disarticulation of the suture lines is the most common result of a facial injury. Surgical correction is often necessary for zygomaticomaxillary complex (ZMC) fractures due to the potential for ocular and functional abnormalities. The goals of surgical treatment for ZMC fractures include restoring normal mandibular range of motion, ocular function, antral function, and facial esthetics [1].

Postoperative displacement of the reduced ZMC leads to facial asymmetry and mainly occurs by the masticatory force. Among the most contentious problems in the surgical treatment of zygomatic fractures is the optimal number of fixation points to hold the zygoma in place while the bone heals. Based on the severity and degree of the fracture, many surgical procedures have been introduced, such as one-, two-, three-, and four-point fixation [2].

The three-dimensional position of the reduced zygoma should be considered in the evaluation of treatment outcome. In the present study, we use the asymmetry index to show the outcome of the 2-point fixation technique in the management of unilateral ZMC fractures [3].

This study aimed to evaluate the facial asymmetry after management of unilateral zygomaticomaxillary complex fracture using a two-point fixation technique.

PATIENTS AND METHODS

The study was conducted on twenty patients with unilateral ZMC fractures. Inclusion and exclusion criteria were met for selecting the sample. All patients enrolled in this study had unilateral, recent, uninfected, and non-comminuted ZMC fractures. Patients were excluded from this study when anatomic reduction could not be confirmed using two-point fixation.

The sample size was estimated using G*power version 3.1.9.6 for Mac OS. A total sample size of 20 was sufficient to detect an effect size of 0.35 at a power of 0.9 (90%) at a partial eta squared of 0.11 [3].

Surgical procedures

The surgical procedure was carried out under general anesthesia, and the reduction of the fractured ZMC was done by Gillie's temporal approach or Keen's approach. Three anatomical points of fixation were used for internal fixation of the zygomaticomaxillary complex fractures: zygomaticomaxillary buttress, frontozygomatic suture, and infraorbital margin.

We used the zygomaticomaxillary buttress as our primary point of fixation in every case. The second

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point of fixation, which we achieved with micro plates, was either the infraorbital border or the frontozygomatic suture.

Radiographic measurements:

Radiographic assessment of the CT scans was done by measuring the malar width, malar projection, and malar height on the fracture side and the normal side both preoperatively and postoperatively after 1 week and after 1 month. The asymmetry index comparing the normal side with the fracture side was measured both preoperatively and postoperatively to determine the accuracy and validity of the 2-point fixation technique in stabilizing the reduced ZMC fractures.

Preoperative radiographic measurements:

Measurement of malar width and malar projection in axial cut: Define the malar eminence: A line that ran laterally from the depth of the maxillary frontal process's concavity and another line that ran parallel to the axial midline from the most lateral part of the zygomatic arch met to produce this point. From their intersection to the zygoma's exterior (white arrow), a bisecting line is shown in figures 1 and 2 [4,5].

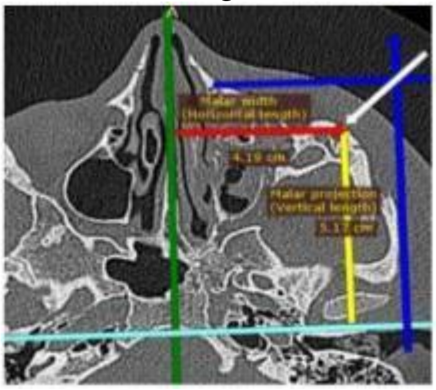

Figure (1): Preoperative radiographic malar width and malar projection on the fracture side.

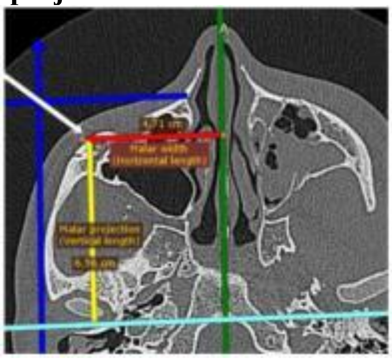

Figure (2): Preoperative radiographic malar width and malar projection on the normal side.

Malar width, or horizontal length: to determine the malar eminence's location in the mediolateral dimension, the bilateral distances between it and the midsagittal plane were determined (red line). Malar projection, or vertical length: To determine the malar eminence's location in the anteroposterior dimension (yellow line), the bilateral lengths between it and a coronal plane that passes across the anterior edge of the foramen magnum were measured.

The axial measures were taken from the image slice that showed the thickest zygomatic arches. We used two axial images—one for the right side and one for the left—because one of them didn't provide good enough views of the zygomatic arches [4,5].

Measurement of malar height in coronal cut: Define the malar eminence: as the most lateral aspect of the curved surface of the zygoma.

Malar height: to determine the malar eminence's location in the superior-inferior dimension, the bilateral distances between it and a transverse plane that passes through the superior orbital rims were determined. Both the arches and the full lateral orbital rims were present in the chosen coronal imaging slice. As seen in figures 3 and 4, two coronal pictures were employed when one was not optimal, one for the right side and bone for the left [4-5].

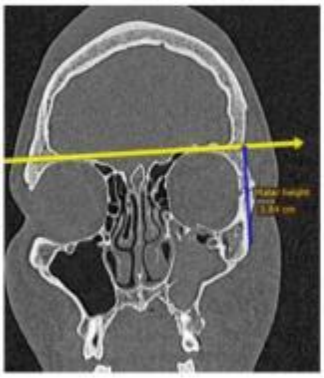

Figure (3): Preoperative radiographic malar height on the fracture side.

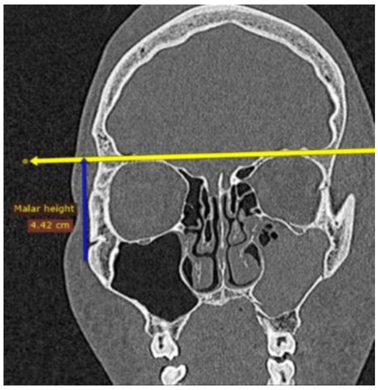

Figure (4): Preoperative radiographic malar height on the normal side.

Preoperative Asymmetry Index:

After measuring the malar width, malar projection, and malar height. The preoperative asymmetry index was calculated to show the degree of ZMC displacement. According to the methods outlined by **Khaqani *et al.*** [4] **and Ras *et al.*** [5]**,** the asymmetry index was computed by comparing the disparity in zygomatic eminence prominence.

Asymmetry index =

$$\sqrt{(Wr - Wl)^2 + (Pr - Pl)^2 + (Hr - Hl)^2}$$

Where Wr is right malar width, Wl is left malar width, Pr is right malar projection, Pl is left malar projection, Hr is right malar height, and Hl is left malar height.

Postoperative radiographic measurements:

Malar width and malar projection were measured from the axial cut as shown in figure 5, and malar height was measured from the coronal cut as shown in figure 6.

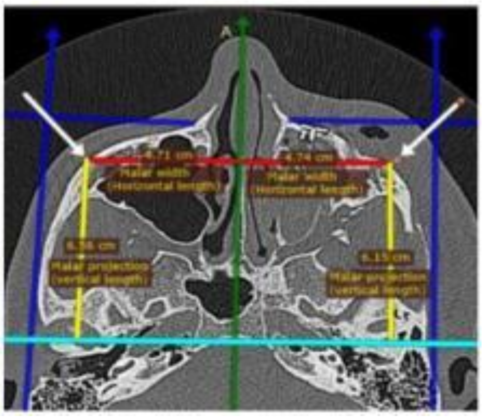

Figure (5): Postoperative radiographic malar width and malar projection on both sides.

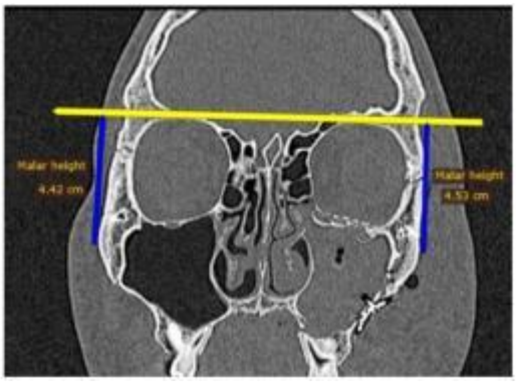

Figure (6): Postoperative radiographic malar height on both sides.

After measuring the malar width, malar projection, and malar height on both sides, the postoperative asymmetry index was calculated [4-5] as aforementioned in the preoperative calculation.

Ethical approval:

After receiving thorough explanations of the method, all participants were asked to sign an informed consent form. The Faculty of Dentistry at Suez Canal University's Research Ethics Committee gave their clearance on March 5, 2020, with the reference number 277-2020. The study was authorized by the Research Ethics Committee, Faculty of Dentistry Suez Canal University, established according to WHO-2011 Standards Approved in 3\5\2020 with (serial no. 277\2020).

Statistical analysis:

Data were collected, handled, and analyzed using IBM-SPSS version 28.0 for Mac OS. The normality of data was evaluated using the Shapiro-Wilk test to check whether the quantitative data were parametric or nonparametric. Quantitative data were presented as mean, standard deviation (SD), and range. Qualitative data were presented as frequency and percentage. P value < 0.05 was considered significant.

RESULTS

Demographic Data

The study included 14 males (70%) and 6 females (30%) and the age of studied patients ranged between 18 years to 65 years with an average age of 41.5±14.4 years. Accidents involving motor vehicles were the leading cause of this type of injury (Figure 7). The majority of the injuries in our study occurred on the left side, affecting 13 patients or 65% of the total, while the right side was harmed on 7 patients or 35%.

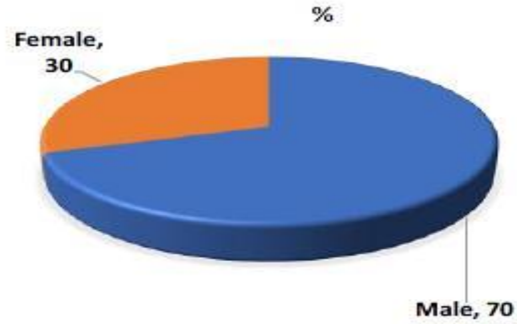

Fig (A)

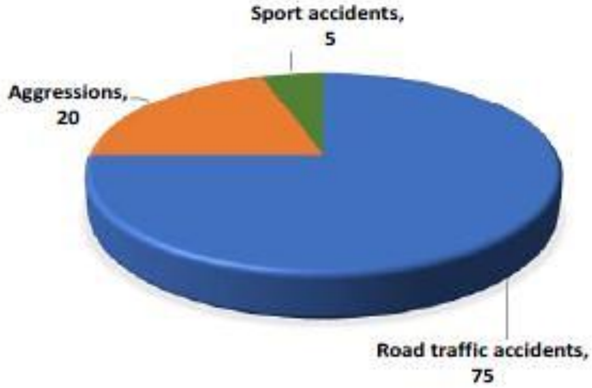

Fig (B)

Figure (7): (A) Distribution of patients according to genders, (B), Pie chart present the causes of the trauma in the studied patients.

Surgical procedures

The reduction was achieved through Gillie's approach in 4 cases, keen's approach in 13 cases, and by manipulating mini screws in 3 cases. The zygomaticomaxillary buttress was exposed through the intraoral buccal approach and used as the main point of fixation in all cases. The infraorbital rim was used as the second point of fixation in 15 cases and was exposed by a subtarsal incision in 9 cases (45%) and a subtarsal incision in 6 cases (30%). The frontozygomatic suture was exposed by a lateral eyebrow incision and used as the second fixation point in 5 cases (25%). The orbital floor was explored in 15 patients (75% of cases); reducing the fat hernia and freeing the inferior rectus muscle were both achieved during the procedure. Compression helped to slowly release the infraorbital nerve. Ten patients (or 50% of the cases) had their orbital floors rebuilt using a soft titanium mesh.

Radiographic Analysis

Malar Width:

The malar width on the normal and fractured sides showed an average (±SD) of 45.6±4.4 and 42.9±5.9 with a highly significant difference between them as revealed by paired t-test (p=0.003). However, postoperative recorded an average (±SD) of 45.1±4.4 and 45.1±4.5 after 1 week and 1 month; respectively. The difference between 1 week postoperative and preoperative fracture was highly significant as revealed by paired t-test (p=0.007), furthermore, the difference between 1 month postoperative and preoperative fracture was highly significant as revealed by paired t-test and LSD (Figure 8).

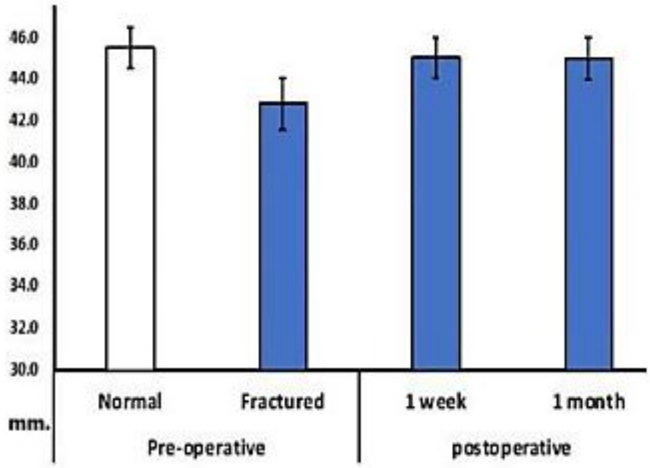

Figure (8): Preoperative and postoperative radiographic malar width.

Malar Projection:

The radiographic malar projection in the normal side and fractured side showed an average (±SD) 61.1±3.9 and 58.4±3.2 mm with a highly significant difference between them as revealed by paired t-test (p=0.009). However, postoperative recorded an average (±SD) of 60.7±3.3 and 60.7±3.3 after 1 week and 1 month; respectively. The difference between 1 week postoperative and preoperative fracture was highly significant as revealed by paired t-test (p=0.002), furthermore, the difference between 1 month postoperative and preoperative fracture with highly significant as revealed by paired t-test (p=0.003) and LSD. The difference between preoperatively normal, fracture, and postoperative 1 week and 1 month was significant as evaluated by repeated measure ANOVA (p=0.004) (fig.9).

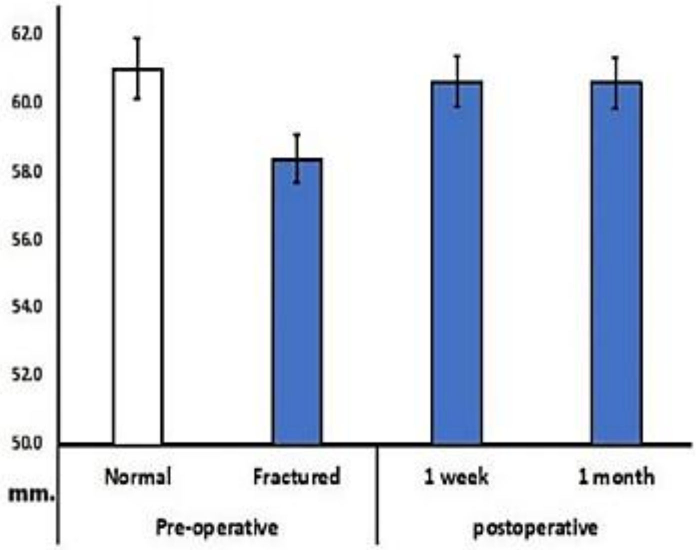

Figure (9): Preoperative and postoperative radiographic malar projection.

Malar Height:

The radiographic malar height on the normal side and fractured side showed an average (±SD) of 44.7±4.6 and 46.8±6.2 mm with a non-significant difference between them as revealed by paired t-test (p=0.128). However, postoperative recorded an average (±SD) of 44.9±4.1 and 44.9±4.1 after 1 week and 1 month; respectively. The difference between 1 week postoperative and preoperative fracture was non-significant as revealed by paired t-test (p=0.117), furthermore, the difference between 1 month postoperative and preoperative fracture was non-significant as revealed by paired t-test (p=0.111) and LSD. The overall difference between preoperative normal, fracture, and postoperative 1 week and 1 month was nonsignificant as evaluated by repeated measure ANOVA (p=0.125) (Fig.10).

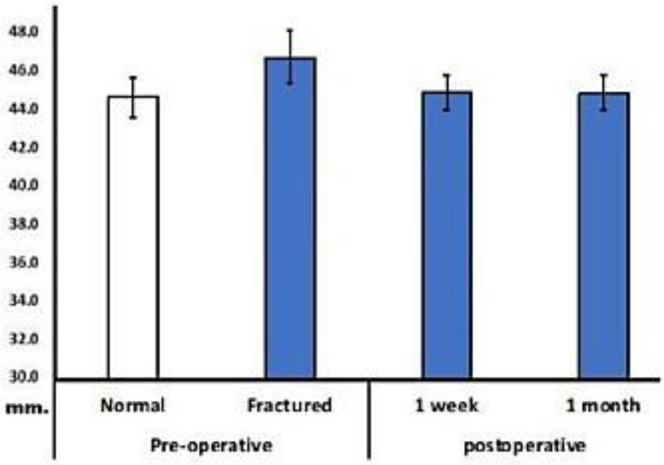

Figure (10): Preoperative and postoperative radiographic malar height.

Asymmetry index

The postoperative asymmetry index was calculated to show the degree of ZMC reduction and alignment using the 2-point fixation technique as presented in figure (11). The asymmetry index differed significantly (p<0.001) between the timepoints before and after the operation (1 week, 1 month). The average asymmetry index in preoperative, and postoperative time points was 8.3±3.1, 2.6±1.3, and 2.6±1.2; respectively. The asymmetry index decreased significantly postoperatively by 1 week (p<0.001***) and 1 month (p<0.001***).

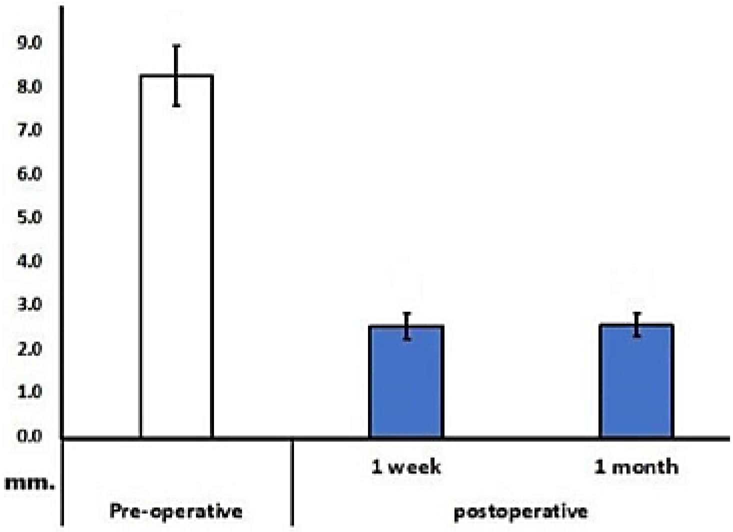

Figure (11): Preoperative and postoperative asymmetry index in the studied patients.

DISCUSSION

The ZMC is a frequently injured facial skeleton component, especially in cases of interpersonal aggression and transportation accidents, due to its lateral prominence [6].

Managing ZMC fractures can be challenging due to the need for more consensus among surgeons regarding the most effective surgical technique. However, adhering to four fundamental principles can ensure the successful repair of facial fractures. These principles include providing ample exposure, achieving accurate reduction, attaining stable fixation, and minimizing complications. By following these principles, surgeons can confidently approach the treatment of ZMC fractures [7].

Management of ZMC fractures by only closed reduction without fixation should be limited to simple fractures as **Dingman and Natvig** [8] found that internal fixation and open reduction were better options for displaced ZMC fractures than closed reduction, and that most fractures treated with the latter resulted in worse abnormalities than before the operation.

The optimal number of fixation sites to secure the zygoma in its proper position while the bone heals is a hotly debated subject in the field of zygomatic fracture treatment [9]. Surgeons have traditionally prioritized repairing the ideal number and position of buttresses for ZMC fracture stability. Stability of the fracture and the quantity of hardware needed to keep the fracture reduced throughout healing should determine the requirement for one-point, two-point, three-point, or four-point fixation [10].

Postoperative displacement of the reduced ZMC can cause facial asymmetry, mainly due to masticatory force. The masseter muscle is the most significant contributor to this force, and its action tends to force the ZMC fractured segment mainly inwardly [11].

There are numerous reasons why many authors favor intraorally fixating the zygomatic buttress instead of the FZ region: there is no external scarring, it is easy to access the area during surgery, there is enough soft tissue cover, the plate is not palpable, it is easier to remove the plate if necessary, and most importantly, the ZM buttress is a better indicator of zygoma alignment than the FZ region because of its wider area of articulation. Placing the plate on the ZM buttress will counteract the masseter muscle action and prove to be more stable [12]. In the present study, the zygomatic buttress was used as the key point of fixation in all cases. There was significant improvement in clinical and radiographic results after 1-week and 1-month, indicating stable ZMC fixation.

Kühnel and Reichert [13] successfully treated displaced, non-comminuted ZMC fractures using a single-point fixation technique in the maxillary buttress. **Kim *et al.*** [14] **and Chen *et al.*** [15] both used a 1-point fixation approach at the zygomatic buttress without addressing other regions such as the frontozygomatic or infraorbital region. They concluded that this method can provide satisfactory aesthetics and high surgical stability.

The current study agrees with the above-mentioned studies in the importance of fixation of the zygomatic buttress as a key point for stabilizing the reduced ZMC. However, one-point fixation may fail to address the three-dimensional stability of the ZMC and can lead to facial asymmetry and permanent deformity.

According to **Rinehart *et al.*** [16] cadaver studies have shown that utilizing a 2-point or 3-point mini-plate fixation approach can withstand static and oscillating loading similar to natural chewing forces, while a single-miniplate fixation approach may not be sufficient to stabilize the zygoma against similar forces. These findings support the idea that multi-point fixation approaches may offer superior stability for the reduced ZMC compared to a single-point fixation approach.

According to a study by **Parashar *et al.*** [17]**,** it was found that using a single fixation method does not provide a stable three-dimensional support as it cannot counteract rotational forces. Moreover, they also noted that utilizing a three-point fixation method may result in unsightly scars and nerve palsy. A retrospective study was conducted by **Zhang *et al.*** [18] on 155 patients with ZMC fractures. They used ZM buttress and ZF suture area as the two points of fixation in 103 patients. They develop a quantified localizer for zygomatic asymmetry. After an average of 18 months of follow-up, 2 patients had zygomatic asymmetry, 2 patients had numbness in the infraorbital area, 1 patient had limited mouth opening, and 3 patients had plates removed.

Gandi *et al.* [19] established that, when using small plates, two-point fixation provides the same level of stability as three-point fixation. A study by **Na *et al.*** [20] included two groups of twenty-two patients were divided into: one that underwent two-point fixation and another that underwent three-point fixation for unilateral ZMC fractures. They found no difference in stability between two-point and three-point fixation when they measured the zygoma's lateral projection and height at two landmark positions on preoperative and postoperative frontal 3D CT images: the zygomaticofacial foramen and the frontozygomatic suture.

Another study on the stability of two-point fixation was conducted on 20 patients by **Mittal *et al.*** by comparing the values of the malar height and vertical dystopia disparity in the water's view radiograph before and after the operation. The study demonstrated that radiographic and clinical indices significantly improved after surgery, demonstrating that two-point fixation successfully stabilizes the fragmented pieces [21]. The results of the present study agree with the conducted results above as clinically and aesthetically sufficient results were obtained after fixation of ZMC by the 2-point technique providing the reliability of using the 2- point technique for management of ZMC fractures.

A study conducted by **Rana *et al.*** [22] where group 1 had two-point fixation, and group 2 received three-point fixation; each group consisted of 100 patients having a unilateral ZMC fracture. Vertical orbital dystopia and malar height disparity were assessed. The patient's vertex view was used to measure the malar height by comparing the fractured site with the normal site and using a vernier caliper. Vertical dystopia was determined by palpation and comparing the level of the bony orbits with the normal side. This was then measured on Waters view using a scale. Tracing paper was used to outline the infraorbital margin. The study concluded that three-point fixation with micro plates is the most effective method currently available for treating zygomatic bone fractures, since it resulted in somewhat larger improvements in malar height and vertical dystopia compared to two-point fixation. However malar height alone didn’t address the three-dimensional position of the reduced ZMC, and for accurate postoperative assessment of adequacy of ZMC fracture reduction three dimensional positions of the reduced zygoma should be recorded by measuring the malar width, malar projection, and malar height of both preoperatively and postoperatively from CT scans.

The identification, evaluation, and surgical treatment of ZMC fractures have been the subject of a great deal of research. Nevertheless, quantitative measurement of postoperative malar asymmetry has not been the basis of many studies [21-23]. Using paired landmarks, the asymmetry index may measure the three-dimensional face symmetry. In healthy adults, **Pau *et al.*** found that the average difference between the two sides of the malar eminence was under 2 millimetres [24].

In the present study, we used the asymmetry index to show the degree of postoperative ZMC stability using the 2-point fixation technique. At both the pre- and postoperative intervals, the asymmetry index was significantly different (1 week, 1 month). The average asymmetry index in preoperative, and postoperative time points was 8.3±3.1, 2.6±1.3, and 2.6±1.2; respectively. The asymmetry index decreased significantly postoperatively by 1 week and 1 month indicating the reliability of the 2-point fixation technique. If fewer fixation points can obtain similar stability; there is clinical significance in reducing the number of fixations performed in order to shorten the operation duration, alleviate postoperative edema, and decrease the likelihood of postoperative sequelae.

Although the small number of patients involved in the study may be viewed as a limitation, the findings present a unique opportunity for further investigation. By expanding the scope of the research, we can gain a more comprehensive understanding of ZMC fracture management with fewer fixation points and potentially uncover valuable insights that could improve clinical outcomes for patients with facial trauma. Studies that included a greater number of patients and longer follow-up periods with quantitative analysis of postoperative symmetry are recommended.

CONCLUSIONS

Because of its contributions to orbital volume, facial width, and malar prominence, ZMC is an essential part of the structure and function of the face. Facial and orbital harmony can be easily restored with proper diagnosis and therapy; nevertheless, severe deformities that are difficult to heal secondary to an extent can result from insufficient treatment. Adequate esthetic outcomes and stable fixation results can be obtained by using a 2-point fixation technique in non-comminuted ZMC fractures.

The zygomatic buttress as a key point of fixation through intra-oral access has the best esthetic and functional outcome. When the orbital floor needs reconstruction, the infraorbital rim is used as the second point of fixation, otherwise, the frontozygomatic suture area can be used as a second point of fixation.

Conflict of interest: None declared.
Fund: Non-fundable.

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