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EVALUATION OF THE REDUCTION OF ANTERIOR ZYGOMATIC ARCH FRACTURES VIA INTRAORAL MAXILLARY VESTIBULAR APPROACH WITH INTERNAL FIXATION AND WITHOUT INTERNAL FIXATION (RANDOMIZED CLINICAL TRIAL)

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ABSTRACT

The aim: Radiographic evaluation of intraoral maxillary vestibular approach to the zygomaticomaxillary buttress and anterior arch fracture reduction technique with fixation versus without fixation for anterior arm of the arch.

Patients and methods: Twelve male patients with unilateral zygomaticomaxillary fracture involving the zygomatic arch, reduction, and fixation applied by an intraoral maxillary vestibular approach. Group A comprised 6 patients with fractured zygomatic complex reduced and fixation with reduction of the zygomatic arch without fixation, Group B comprised 6 patients whose fractured zygomatic complex reduced and fixation with reduction of the zygomatic arch and fixation of anterior arm of the arch. CT scans performed, preoperatively and immediately postoperative, to assess the accuracy of reduction to the zygomatic buttress and anterior part of the arch.

Results: The preoperative anteroposterior dimensions on the axial cuts of the CT scans for both groups showed the mean values of points A and B on the intact side to that of the fractured side no statistically significant difference. Comparing the mean values of point C on the intact side to that of the fractured one stated statistically significant difference between them. The immediate postoperative axial cuts comparing the mean values of the points A, B, and C on the intact side and the reduced side, there was no statistically significant difference between them for groups A and B.

Conclusions: Reduction without fixation in uncomplicated cases where minimal intervention is sufficient, whereas fixation is crucial for achieving stability and reliable outcomes in more complicated scenarios.

KEYWORDS: zygomatic arch fracture fixation, maxillary vestibular approach, computed tomography scan.

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INTRODUCTION

The most significant skeletal injuries are facial fractures especially the zygomatic buttress and the arch because of their prominent projection with vulnerable anatomy and their essentiality in facial aesthetics, in addition to their subsequent impairment on mouth opening and mastication, in addition to aesthetic concerns like facial asymmetry and disfigurement.[1,2]

Zingg et al[3] in 1992 classified the zygomatic maxillary complex (ZMC) fractures into three types; Type A where an incomplete zygomatic fracture in which only one articulation of the zygoma is involved, with subtypes A1 (zygomatic arch fracture), A2 (lateral orbital wall fracture) and, A3 (infraorbital rim fracture). Type B where all four articulations of the ZMC are disjunction (a complete tetrapod fracture), with intact zygomatic bone complex, and Type C where a comminuted disjunction zygomatic bone.[3]

The choice of approach depends on several factors: the complexity of the fracture, the patient's overall health, and the surgeon's experience and skill level. Regarding the esthetic outcomes, no certain approach to ZMC fracture management is ideal, while adequate exposure of the surgical site and prevention of postoperative complications are the most crucial intended outcomes.[4,5]

The intraoral buccal approach was first described by Keen in 1909 with subsequent modifications that were introduced afterwards for improving the approach to the buttress and the arch as a minimally invasive technique, minimizing the risk of visible scar and better acceptance by the patients.[4-6]

Reduction without using fixation hardware is often considered in cases where the fracture is simple, stable, intact zygomatic body and arms, where the inherent stability mainly depends on adjoining soft tissues (fascia and muscular attachments) and the patient's bone anatomical structure. However, it might carry the risk of postoperative displacement followed by functional and/or aesthetic drawbacks.[7-9]

On the other hand, reduction and fixation with plates and screws secure the fracture in place, offering better stability and predictability, particularly in unstable or complex ZMC fractures, although there might be an increase in surgical time, cost and the overall potential risks associated with hardware installation.[7-9]

In this research, we aim to provide a radiographic evaluation of the intraoral maxillary vestibular approach to the zygomaticomaxillary buttress and anterior arch fracture reduction technique with fixation hardware installment versus without fixation for the anterior arm of the arch, regarding the accuracy of reduction and stability of fixation utilizing both techniques.

PATIENTS AND METHODS

Twelve male patients suffered from unilateral zygomaticomaxillary fracture involving the zygomatic arch, free of severe inferior orbital rim deformity, and diplopia. Patients were selected from the outpatient clinic of the Oral and Maxillofacial Surgery department, Faculty of Dentistry, Cairo University, Egypt. The cause of the fractures was attacks or interpersonal brutality and road traffic accidents. Ethical approval for this study was obtained from the ethical committee, and informed written consent was performed.

The samples were divided into two groups, Group A: comprised 6 patients in which their fractured zygomatic complex was reduced and fixation of the fractured zygomatic buttress by mini-plates applied via an intraoral maxillary vestibular approach with reduction of the zygomatic arch without fixation, and Group B: comprised 6 patients in which their fractured zygomatic complex was reduced and fixation of the fractured zygomatic buttress by mini-plates applied via an intraoral maxillary vestibular

approach with reduction of the zygomatic arch and its fixation by plating of the anterior arm of the arch with the zygomatic buttress.

The age of the enrolled patients ranged from 20 to 43 years with a mean of 36.5 years. All patients were healthy according to the American Society of Anesthesiologists (ASA1)[10] without any contraindication for oral and maxillofacial surgery and general anesthesia. Exclusion criteria included the fracture that needs an extraoral approach, patients who are medically compromised, those with acute infection, nondisplaced ZMC fracture, bilateral ZMC fractures, comminuted ZMC fractures, history of craniofacial surgery, ZMC fractures with other facial fractures, and history of congenital facial asymmetry.

Clinical examination and preoperative CT scan were performed for proper diagnosis and also for comparison between the two groups pre, and postoperatively.

The time interval between injury and surgical intervention under general anesthesia ranged from 4 to 7 days (the mean 5.5 days). Patients of both groups presented with flattening of the cheek (89%), restricted mouth opening (53%), malocclusion, and neurosensory disturbances of the infraorbital nerve (69%).

Surgical treatments were operated under general anesthesia and aseptic environments. Patient scrubbing & draping were completed in standard fashion, local anesthesia (articaine HCL 4% with 1: 100,000 vasoconstrictor -Septanest SP, Septodont pharmaceutical Industries, France) was administrated.

Surgical access was performed via an upper maxillary vestibular incision from the canine to the first molar (Keen's approach) to expose the zygomaticomaxillary buttresses and the infraorbital neurovascular bundle was recognized and conserved.

The depressed zygomatic fractures were reduced and stabilized using a Carroll-Girard screw. Fracture fixation with adequate mini-plates osteosynthesis was performed involving the zygomaticomaxillary buttress for group A and the zygomaticomaxillary buttress and the anterior arm of the zygomatic arch for group B using the trans-buccal trocar. A percutaneous stab incision was used for placement of the Carroll-Girard screw, with blunt dissection to avoid facial nerve affection or through facial laceration.[1]

The sulcus incision was closed using absorbable sutures by Vicryl 4-0 and Proline 4-0 for the skin incision of the buccal trocar.

All the surgically operated patients were dismissed the same day after recovery from the surgery and advised not to apply pressure on the fractured side for a period of six weeks.

Follow-up:

Postoperative instructions were given, and patients were prescribed antibiotics, analgesics, and an intraoral mouthwash, and oral hygiene measures were instructed. Clinical follow-up for all patients includes postoperative pain, edema, bleeding, and infection. Post-operative CT scans were performed to assess the accuracy of reduction and to compare both groups together.

The two groups were recalled for follow-up intervals of one week, one month, and three months to assess the progress and monitor any complications and possible aesthetic changes.

Radiographic evaluation:

CT scans were performed for each patient in the two groups, preoperatively and immediately postoperative, to assess the accuracy of reduction to the zygomatic buttress and anterior part of the arch, where preoperative and postoperative measurements were taken on the same axial cut of the CT scan with the anterior nasal spine taken as a reference point. This was done according to **Ellis et al** measurements.[11]

Anteroposterior measurements:

A horizontal line was drawn as a reference line perpendicular to the midsagittal plane and anterior to the nasal bone. Three measurements were taken from this line to the zygomatic buttress and zygomatic arch with 2cm intervals.[11] **Figure (1)**

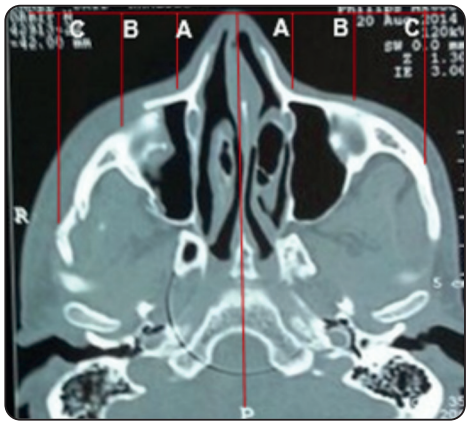

Fig. (1) 2D axial cuts with 2cm spaced anteroposterior measurement reference points, point A: 2cm from the midsagittal plane, point B: 4cm from the midsagittal plane, point C: 6cm from the midsagittal plane.

Comparing the mean values of the anteroposterior measurements taken at the reference points A, B, and C marked at 2 cm intervals on the horizontal line drawn on the axial CT cut for both the healthy and the affected sides on the pre and post–operative CTs to assess the accuracy of reduction, this was done for each patient enrolled in the study in either group.

Statistical analysis:

The collected data were statistically analyzed. The significance mark point of the collected data between the preoperative and postoperative data at the equivalent reference points A, B, and C (regarding zygomatic complex projection) and facial asymmetry in 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 $p \leq 0.05$.

RESULTS

Comparing the preoperative anteroposterior dimensions from the reference points on the axial cuts of the CT scans for both groups showed that the mean values of the two points A and B on the intact side to that of the fractured side showed no statistically significant difference between them. Comparing the mean values of the more lateral point C on the intact side to that of the fractured one in the anteroposterior dimensions stated a statistically significant difference between them. **Table (1)**

TABLE (1) Comparison between the mean values of A, B, and C points on the intact and fractured zygoma, A anterior point lateral to the mid-sagittal plane, B middle point, C posterior point the most lateral point from the sagittal plane. Probability value $p \leq 0.05$.

	Mean	Std. Deviation	P value
A-A	1.72	1.19	0.64
B-B	3.21	5.03	0.36
C-C	5.08	8.68	0.03*

Post-operative analysis:

Group A: the immediate postoperative axial cuts comparing the mean values of the points A, B, and C on the intact side and the reduced side in the anteroposterior dimensions, there was no statistically significant difference between them. **Table (2) Figures (2 & 3)**

Group B: the immediate postoperative axial cuts comparing the mean values of the points A, B, and C on the intact side and the reduced side in the anteroposterior dimensions, there was no statistically significant difference between them. **Table (3), Figures (4&5)** For both groups dental occlusion, interincisal mouth opening, and patients' perception of infraorbital paresthesia, pain, and tenderness were self-resolved with no postoperative complications or need for re-operation and/or secondary correction of the operated zygomatic complex.

TABLE (2) Comparison between the mean values of A, B, and C points on the intact and fractured sides, A anterior point lateral to the mid-sagittal plane, B middle point, C posterior point the most lateral point from the sagittal plane. Probability value $p \leq 0.05$.

	Mean	Std. Deviation	P value
A-A	0.01333	0.06186	0.62
B-B	0.09167	0.1259	0.13
C-C	0.12	0.04472	0.023

TABLE (3) Comparison between the mean values of A, B and C points on the intact and fractured sides, A anterior point lateral to the mid-sagittal plane, B middle point, C posterior point the most lateral point from the sagittal plane. Probability value $p \leq 0.05$.

	Mean	Std. Deviation	P value
A-A	0.3367	0.6033	0.23
B-B	0.1733	0.2524	0.15
C-C	0.1617	0.225	0.138

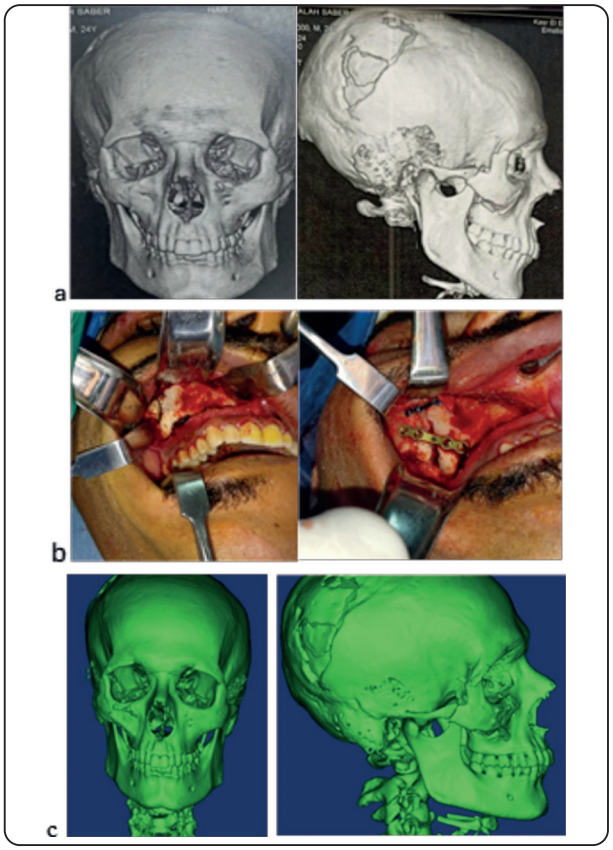

Fig. (2) Showing a- The preoperative radiographs, b- The intra-oral maxillary vestibular approach and reduction and fixation of the maxillary buttress, and c- The postoperative radiographs.

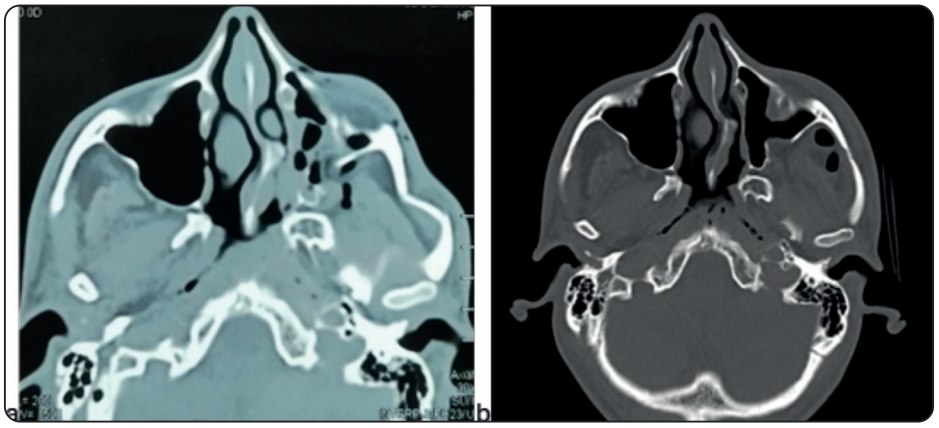

Fig. (3) Radiographic axial cuts CT of group A showing a- the preoperative radiograph, b - the postoperative radiograph.

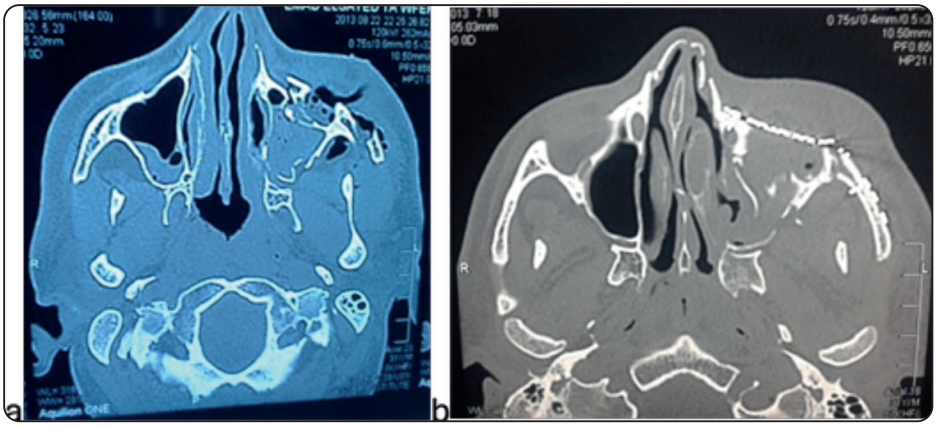

Fig. (4) Radiographic axial cuts CT of group B showing a- the preoperative radiograph, b - the postoperative radiograph.

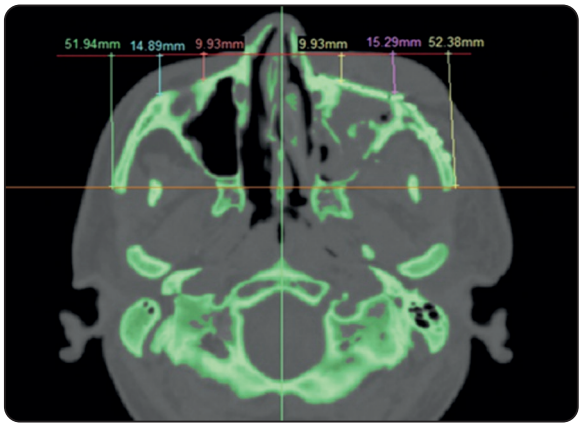

Fig. (5) Radiographic axial cut CT of group B showing the postoperative radiograph with measurements.

DISCUSSION

Twelve patients were enrolled in this study, all of whom met the inclusion criteria and suffered from zygomatico-maxillary fractures involving the zygomatic arch. The mean age of enrolled patients was 36.5. Adekeye [12] justified that the adult age group was stated to be more prone to facial trauma because of the increased outdoor activities. Most of the involved individuals are males coinciding with other studies showing that males are usually involved more than females in zygomaticomaxillary complex fractures.[1-4] The mean duration between the injury and surgical operation was 5.5 days and this was in accordance with many authors who stated that surgical intervention should be initiated before setting of the bony segments in their post-traumatic displaced positions. [1]

Facial bones fractures involving the zygomaticomaxillary complex can often lead to aesthetic defects with various degrees of malar depression, which in turn needs to be corrected to restore normal facial contour and symmetry. Fractures can also result in marked functional disability, trismus and affection of the infraorbital neurovascular bundle.[1]

In 2019 a meta-analysis was published by Jazayeri et al [2] who suggested that the zygoma and its articulations should be palpated and meticulously evaluated after fixation to determine if additional fixation points are required. In addition, postoperative CT scans should be utilized to assess the articulations of the reduced zygoma and to verify adequate reduction and fixation.

In the present study most, enrolled cases were ZMC fractures type B (tetrapod fracture according to **Zingg's classification** system of ZMC fractures) that were mildly displaced.[3] Where a Keene maxillary approach was used for reduction and fixation in both groups with improvement in the infraorbital nerve affection without any post-operative complications as infection or wound dehiscence.

As most zygomatic tetrapod fractures require open reduction and internal fixation, fixation points could vary according to the magnitude of displacement and the stability of the complex after reduction and fixation of at least one arm of the complex. Where single-point fixation is usually

performed at the zygomaticomaxillary buttress or the zygomaticofrontal suture, two-point fixation at both the zygomaticomaxillary buttress and the zygomaticofrontal suture, and three-point fixation at the zygomaticomaxillary buttress, the zygomaticofrontal suture and inferior orbital rim. The zygomatic arch can be plated through a coronal incision or a preexisting laceration as the fourth point of fixation if all the other points are not enough to stabilize the complex. In the current study, two-point fixations were utilized at the zygomaticomaxillary buttress and anterior part of the zygomatic arch via the maxillary intra-oral **Keen's approach**.[6,17]

In both groups, the pre-operative assessments of the axial cuts of the CT scans stated that there was a marked difference between the intact side and the fractured side at point C, and that was due to the displacement of the fracture because of the direct trauma and masseter muscle pull which is attached to the zygomatic arch on the lateral and inferior aspect. Although the displacement caused by the muscle pull is usually counteracted by the thick periosteum and fascia enveloping the arch, however, when the periosteum and fascial envelope are damaged by high magnitude injuries, the fractured segments show more displacement that usually requires surgical intervention.[4,13-14]

According to Starch-Jensen et al., fractures exhibiting a bone diastasis ≥3 mm were defined as inadequate anatomic alignment and thereby implies the need for open reduction and fixation.[15]

Post-operative assessment for points A–A (anterior point), both treatment groups demonstrated non-significant differences. Similarly, for points B–B (middle point), no statistically significant differences were recorded between the two groups, also points C–C (posterior point) revealed a non-marked contrast between the two groups. A statistically non-significant difference ($p = 0.123$) indicates a non-stated difference in both methods of management of the fractured zygomas. Although the freehand surgical technique for an expert provides respectable results for zygomatic arch reduction without fixation, the principal cause of post-reduction instability is utmost due to displacing forces of the masseter together with post-operative instructions uncompliant patient.

The primary advantage of reduction without fixation is its relatively minimally invasive nature, leading to reduced intra-operative duration and reduced costs. This technique is particularly suitable for patients with contraindications to prolonged surgery duration or for those seeking cost effective treatment. Despite these benefits, the lack of zygomatic arch fixation can result in variable outcomes, especially in cases where the fracture is prone to displacement under functional loads, thereby, the reliability of this technique in ensuring long-term stability and overall patient satisfaction is under questioning.[16,17]

In the current study, there was no statistically significant difference between the post operative CT scan assessments of both groups, denoting that the success of reduction and stabilization of the arch and zygomatic complex was successful either without fixation of the anterior arch or with anterior fixation of the arch via plating through the intraoral maxillary approach. Also, as the reduction and fixation through the intraoral approach were proven successful, the need for the coronal approach thereby could be avoided together with the subsequent reduction in the operating surgical time and postoperative complications that might result from the coronal approach.[15-18]

CONCLUSION

Despite the widespread adoption of both techniques, there remains a noticeable lack of consensus regarding their comparative efficacy, as the existing literature provides valuable insights but is often limited by small sample sizes, retrospective designs, and the variability in reporting outcomes. Randomized controlled trials and wide scale studies are needed to establish standardized guidelines for

selecting the most appropriate treatment method. The comparison between these two methods highlights a fundamental trade-off between simplicity and stability. Reduction without fixation is beneficial in uncomplicated cases where minimal intervention is sufficient, whereas fixation is crucial for achieving optimal stability and reliable outcomes in more complicated scenarios.

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