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Research Paper

Management of ZMC Fractures - A Review Article

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ABSTRACT
Fractures of the zygomaticomaxillary complex (ZMC) are frequent face injuries treated with two- or three-point fixation procedures. This review examines the benefits and drawbacks of each strategy. For less complicated fractures, two-point fixation is less invasive and also requires less time during surgery, but it may not provide adequate stability. More structural support is provided with three-point fixation, especially in cases of comminuted or displaced fractures, although the procedure takes longer and may raise the risk of infection. In order to determine the best fixing option based on fracture severity and patient-specific characteristics, this article contrasts clinical and biomechanical investigations. A tailored approach is recommended for the best outcomes.

KEYWORDS: *ZMC fractures, 2-point fixation, 3-point fixation*

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I. INTRODUCTION

In recent days, road traffic accidents and assaults have elevated enormously which are also commonly said to be the cause of facial bone fractures especially involving the zygoma. The Zygomaticomaxillary complex is a major component of the facial form which involves the zygoma, maxilla and surrounding structures. The zygomatic bone, having a tetrapod-like shape, forms the midfacial area and the horizontal buttress bones of the face [1].

The zygomatic bone builds the orbital floor, the prominence of the cheek, and a portion of the inferior and lateral orbital rim. In addition to facilitating the flow of infraorbital nerves and arteries that innervate the mid-facial region, the zygomatic complex plays an indispensable part in the functioning of the globe and facial symmetry[2].Trauma to this complex obviously results in loss of facial form, function and stability, further affectingthe patient both physically and psychologically.

Achieving normal anatomic shape and position of the zygomatic body and malar eminence following management of the ZMC fractures is essential to produce satisfactory outcomes in midface reconstruction. In order to reestablish the intricate, versatile interaction between the zygoma and surrounding structures, therapy for the fracture has to produce an appropriate and stable reduction at the fracture site[3].

All of this points that diagnosing and treating it promptly is essential to restore the lost function, form, stability and also the patient's confidence.Also, the management of the fracture varies according to the affected site, type of fracture, severity of trauma and patient's history. The treatment goes from closed reduction to open reduction with internal fixation (involving one point to four point fixations). This review article's sole objective is to contrast the various components of internal fixation - two and three pointsin ZMC fractures.

ZYGOMATICOMAXILLARY COMPLEX

The zygomaticomaxillary complex acts as the cornerstone to a one's appearance. Anatomically, possesses four points of articulationwith frontal bone at zygomaticofrontal suture, temporal bone at zygomaticotemporal suture, maxilla at zygomaticomaxillary buttress, and greater wing of the sphenoid at the zygomatico-sphenoid suture. Hence, described as a "tetrapod"[4].

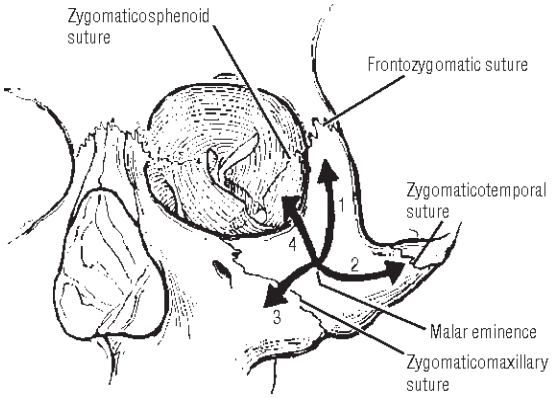

Figure 1 – Sutures of ZMC [5]

Zygoma also provides attachment point to the muscles of mastication and facial expression. Among all the muscles, masseter exerts the most substantial intrinsic deforming force on the zygomatic body and arch [4].

CLASSIFICATION OF ZMC FRACTURES [6]

Based on ZMC's rotational axis and stability following reduction - Rowe and Williams' classification :

Following elevation, fractures were regarded as stable when they demonstrated:

- Fracture limited to the arch with medial displacement
- Rotation (laterally or medially) about the vertical axis

Following reduction, fractures were deemed unstable if they presented:

- Fracture limited to the arch with inferior displacement
- ZMC fracture rotated on its horizontal axis
- Dislocated (inferiorly, laterally, and medially) en bloc
- Comminuted

Based on the severity of impact due to the trauma :

Lowenergy type –undisplaced or minimally displaced en bloc
Medium-energy type - displaced fractures with or without fragmentation
Highenergy type - fractures with massive displacement, or fragmentation

Zing et al.'s classification – 1992 :

Type A: a partial zygomatic fracture involving a single zygoma articulation
A1: fracture of the zygomatic arch
A2: fracture of the lateral orbital wall
A3: fracture of the infraorbital rim
Type B: A complete tetrapod fracture, involving all four articulations
Type C: A multi-fragment zygomatic fracture in which there is also a zygoma body fracture

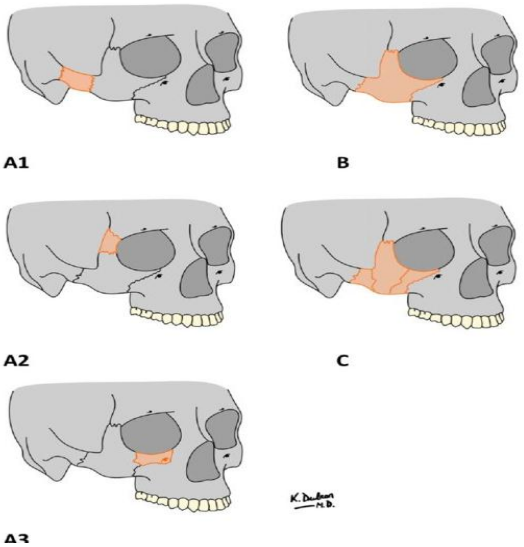

Figure 2 – Classification by Zing et al. [7]

ETIOLOGY

The etiology of ZMC fractures typically involves high-impact trauma. The most common cause of ZMC fractures, as these incidents often involve significant blunt force trauma to the face.Physical altercations can result in direct blows to the cheek area, leading to fractures of the zygomatic complex.Accidental falls, particularly in the elderly or intoxicated individuals, can result in facial trauma. Contact sports like boxing, football, or hockey can cause significant facial trauma. Injuries involving heavy machinery or construction-related incidents can also lead to such fractures[6].

While Chowdhury and Menon and Fasola et al. reported high rates of automobile accidents, Kovacs et al. (46.2%) found that assault was the most common cause of zygomatic fractures. Remarkably, sports injury was recorded by Sulliven et al. around 27.5%. Four cases of open and comminuted ZMC fractures with bear bite injuries were also recorded in a study. Over decades, the causes of facial fractures hassignificantly evolved and keeps evolving [8].

CLINICAL FEATURES

Major clinical presentation includes periorbital ecchymosis and edema, pain, facial asymmetry, epistaxis, step deformity and ocular defects[9].

Figure 3 – Flattening of left zygomatic prominence [10]

Figure 4 – Periorbital ecchymosis[2]

INVESTIGATION

Imaging and clinical evidences should be integrated to arrive at an accurate diagnosis of zygomatic fractures. Also, the main diagnostic method used for confirming the ZMC fractures is computed tomography (CT)[11].

It is exceptionally beneficial to use CT to evaluate mandibular,zygomaticomaxillary complexand com minuted fractures in the midface because it doesn't require any additional radiation or scanning time[12].
As per Ricci et al. (2018), when evaluating facial trauma, facial CT is favored over head CT[12].

Figure 5 – 3D CT showing displaced ZMC fracture [9].

Intraoperative CBCT imaging should be used in cases of comminuted ZMC fractures in accordance with the research conducted by Cuddy et al. (2018). While 0% of patients in a study on ZMC fractures treated with intraoperatice CBCT imaging needed a secondary surgical intervention, 9% of patients in a previously published study on mid-face fractures treated without intraoperative CBCT, needed one to correct ZMC malalignment (Van Hout et al., 2016) [12].

MANAGEMENT

The last few decades have seen a significant shift in the care of ZMC fractures due to advancements in imaging technologies, surgical techniques, and a deeper comprehension of facial anatomy. In addition to restoring facial symmetry and function, effective care is necessary to minimize any potential long-term problems.The treatment options range from conservative treatments like observation and immobilization to more invasive ones like open reduction and internal fixation (ORIF).

When treating fractures that are comminuted or that can become unstable post-reduction, the preferred method should be open reduction with internal fixation. Regarding the number of fixation points required for treating ZMC fractures, there is no agreement. Generally speaking, more fixation points are required to assure a successful outcome the more comminuted or unstable a fracture is. Generally, the more comminuted or unstable a fracture is, the more fixation points will be required to ensure better results [13].

REDUCTION AND FIXATION

Open reduction is most commonly required for displaced, unstableor comminuted fractures and typically involves making an incision to access the fracture sites. Keen’s approach, Gillies’ approach, coronal approach or the Dingman’s approach are the various incisions used. Given that Gillies' approach is uncomplicated to use and renders no scar on the face, it is seen as being aesthetically pleasing[14].After this, the fracture fragments are aligned anatomically.

Miniplates and Screwsisthe most common method of fixation. Used at three or four points: zygomaticofrontal, infraorbital rim, zygomaticomaxillary buttress, and zygomatic arch. The main aim is to ensure stable fixation and restoration of the ZMC position.

For 2pointfixation - frontozygomatic sutureand zygomaticomaxillary buttress and for 3 point fixation technique - fixationdone at frontozygomatic suture, infraorbital margin andzygomaticomaxillary buttress [15].

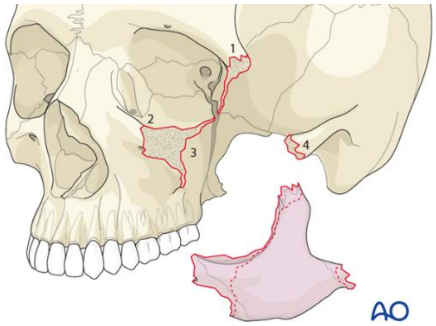

Figure 6 – Zygomaticomaxillary complex fracture [16]

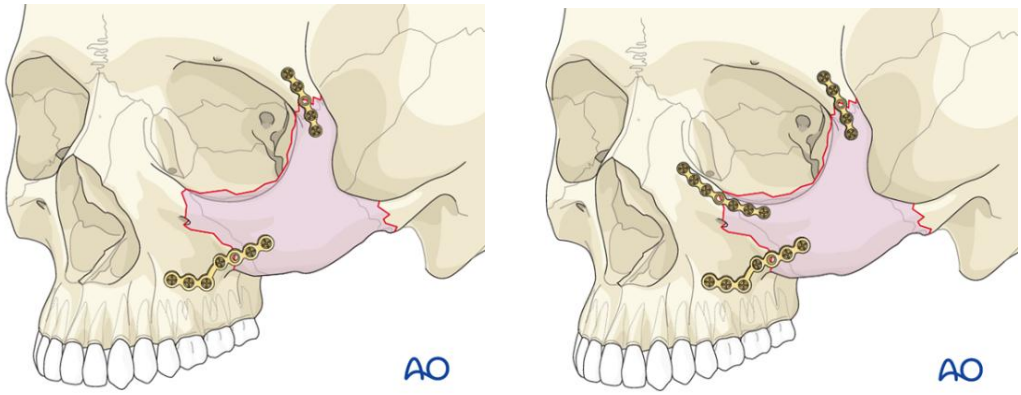

Figure 7 – (A) Twopoint fixation [17]; (B) Three point fixation [18]

Advantages of Two-Point Fixation

According to several authors, a quicker, less invasive operation with lower risks of consequences like infection and nerve injury can be achieved with fewer incisions and less dissection—a benefit that is especially useful for patients with medical comorbidities and urgent cases. Gives mildly displaced or non-comminuted fractures enough stability to produce better results without the need for additional fixing. Fewer plates and screws are needed, which lowers the cost, particularly in settings with restricted resources[19]. Smaller incisions and less scarring results from fewer fixation points, which enhances the cosmetic results. Appropriate for milder instances, enabling quicker recuperation and outpatient surgery[20].

Advantages of Three-Point Fixation

Provides enhanced biomechanical stability, lowering the possibility of postoperative displacement and misalignment—a crucial factor in cases of comminuted or severely displaced fractures[11] [20]. More successful in regaining the natural contour of the cheekbones and avoiding side effects like enophthalmos and malar flattening [19].Reduces the possibility of complications following surgery and the necessity for corrective surgery by offering complete stability [20]. Maintains the occlusal stability and midface structure intact, preventing malocclusion and functional deficits. Ensures the secure fixation of all fragments and provides increased adaptability and stability for complicated and comminuted fractures[19].

Disadvantages of Two-Point Fixation

Two-point fixation frequently lacks sufficient biomechanical stability, particularly in comminuted or significantly displaced fractures. This can result in postoperative displacement and malar asymmetry, increasing the likelihood of subsequent corrective procedures[19][2]. Because of the lack of stabilization at a vital third site, two-point fixation may fail to restore malar prominence, resulting in inferior aesthetic consequences such as malar flattening and cheek asymmetry. Without the third fixation point, there is a greater risk of poor orbital volume reduction and stabilization, which can lead to enophthalmos and long-term ocular disorders such as double vision[2].

Disadvantages of Three-Point Fixation

Three-point fixation requires more incisions and a more complicated surgical process. This lengthens the surgery duration, which can lead to more anesthetic exposure and an increased risk of intraoperative problems[19]. Three-point fixation requires more extensive dissection, which increases the risk of surgical complications such as infraorbital nerve injury, which causes sensory deficiencies, as well as a higher risk of

postoperative infections[2]. The necessity for additional hardware (plates and screws) and more extensive surgical dissection might result in higher overall expenditures and a larger risk of visible scarring, particularly for patients worried about cosmetic outcomes[19].

BIOMECHANICAL STABILITY

Cadaver investigations indicated that three-point attachment offers enhanced resistance against both horizontal as well as vertical displacement pressures, prevalent during mastication. According to Rinehart et al. two-point fixation is insufficient, to stabilize the zygomatic complex against strong masticatory forces, which could cause the fracture segments to fail or shift [20].The results of cadaver investigations are corroborated by computational models, such as finite element analysis, which show that incorporating a third fixation point greatly lowers stress concentrations at the fracture lines and increases the overall stability[11].

Certain clinical trials that compared the fixation methods on patients have established that three-point fixation is more stable and has a reduced rate of postoperative difficulties, including vertical dystopia and malar asymmetry. These advantages do, however, come with more complex surgery and the possibility of side effects like palpable hardware and noticeable scars[15].

AESTHETIC OUTCOMES

Outcomes of a 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 outcomes concur with those of Naser et al.3, who found no discernible difference in face asymmetry between two- and three-point fixation methods[6].

A 2004 study found that although 2-point fixation was adequate to restore symmetry in less complicated fractures, it occasionally caused a slight asymmetry in the cheekbone area, especially in patients with more severe fractures. According to a 2003 study by Motamedi, 3-point fixation considerably improves cosmetic results in patients with more displaced fractures than 2-point fixation, leading to more significant overall facial symmetry[14].

Ellis et al. (1996) discovered that although 2-point fixation had the benefit of leaving less scarring, some patients experienced asymmetry or soft tissue anomalies as a result of insufficient bone reduction, especially in the cheek and midface regions. Despite a slightly higher risk of scarring, Manisali et al. (2015) found that the improved control over the zygomatic bone's location with 3-point fixation led to more uniform soft tissue patterns and better overall face aesthetics[21].Revision surgery was frequently necessary for patients with more severe fractures, according to Cole and Kaufman's - 2009 retrospective assessment. Patients with simple ZMC fractures treated with 2-point fixation expressed immense fulfillment with their cosmetic results[22].

POSTOPERATIVE COMPLICATIONS

The clinical advantages of three-point fixation in reducing postoperative problems were emphasized by Iatrou et al. in 2010. According to their research, three-point fixation considerably lowers the likelihood of issues including malar asymmetry and vertical dystopia, even though two-point fixation may be appropriate in some circumstances. When treating complex or comminuted fractures, they suggested three-point fixation[23].

Two point fixation is often insufficient in complex fractures, leading to malalignment and postoperative asymmetry while 3 point fixation provides better three-dimensional control and stability with reduced malreduction risks, especially in displaced fractures .2 point fixation hashigher risk of inadequate orbital volume restoration, leading to enophthalmos and diplopia. 3 point fixation is found to be more effective at restoring orbital volume by stabilizing the zygomatic arch[24].

Hollier et al. - 2005 observed that in clinical practice, three-point fixation resulted in fewer long-term complications and better aesthetic outcomes compared to two-point fixation. Various studies suggested that while three-point fixation might be more invasive, the improved biomechanical stability justifies its use in complex fractures[25].

In 2 point fixation, fewer fixation points reduce infection risks, but inadequate stability may necessitate revision surgery and also there is lower risk of direct injury but may cause indirect nerve compression due to malalignment. The additional hardware increases the risk of infection and soft tissue complications and higher risk of nerve damage due to increased exposure during surgery are established in 3 point fixation.

II. CONCLUSION:

In conclusion, on comparing multiple articles, the treatment of zygomaticomaxillary complex (ZMC) fractures frequently employs both two-point and three-point fixation techniques, each with distinctive benefits and clinical results.

There are particular advantages to both 2-point and 3-point fixation techniques when treating Zygomaticomaxillary Complex (ZMC) fractures. For less complicated fractures, 2-point fixation is frequently used because it offers sufficient stability, a quicker healing time, and less morbidity. It has lower surgical risks, such as infection and scarring, and performs well when littlecorrectionisrequired.By anchoring the zygomatic bone at three crucial places, 3-point fixation offers greater stability for more displaced or complex fractures while lowering the risk of problems including malunion or asymmetry. 3-point fixation produces superior long-term results in terms of facial symmetry and function during extensive trauma, although being more intrusive[26] [27].

While 2-point fixation may suffice in selected cases of ZMC fractures, 3-point fixation can remain the treatment of choice for achieving optimal stability and alignment in more complex fractures. However, evolving advancements in surgical techniques and imaging may help refine the treatment planning and further improve the outcomes in ZMC fracture management.

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