كليـــــــــة الـطـب
و الصيـدلـة - مراكش
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ET DE PHARMACIE - MARRAKECH
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Zygomatico maxillary complex fractures. What osteosynthesis? 1, 2, 3 or 4 point fixation.

THÈSE

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PAR

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Née le 12 Décembre 1992 à Ait Melloul

Médecin Interne du CHU Mohamed VI

POUR L'OBTENTION DU DOCTORAT EN MÉDECINE

MOTS-CLÉS

Zygomatico maxillary complex - Fracture - Internal fixation - Point fixation

JURY

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﴿رَبِّ أَوْزِعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ الَّتِي أَنْعَمْتَ عَلَيَّ
وَعَلَىٰ وَالِدَيَّ وَأَنْ أَعْمَلَ صَالِحًا تَرْضَاهُ وَأَدْخِلْنِي
بِرَحْمَتِكَ فِي عِبَادِكَ الصَّالِحِينَ﴾

Hippocratic Oath

I swear to fulfill, to the best of my ability and judgment, this covenant:
I will respect the hard-won scientific gains of those physiciansin whose steps I walk, and gladly share such knowledge as is mine with those who are to follow.
I will apply, for the benefit of the sick, all measures [that] are required, avoiding those twin traps of overtreatment and therapeutic nihilism.
I will remember that there is art to medicine as well as science, and that warmth, sympathy, and understanding may outweigh the surgeon's knife or the chemist's drug.
I will not be ashamed to say "I know not," nor will I fail to call in my colleagues when the skills of another are needed for a patient's recovery.
I will respect the privacy of my patients, for their problems are not disclosed to me that the world may know. Most especially must I tread with care in matters of life and death. If it is given me to save a life, all thanks. But it may also be within my power to take a life; this awesome responsibility must be faced with great humbleness and awareness of my own frailty. Above all, I must not play at God.
I will remember that I do not treat a fever chart, a cancerous growth, but a sick human being, whose illness may affect the person's family and economic stability. My responsibility includesthese related problems, if I am to care adequately for the sick.
I will prevent disease whenever I can, for prevention is preferable to cure.
I will remember that I remain a member of society, with special obligations to all my fellow human beings, those sound of mind and body as well as the infirm.
If I do not violate this oath, may I enjoy life and art, respected while I live and remembered with affection thereafter. May Ialways act so as to preserve the finest traditions of my calling and may I long experience the joy of healing those who seek my help.

Declaration of Geneva, 1948

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LISTE ARRÉTÉÉ LE 12/02/2018

بسم الله الرحمن الرحيم

سُبحَانَكَ

لاَ عِلمَ لنَا إلاَ مَا عَلَمتَنَآ

إِنكَ أَنتَ

العَلِيمُ الحَكِيمُ

اَللّٰهُمَّ صَلِّ عَلٰى مُحَمَّدٍ
وَّعَلٰٓى اٰلِ مُحَمَّدٍ كَمَا صَلَّيْتَ
عَلٰٓى اِبْرَاهِيْمَ وَعَلٰٓى اٰلِ اِبْرَاهِيْمَ
اِنَّكَ حَمِيْدٌ مَّجِيْدٌ ٥
اَللّٰهُمَّ بَارِكْ عَلٰى مُحَمَّدٍ وَّعَلٰٓى
اٰلِ مُحَمَّدٍ كَمَا بَارَكْتَ عَلٰٓى
اِبْرَاهِيْمَ وَعَلٰٓى اٰلِ اِبْرَاهِيْمَ
اِنَّكَ حَمِيْدٌ مَّجِيْدٌ ٥

DEDICATIONS

First and foremost, praises and thanks to Allah, the Almighty, for His showers of blessings.

الحمد لله رب العالمين

To the beloved memory of my late Grandfathers Dadda Mhand and Dadda Ahmed, may Allah bless their souls and grant them the highest levels of Jannah.

۞ وَقَضَىٰ رَبُّكَ أَلَّا تَعْبُدُوا إِلَّا إِيَّاهُ
وَبِالْوَالِدَيْنِ إِحْسَانًا ۚ

سورةالإسراء, آية٢٣

(17:23) And your Lord has decreed that you not worship except Him, and to parents, good treatment.

Aya23 Surat Al israa

To my dear parents: Naima EL BAZI and Ahmed TAOUFIK

To the ones who gave me strength to achieve all the glory. To my dearly beloved parents, my greatest pride and joy; no words would be strong enough to express my wholehearted gratefulness for your endless love, great sacrifice, inestimable support and precious guidance during my whole life. Every hard step I took to pursuit my dreams was magically made easier by your encouragements. I owe you my life, my upbringing and my happiness. I hope I have been up to your expectations. I thank God for the chance of having you always around. May God bless you and protect you eternally. . I am grateful that you are, have always been and will always be the warm wind beneath my wings. I love you and I dedicate this thesis especially to you.

To my dear brother Oussama, my forever friend

To the first friend ever and partner in crime, to our ridiculous karaté combats and serious pillow fights, to hating while adoring each other. No matter how far the distance, you'll always be in my heart. I miss you tremendously and I wish you all the best. God bless you.

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Professor Badreddine ABIR

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ABBREVIATIONS

List of abbreviations

ZMC	:	Zygomatico Maxillary Complex
ORIF	:	Open Reduction Internal Fixation
FZ	:	Fronto Zygomatic
ZMB	:	Zygomatico-Maxillary-Buttress
ZA	:	Zygomatic Arch
CT	:	Computed Tomography
CR	:	Central Ray
IM	:	Infraorbito Meteal
IOR	:	Infraorbital Rim
SD	:	Sensory Disorders
MOL	:	Mouth Opening Limitation
RTA	:	Road Traffic Accidents

PLAN

INTRODUCTION

The face occupies the most prominent position in the human body making it vulnerable to injuries. The prominence of the zygomatic region predisposes it to bearing the impact of the facial injuries.

The zygomatico maxillary complex (ZMC) is a major buttress of the midfacial skeleton. The ZMC is important to structural, functional, and aesthetic appearances of the facial skeleton. A ZMC fracture is also known as a tripod, tetrapod, or quadripod fracture, trimalar fracture or malar fracture [1],[2]. The convexity on the outer surface of the zygomatic body forms the point of greatest prominence of the cheek. Injuries to the face, head and neck are relatively common and yet, in the overall trauma literature, the etiology of maxillofacial injuries has received relatively little attention.

Zygomatico maxillary complex is the second most common mid-facial bone fractured after the nasal bones and overall represents 45% of all midface fractures[3].However, the incidence and etiology varies from area to area. According to literature zygomatic bone fractures are commonly found among young males and the most common cause was found to be road traffic accidents. Although the widespread use of seat belts and airbags has decreased the prevalence of injuries resulting from motor vehicle accidents, orbitozygomatic malar fractures still comprise a substantial portion of the facial trauma seen by plastic surgeons. The sex distribution is markedly higher for males than for females.

The causes of the fractures are mainly attributed to assault and road traffic accidents (RTA), which is inconsistent with worldwide experience. However, in many places, either RTA or assault was consistently the main contributing cause with one of these two consistently dominating the other by a large degree.

The architectural pattern of zygomatic bone allows it to withstand blows of great forces without fracturing. Because of such heavy forces zygomatic bone gets separated from adjacent bone at or near the suture lines. It may be separated from its four articulations, resulting in a zygomatico-maxillary complex, zygomatic-complex or orbito-zygomatic fracture. These articulations encompass an area which has the horizontal and vertical lines of osteosynthesis as described by Gruss and Mackinnon [4]. The association of the zygoma with the thin articulations along the anterior and posterior maxillary sinus and within the lateral orbit makes fractures in these areas common. Fractures of this complex are one of the most common types of maxillofacial injuries to treat. They are seen as isolated or in association with other facial fractures due to the complex midface anatomy.

Management of ZMC fractures is a frequent challenge in maxillo facial surgery. The surgical approach is decided based on the findings from the physical examination and imaging studies. Adequate exposure and mobilization of the fracture fragments are critical for ensuring appropriate anatomical reduction.

Whether it is about reduction methods, incisions or fixation points, various surgical techniques have been described for the reduction of zygomatic complex fracture. Comparison of different surgical approaches and their complications can only be done objectively using outcome measurements which in turn require protocol management and long-term follow up.

This study was designed to compare 1, 2, 3 and 4 point internal fixation, to find the better clinical results and fewer complications, consequently contributing towards the greater goals of a better treatment option and in due process benefit the concerned patients.

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PATIENTS & METHODS

I. Type of the study :

This is a retrospective study of 45 cases of fractures of the zygomatico maxillary complex, operated in the maxillofacial surgery department of the Avicenne Teaching Military Hospital of Marrakech between January 2011 and December 2017.

II. Purpose of the study :

The purpose of this study was to quantitatively evaluate and compare the differences of post-surgical outcome in patients with simple fractures of the ZMC treated through different numbers of point fixation. And that by setting side by side, the results of our 2 point fixation approach at the maxillofacial surgery department of the Avicenne Teaching Military Hospital and approaches described in the preexisting literature.

III. Patients :

1. Inclusion criteria :

Our study included only patients with CT scans showing fractures at the three ZMC buttresses (Stage B of Zing's classification):

- Fracture of the zygomatic arch and/or diastasis of the temporozygomatic suture
- Fractures of the inferior orbital rim and anterior and posterior maxillary sinus walls and/or diastasis of the zygomaticomaxillary suture
- Fracture of the lateral orbital rim and/or diastasis of the frontozygomatic suture

2. Exclusion criteria :

Our study excluded patients with:

- Comminuted fractures
- Associated facial fractures
- Bilateral ZMC fractures
- Patients with systemic diseases contraindicating general anesthesia

IV. Data collection :

1. Methodology :

The data was collected from medical records analysis: clinical, para-clinical and therapeutic data.

2. Studied parameters :

2.1. Epidemiology:

a. Gender
b. Age
c. Trauma circumstances
d. Mechanism
e. Fractured side

2.2. Clinical signs:

a. Periorbital edema and echymosis
b. Pain
c. Subconjunctival hemorrhage
d. Skelletal deformities:

Flattening of the malar prominence, Deformity of orbital margin, Deformity of zygomatic buttress

e. Diplopia:

Diplopia is initially most often due to incarceration of the lower right muscle in the fracture site at the orbital floor. It is a therapeutic emergency. When the muscle is not released in the few hours following the trauma, fibrosis caused by muscular ischemia results in persistent and most often definitive diplopia. In rare cases, diplopia is of neurological origin (contusion or injury of the oculomotor nerves in the superior orbital fissure) and is often accompanied by suggestive associated signs (mydriasis, ptosis). CT makes it possible to specify if the orbital cone bone is affected.

f. Enophthalmos:

They are explained by the orbital volume increase related to the collapse of the side walls and especially the orbital floor. The absence of anatomic surgical repair of these walls causes definitive enophthalmos and diplopia.

g. Infra orbital hypoesthesia (V2):

It is explained by an impairment of the nerve at its intra-orbital trajectory and / or at its emergence (infraorbital foramen). The reduction of the fracture, possibly associated with the nerve release the nerve in the foramen, allows in almost 80% of the cases a complete recovery of the sensitivity in several months.

h. Mouth opening Limitation:

The mouth opening limitation is explained by the snapping of the temporal muscle tendon at the temporal process of the zygomatic bone. It usually regresses after fracture reduction and reeducation. If it persists, premature contact between the coronoid process and the posterior surface of the zygoma (malunion) should be looked for.

i. Infectious complications

Zygomatico maxillary fractures are considered to be deeply open in the maxillary sinus. Intraorbital infectious complications, as rare as they are, are always possible and their occurrence should be feared. Thus, prophylactic antibiotherapy is necessary.

3. Paraclinical investigations:

- Conventional radiography: Water's view
- CT scaning
- Lancaster test
- Forced duction test

4. Treatment:

- Time between trauma and admission
- Operating time
- Surgical approach
- Surgical protocol

5. Evolution :

a) Immediate assessment: Before discharge

b) Long term evolution

   - Clinical follow up
   - Scar evolution

RESULTS

I. Epidemiological data:

1. Age :

The patients' main age was 43 years (extremes: 21-65 years).

2. Gender :

Our study included 37 males (82,2%) and 8 females (17,8%).

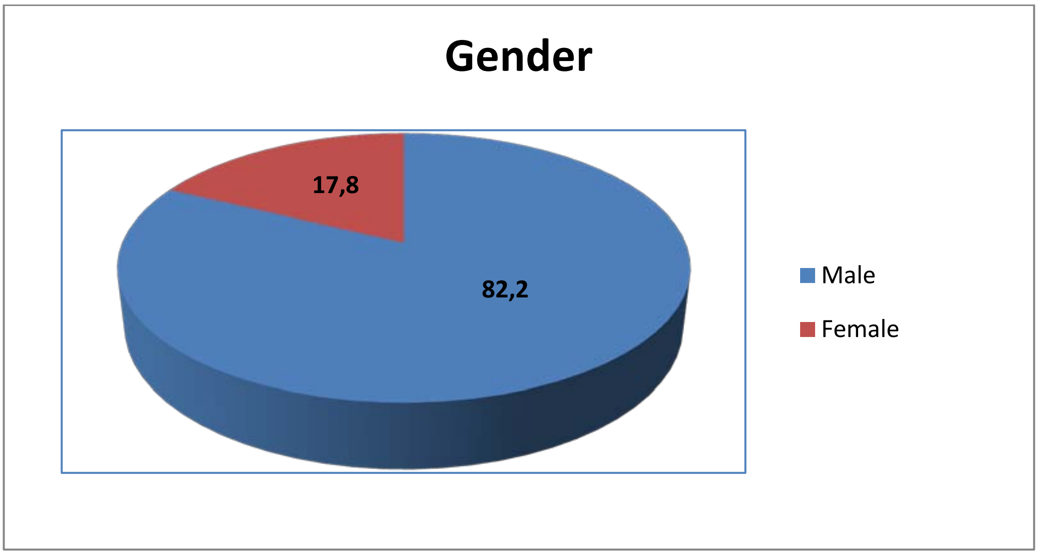


Figure 01: Gender distribution of the studied group

3. Etilologies :

The most usual circumstances of the occurrence of the traumatism are:

- Road traffic accidents: 29 cases from 45 (64,4%).
- Brawls or aggressions: 7 cases from 45 (15,5%).
- Sport accidents: 5 cases from 45 (11,3 %).
- Domestic accidents: 4 cases from 45 (8,8 %).

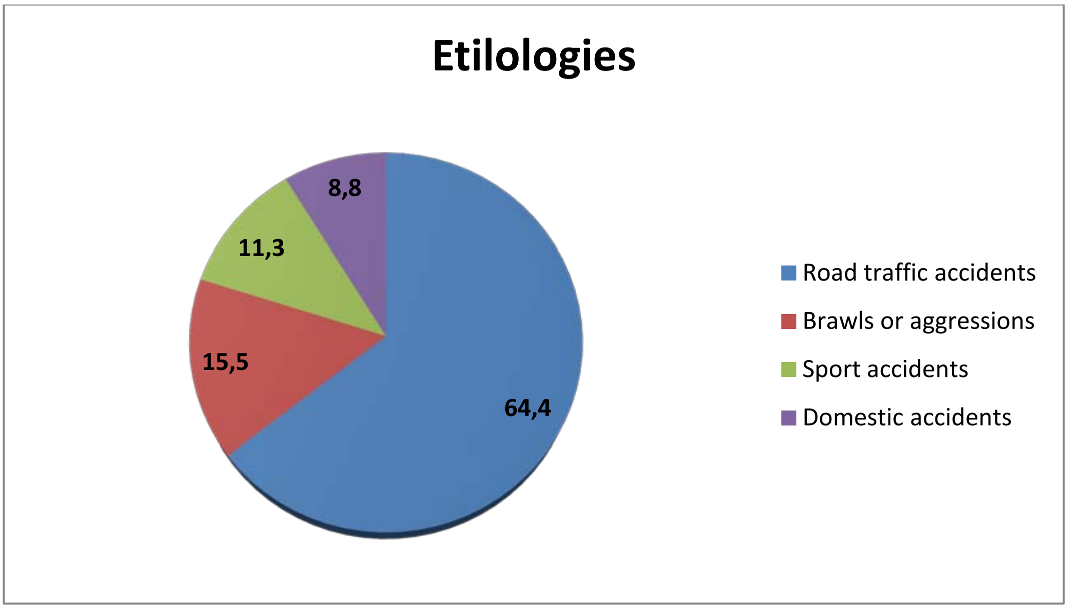


Figure 02: Distribution of ZMC fractures' etiologies

4. Fractured side:

The right side was the most frequently injured in our study in 53,34% of the cases (24 patient), the left side in 46,66% (21 patient).

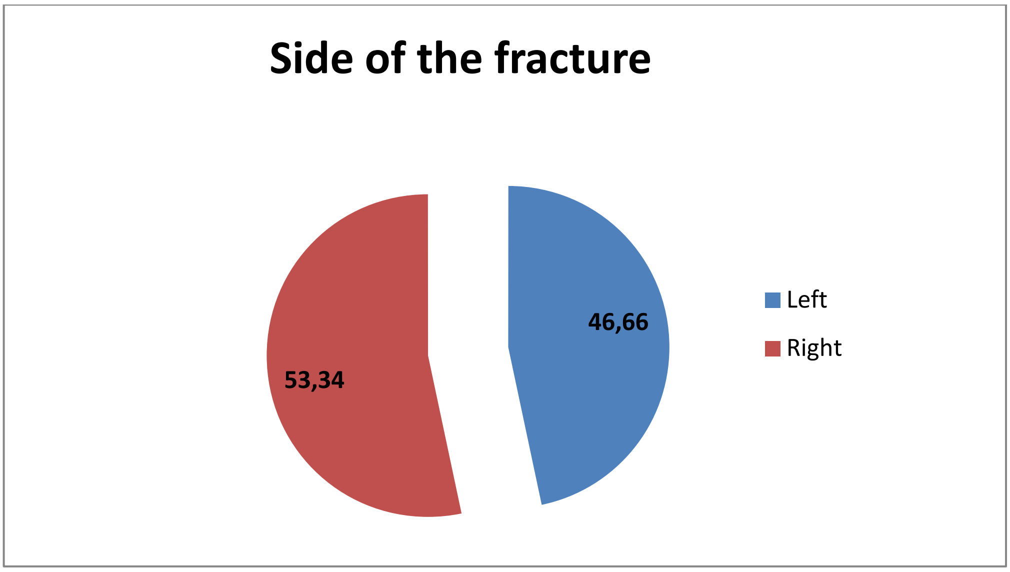


Figure 03: Distribution of the fractured side

5. Mechanism of trauma :

The mechanism of zygomatic trauma was direct in 94,29% of the cases and indirect in 5,71% of the cases. Their occurrence may follow impacts with moderate to high energy, either by a direct blow on the malar eminence or violent blows on the contra lateral midface causing a dislocation by reciprocal transfer of forces from the opposite side of the facial skeleton.

II. Clinical signs:

1. Mouth opening limitation:

Out of 45 patients 25 (55,56%) had limitation of mouth opening.

2. Enophthalmos :

Enophthalmos was found in 6,66 % in 3 patients.

3. Diplopia :

Among patients who had enophthalmos, 2 (4,5%) were diagnosed with vertical diplopia.

4. Sensory disorders :

Sensory disorders were common and they represented 35,56% (16 cases). They consisted in hypoesthesia at the region of the infraorbital nerve V2 (Lower eye lid, upper lip and lateral side wall of the nose).

5. Skeletal deformities :

A total of 29 (64,5%) patients had skeletal deformities such as flattening of the malar prominence, deformity of orbital margin and deformity of zygomatic buttress.

6. Associated signs :

41 (91,3%) of patients other clinical signs were palpebral edema, ecchymosis and wounds.

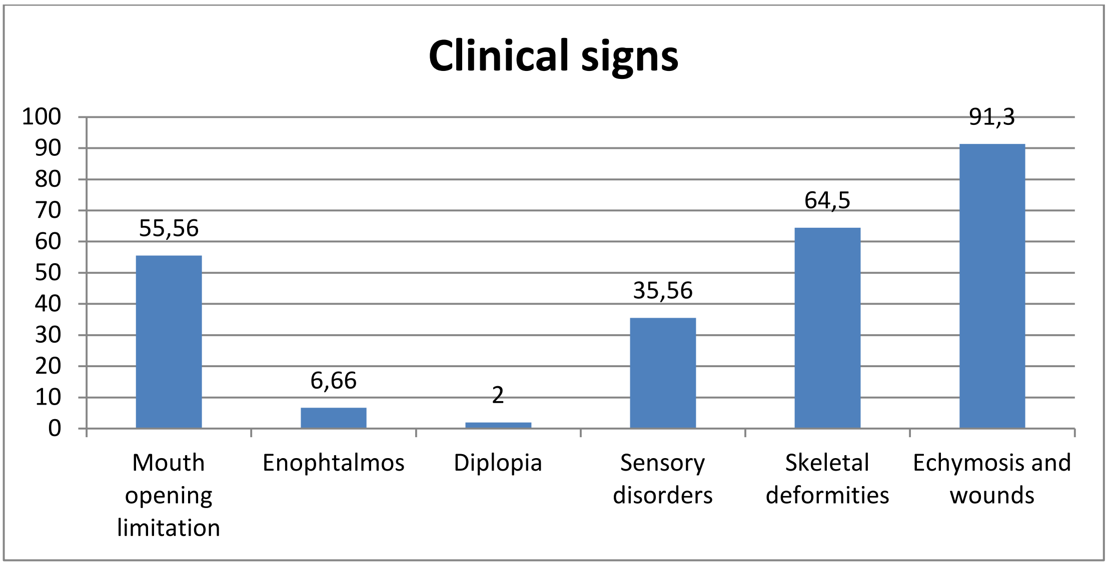


Figure 04: Distribution of clinical signs presented by our group study

Figure 05: ZMC fracture clinical signs (subconjunctival hemmoragea, loss of malar prominence)

III. Radiographic features :

1. Conventional radiography:

1.1. Water's view radiography:

It was achieved in all our patients showing the direct and indirect signs of the fracture

Directs signs: line fractures on facial bones.

Indirect signs: widening of the orbital frame, maxillary sinus opacity recalling a hemosinus, tear drop sign signing the herniation of intra-orbital fat in the maxillary sinus.

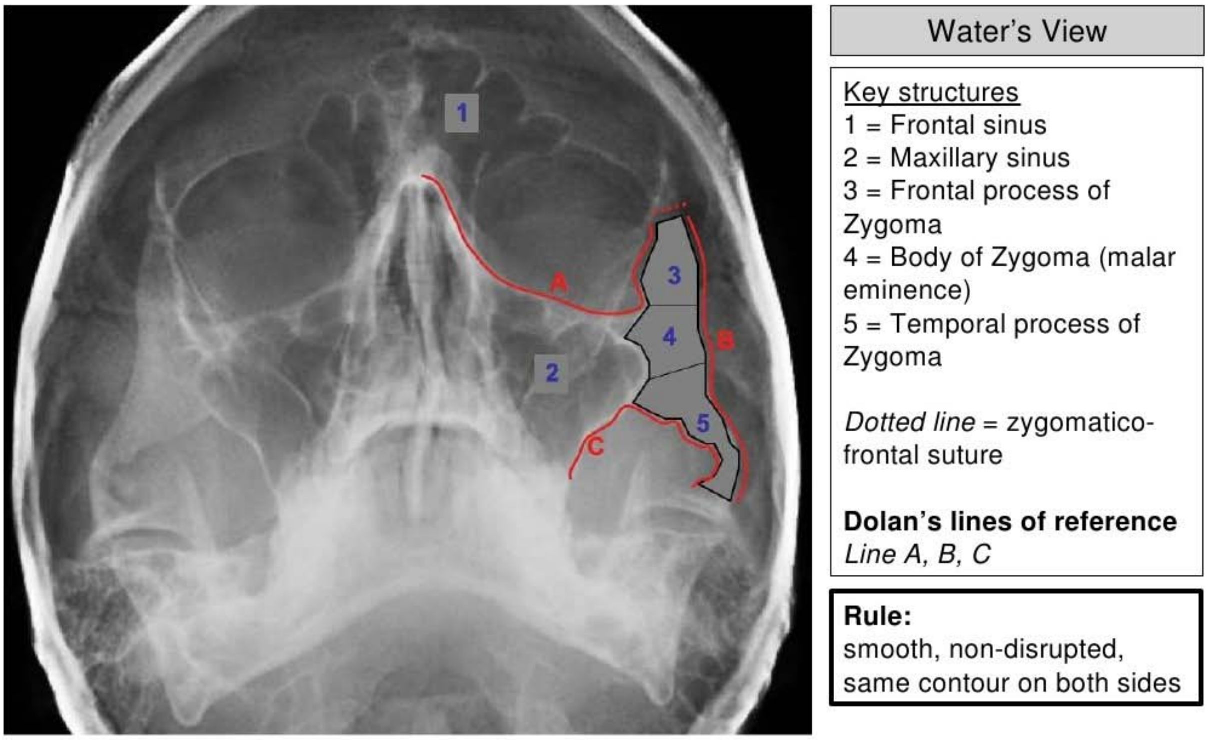


Figure 06: ZMC radiographic markers on Water's view radiograph [5]

Dolan's lines:

A: Orbital line , B: Zygomatic line ,C: Maxillary line

1.2. Orthopantomogram:

It was achieved to detect associated mandibular fractures

2. Computed tomography (CT):

The CT scan is necessary in case of diagnostic doubts (bone superposition on standard imaging, slightly displaced fracture) and comes to be very useful, especially in cases of ocular functional signs, to assess the importance of the orbital walls fractures (floor in particular). In this context, centered on the orbit with frontal and sagittal reconstructions are the most informative.

In our study, CT scans were achieved in all the cases in axial, coronal and sagittal sections. We also accomplished 3D reconstructions in every case.

3. Results of the radiological assessment:

Our study included only patients with CT scans where the association of the following three fracture components was identified (Stage B of Zing's classification):

- Fracture of the zygomatic arch and/or diastasis of the temporozygomatic suture.
- Fractures of the inferior orbital rim and anterior and posterior maxillary sinus walls and/or diastasis of the zygomaticomaxillary suture.
- Fracture of the lateral orbital rim and/or diastasis of the frontozygomatic suture.

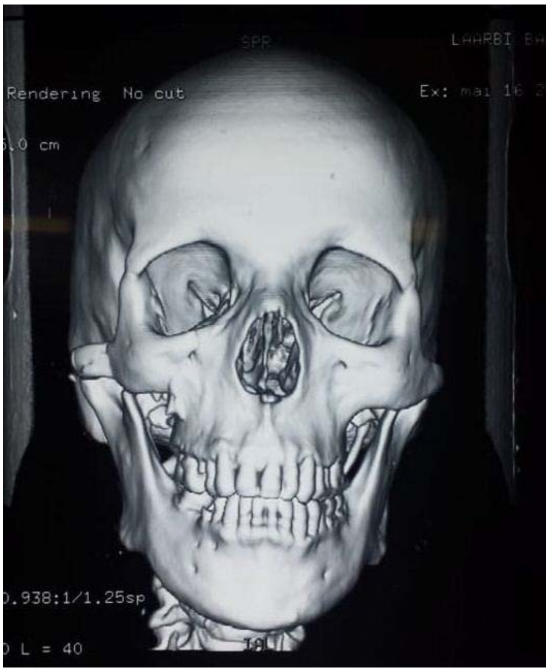


Figure 07: 3D reconstruction of a right Tripod fracture (Type B))

On 3D reconstructions we can evaluate the displacement of ZMC according to the axis of rotation:

Vertical axis: Formed by the line passing through FZ suture and first molar tooth, the ZMC rotates medially or laterally.

Horizontal axis: Formed by the infraorbital foramen and horizontal arch, the ZMC moves upward or downward.

IV. Treatment:

1. Time between injury and admission:

It was from 4 to 15 days.

2. Time of intervention:

It was mainly of 2h.

3. Course of the intervention:

3.1. Admission of patients:

All of our patients were admitted at the acute phase and were administered analgesics and corticosteroids (Solumédrol 1 à 2mg/kg/day) for 05 days. For infectious risk, our patients were administered prophylactic antibiotics.

3.2. Patients' positioning, prepping and draping:

- Supine position
- Neutral head positioning
- Sterile drapes were placed in a way that exposes the facial massif and the iliac crest (for bone graft if necessary)

3.3. Surgical approach:

a. Exposure:

Exposure was achieved for our patients through:

Lateral eye brow incision giving access to the frontozygomatic suture and subtarsal incision giving access to areas along the orbital floor, the medial and lateral rim.

b. Reposition:

Repositioning was achieved through percutaneous Ginstet hook reduction.

The hook was introduced through the intersection point of the vertical line passing through the lateral canthus and the horizontal line passing through the nostril. With the hook securely anchored into the bone, the fractured zygoma is rotated anteromedially.

c. Orbital floor revision:

Orbital floor was explored; inferior rectus muscle was freed when entrapped and fat hernia was reduced. Infraorbital nerve was gently released when compressed.

d. Orbital reconstruction (If necessary):

Orbital floor reconstruction was achieved when reduction of the thin bone fragments was not possible or insufficient to avoid a soft tissue displacement. Materials with different rigidity were used to cover or bridge the defect depending on its size and localization:

Prolene mesh was used for 4 patients who were had for small linear defects (up 1 to 2 cm) and patients with for larger defects (2 patients), iliac bone grafts were used.

e. Fixation :

The reduced bones were fixated with plates and screws using 2 point fixation in the previously exposed areas: frontozygomatic fixation through lateral eye brow incision and infra orbital rim through an infra orbital incision.

Figure 08: Per operative image showing the used approaches in our study

V. Evolution :

1. Immediate post-operative assessment :

Evaluation of the patients vision was performed as soon as they are awakened from anesthesia and then at regular intervals until they were discharged from the hospital.

1.1. Postoperative positioning :

Keeping the patient’s head in an upright position both preoperatively and postoperatively significantly improves periorbital edema and pain.

1.2. Nose-blowing :

To prevent orbital emphysema, patients were told to avoid nose blowing for at least 10 days following orbital fracture repair.

1.3. Medication :

The following medications were prescribed to our patients: analgesia, antibiotics (Amoxicillin clavulanic acide 3g/day), nasal decongestant may be helpful for symptomatic improvement in some patients, regular perioral and oral wound care including disinfectant mouth rinse.

1.4. Ophthalmological examination :

The following signs and symptoms were evaluated by ophthalmologists: vision, extra ocular motion, diplopia, globe position, lid position.

1.5. Postoperative imaging :

Postoperative imaging has to be performed within the first days after surgery. Waters radiographs were achieved to assess the fracture's reductions.

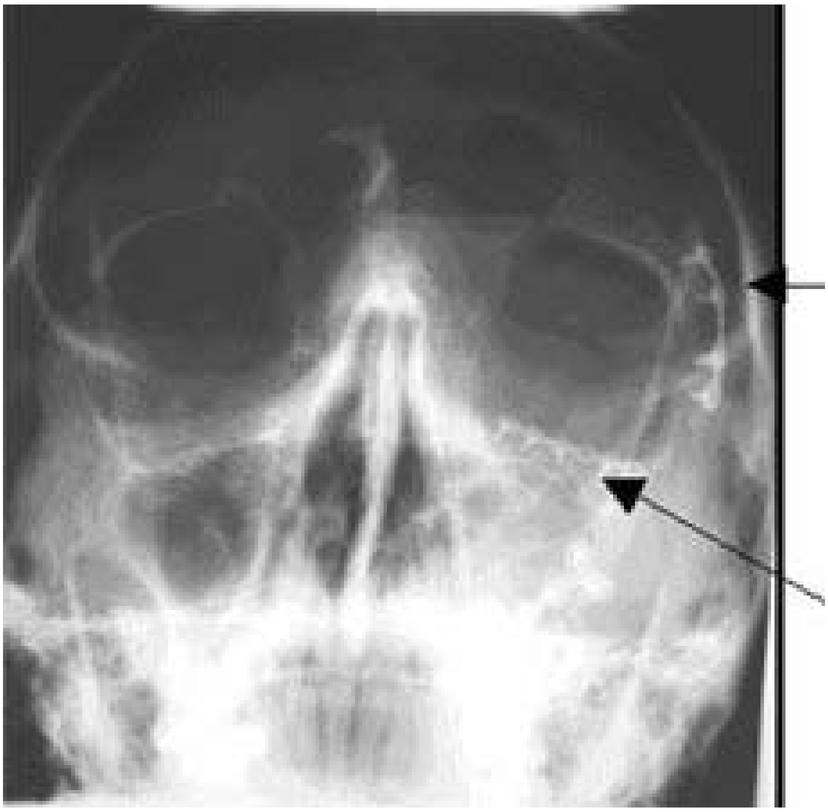


Figure 09: Control Water's radiograph, osteosynthesis at the FZ suture and IOR

2. Long-term evolution :

Long term evolution evaluation examined the principal clinical symptoms: infra orbital nerve hypoesthesia, diplopia, neuralgia, enophthalmos, projection defaults and unfavorable scars. The patients all had an immediate (15 days), 3 months, 6 months and a 1 year follow up.

2.1. Clinical evolution:

Table I: Post-operative signs and their evolution

Number of cases				
	15 days follow up	3 months	6 months	12 months
Hypoesthesia	9	5	3	1
Neuralgia	0	4	2	2
Diplopia	1	1	0	0
Enophthalmos	1	1	1	1
Projection defaults	3	3	3	3

a. Sensitive disturbance:

Persisted in 9 patients from 16 (56,25%) who had preoperative hypoesthesia. At the one year follow up: 1 patient did not fully recover from infraorbital hypoesthesia and 2 progressed to neuralgia.

b. Diplopia :

1 patient had persistence of his diplopia post-operatively 2,22% at the 3 months follow up, then disappeared at 6 month and 1 year follow up (2 patients had preoperative diplopia).

c. Enophthalmos:

Persisted in 1 case (2,22%) from 3 that had preoperative enophthalmos (33,3%). None of our patients presented post-operative enophthalmos.

d. Projection defaults:

6,66% suffer from loss of malar projection.

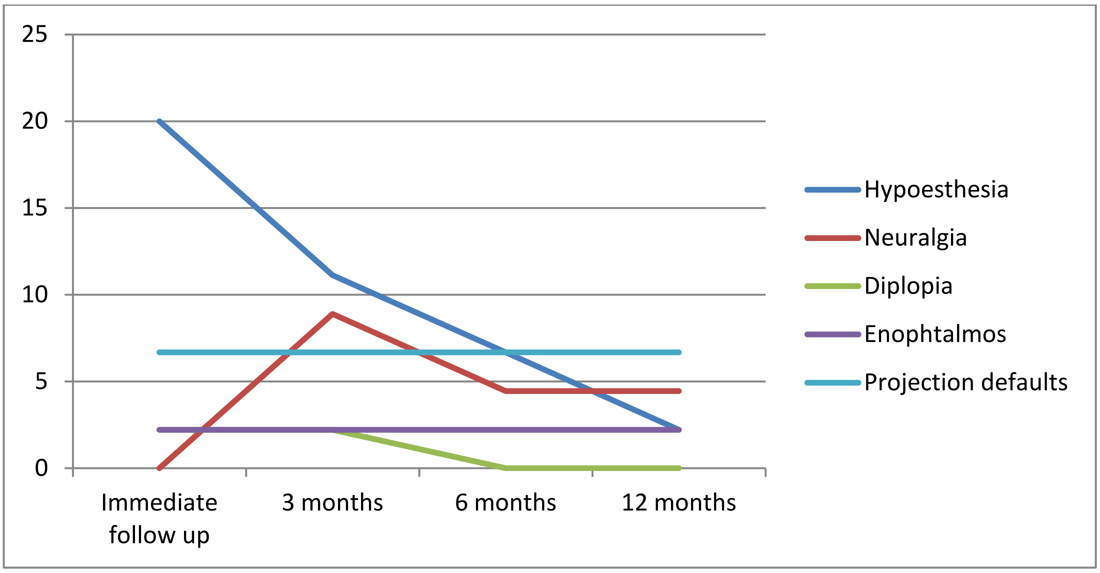


Figure 10: Evolution of post-operative clinical signs over 12 months

Figure 11: Patient's satisfying post-operative evolution

2.2. Scar evolution:

The subtarsal scar was not visible in any of our cases.

The lateral eye brow scar's quality evaluation was carried out on its visibility, aspect, color and length. They have been ranked on a scale ranging from: invisible when they are totally confused with a fold of the skin, slightly visible when noticed from a distance of conversation and visible when spotted without bearing any special attention.

Among 45 lateral eye brow scars: 34 were invisible (75,5%), 6 were slightly visible (13,3%), 5 were visible (11,2%).

DISCUSSION

I. Epidemiology:

1. Age:

ZMC fractures affect young adults in their 30's and 40's [6], [7], [8], [9], [10]. The main age of our study was 43 years, which is consistent with data from the literature; this young age is explained by the frequency of exposure to risky behavior.

2. Gender:

Male predominance is observed in most series with a sex ratio of 5/1 [6], [7], [8], [9], [10]. In our study sex ratio was of 4/1 in our series, and that is due to the nature of military population treated in our series that is predominantly masculine, young and active.

3. Etiologies:

The most common etiologies are road accidents (42,37% and 43,8%) and assaults (64,5% and 38%) [6], [7], [8], [9], [10]. The results of our series are similar to those of the literature: road accidents represent 82.2% and assaults 17,8%. The other etiologies are much less frequent represented by sports accidents and domestic accidents.

4. Side of the fracture :

The results of the literature reveal a predominance of the left side of 62% against 38% of the right side[8],[9].While in our series we have a predominance of the right side (53,34%) against 46,66% of the left side.

5. Epidemiologic conclusion:

There was no significant difference between the results of our series and those of literature ; ZMC fractures account for 13% of all cranio-facial trauma [11] with predominance in young adult males, and that because of their frequent exposure to assaults and risky behavior. The most common etiologies are road accidents followed by aggression. The most affected side in the literature is the left unlike our series. That is most likely due to the fact that road accidents are far more common than assault (Where the opponent is usually right handed).

Table II: Comparative study to epidemiological data

	Mean age	Gender	Etiology
Our series	43 years	4/1	Road traffic accidents: 64,4% Assaults:15,5%
Hwang et Kim[6]	34,7 years	5/1	Road traffic accidents: 23% Assaults:19,4%
Bogusiak et al.[7]	37,1 years	5/1	Road traffic accidents: 13,9% Assaults:64,5%
Uda et al.[8]	33 years	4/1	Road traffic accidents: 11,9% Assaults:38%
Forouzanfar et al.[9]	39 years	3/1	Road traffic accidents: 42,37% Assaults:19,06%
Olate et al.[10]	31 years	5/1	Road traffic accidents: 43,8% Assaults:18,3%

II. Clinical study:

1. General examination:

In general patients with any facial trauma should be considered as patients with panfacial trauma and possible multisytemic injuries.

A (Airway), B (Breathing), C (Circulation) should always be considered first. It is therefore necessary to look for surgical emergencies that may be life-threatening such as massive bleeding (facial wounds, rhinorrhea, midface fractures...) and airway obstruction (bifocal fractures of the symphysal region with glossoptosis, inhalation of blood, dental fragments or pieces of dental prosthesis ...). Multisystemic injuries should also be looked for and stabilized (unstable cervical spine lesions, cerebral contusions, limb trauma).

2. Local examination:

2.1. Inspection:

Locally, the appearance of patients with ZMC fractures is quite remarkable. As for all facial traumas, edema is very important, installs in the few hours following the trauma and persists for several days. It is localized over the malar prominence, lateral orbit, upper and lower eyelids, associated to ecchymosis and tenderness. Loss of malar projection with increased width of the face are also noticed, they can be masked by the importance of the edema. External subconjunctival hemorrhage might be seen, it is explained by the subconjunctival diffusion of the peri-fracture hematoma at the frontozygomatic suture level.

2.2. Palpation:

Physical examination can reveal significant malar depression with step defects at the infraorbital rim, frontozygomatic suture, and zygomatic buttress of the maxilla intraorally. Fractures of the zygomatic bone evoke pain on palpation in more than 90% of patients in our series.

2.3. Clinical findings :

Posterior displacement of the fracture fragment may disrupt movement of the mandible, causing difficulty with mastication. Inferior displacement of the lateral canthal angle may indicate inferior migration of the fractured zygomatic bone [12]. Anesthesia in the distribution of the infraorbital nerve should be carefully evaluated. Many patients will not have sensation over the cheek preoperatively, which should be brought to their attention to avoid postoperative concerns. The same is true for trismus. Many patients with significant malar injuries will have some pain and difficulty in opening the mouth because of impingement of the coronoid process by the displaced malar fragment. This pain may be slow to resolve postoperatively, but it almost always does so without specific intervention. Perhaps the most important part of the preoperative surgical examination is the ophthalmologic assessment. The zygoma constitutes the floor and lateral wall of the orbit and, as such, is always involved in the fracture. In addition, the medial wall is frequently fractured. Consequently, findings such as diplopia or other motility disturbances are not uncommon. In many cases, this is the result of non-mechanical factors, such as contusion of the extra ocular muscles or swelling, which resolve over time. However, entrapment of the muscles in the orbital fracture also occurs, which may influence the decision to proceed with surgery or the timing of surgery [13].

3. Clinical signs:

3.1. Enophthalmos:

It results from a retrusion of the ocular globe into the orbit by several mechanisms

- Widening of the orbital frame
- Herniation of fat and a muscle through the orbital floor
- Both previous mechanisms at once

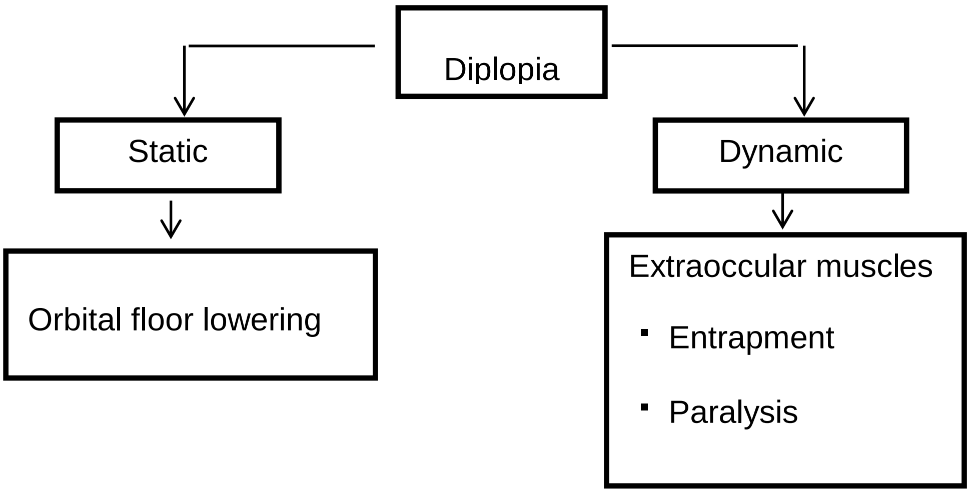
The position of the globe is affected by the integrity of the periorbital fascial support, the direction and degree of displacement of the zygoma, and the degree of concomitant swelling. Fractures that cause an increase in orbital volume (blow-out fracture) will predispose to enophthalmos, but during the acute period, swelling within the orbit may cause some degree of proptosis despite the expansion of the orbit. As swelling resolves, the globe progressively sinks back, revealing the underlying orbital expansion. Zygomatic fractures that present with acute enophthalmos indicate severe displacement and orbital expansion [14].

It is a very common sign in ZMC fractures [15], it is from 4,2 to 65% according to literature. As for our study, it was present in 6,66% of the cases.

3.2. Diplopia:

Its frequency varies from 1 to 49% according to literature.

Diplopia is a troubling and not uncommon complication of malar fractures that is reported in 3.4 to 8 percent of cases [16], [17]. It is perhaps most problematic when in the primary field of vision. Diplopia occurring only at the extremes of gaze is generally better tolerated. This complication may be caused by simple swelling or contusion of the extraocular muscles or their supplying nerves, in which case the diplopia should resolve over time. A normal, forced duction test at the end of the surgery makes this scenario more likely. The biggest concern, however, is entrapment of the extra-ocular or periorbital muscles in the orbitalfloor or medial wall component of the injury. When in question, a postoperative computed tomography scan should help rule this out [13].



Post traumatic diplopia is often due to a fracture of the lower orbital wall with entrapment of the inferior rectus muscle, resulting vertical diplopia. This entrapment will be sought by performing a CT scan with coronal cuts and sagittal reconstruction. It can also be secondary to globe displacement or orbital floor disruption.

The Lancaster test is used to monitor the persistence or disappearance of diplopia. When diplopia is definitive it is often due to permanent entrapment or fibrosis of the oculomotor muscles or nerve palsy.

The semiological approach of post-traumatic diplopia obeys to several rules:

There is no parallelism between the importance of fracture and oculomotor disorders.

The absence of diplopia does not exclude secondary diplopia hence the interest of a Lancaster test immediately after trauma and another for control.

Extraocular movement should also be tested, as should visual fields. Restriction in the movement of the extraocular muscles, especially on upward gaze, should raise the physician's concern for muscle entrapment. When in doubt, either a forced duction test can be performed with local anesthetic or computed tomography (CT) scans can be performed to examine for extraocular muscle entrapment. The exception to this, though, is the patient who presents with facial trauma, suspected orbital floor fracture, who also has nausea, vomiting, and bradycardia (oculocardiac reflex), which is pathognomonic for extraocular muscle entrapment [18].

In our study, evaluation of ocular motility was first done by finger gaze where the finger is moved in front of the eye in all nine directions of gaze at a distance of 30 cm. It essentially seeks limitations of elevation or lowering that theoretically predict the site of the fracture of the orbital floor relative to the equator of the globe.

When diplopia is confirmed, completing by a Lancaster test is useful. This test allows quantifying limitations on a diagram and following the evolution.

a. Forced duction test:

Should be performed anaesthetized eye, lids retracted. The examiner manipulates the globe through its entire range of motion with a globe holding forceps. The inability to rotate the globe superiorly signifies entrapment of inferior rectus muscle in the orblital floor. This test is only significant when performed comparatively to the uninjured side. It signs the mechanic origin of oculomotor disorder.

Figure 12: Forced duction test

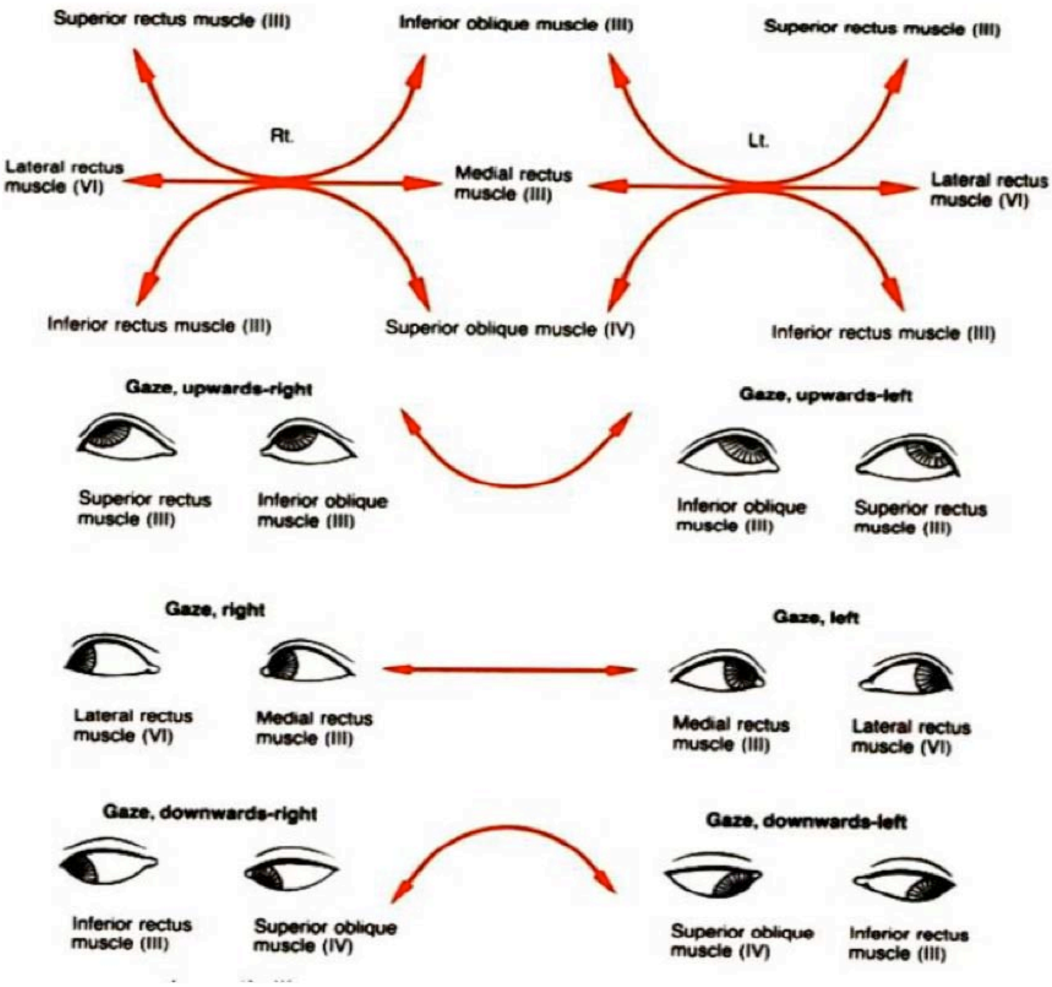


Figure 13: Extraocular muscles' actions

3.3. Sensory disturbance:

Palpation sometimes shows subcutaneous emphysema signifying a communication between the orbital tissues and surrounding sinus cavities; it also evaluates sensory disturbances in the territories of infra-orbital and zygomatico-temporal nerves.

In simple ZMC fractures, hypoesthesia will most often occur in the territory of the infra-orbital nerve. Hyperesthesia may also be found.

Sensation in the V_2 distribution should be tested and noted as sensation in this area is almost always diminished in malar fractures. Therefore, it is important to make note of this finding to avoid postoperative concerns of iatrogenic nerve dysfunction. Sensation often resolves postoperatively without specific treatment. Other physical exam findings are obscured by swelling encountered in the majority of these patients and are not helpful in the acute setting [18].

The frequency of hypoaesthesia varies between 8 and 52% according to literature. As for our series hypoesthesia represents 35.56%.

3.4. Mouth opening limitation:

Limited mouth opening may be present and is generally mild and is typically due to pain with masseteric pull given its attachment to the zygoma. Severe displacement may cause direct impingement on the coronoid process.

Mouth opening limitation varies from 8 to 25%. In our study it represents 55,5%.

Table III: Comparison of our clinical findings to literature

	Our Series	Bogusiak et al.[7]	Olate et al.[10]	Forouzanfar et al.[9]	Zhang et al.[19]
Pain, Echymosis, Edema	91,3%	91,4%	49,7%	30%	8,17
Limitation of mouth pening	55,56%	_	25,5%	13,6%	4,67%
Hypoesthesia	35,56%	58,5%	52,9%	47%	8,64%
Diplopia	4,5%	49,1%	10,4%	8,5%	1,28%
Enopthalmos	6,66%	65,8%	_	4,2%	_
Malar depression	55,5%	_	_	37,3%	11,68%

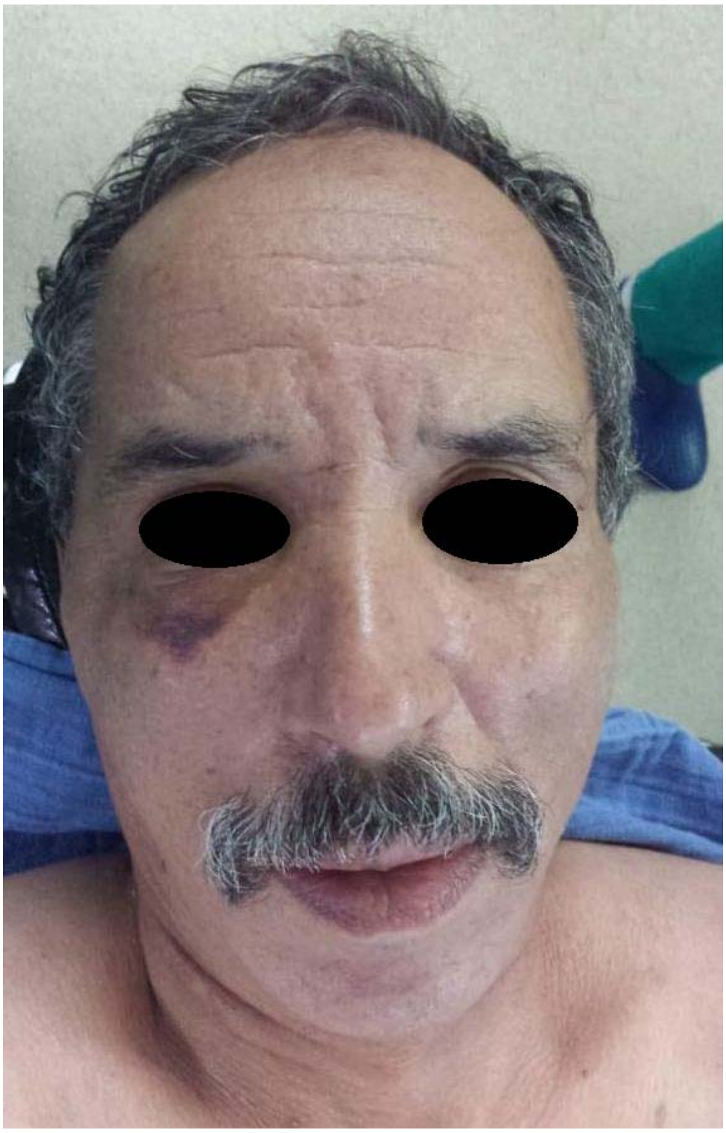


Figure 14: ZMC fracture's clinical features at Day 8 of trauma

III. Paraclinical examinations:

1. Hess Lancaster test

Hess-Lancaster test is a red-green test that allows immediate diagnosis of the paralyzed eye and muscles and to recognize the hyper-muscular actions due to paralysis.

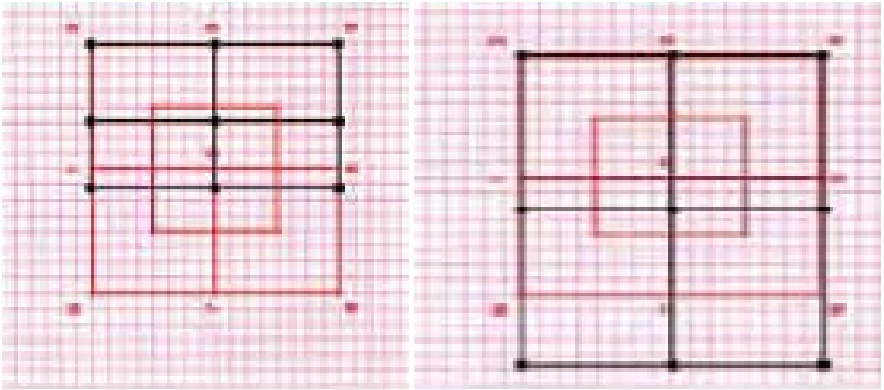


Figure 15: Hess Lancaster test showing vertical diplopia

2. Radiologic investigation:

2.1. STANDARD IMAGING:

It retains its usefulness, even if its importance decreases in favor of recent CT techniques. It is powerful and easy to achieve:

a. **Waters view (Occipito mental):** permits a good vision of the ZMC, orbital floor and infra-orbital rim. It is a posterior anterior incidence, where an X-ray beam is angled at 45° to the orbitomeatal line. The patient's nose and chin are placed in contact with the midline of cassette. The patient should open the mouth as wide as possible before exposure. The rays pass from behind the head and are perpendicular to the radiographic plate (Figure 16).

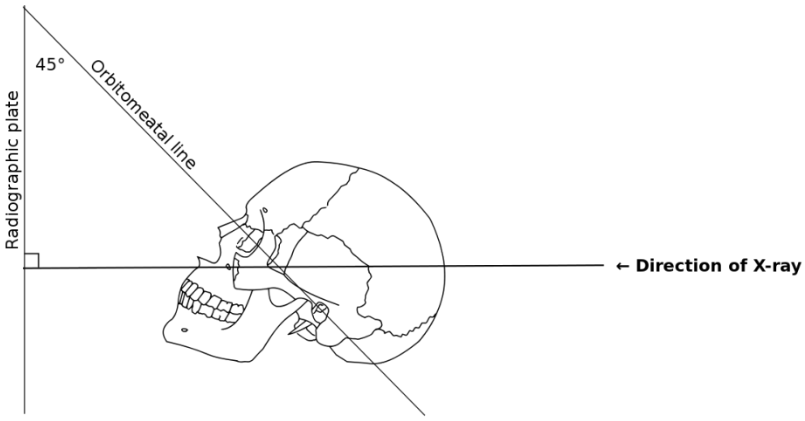


Figure 16: Waters' view radiography

This view is better analyzed using the three lines described by Campbell and McGrigor (Figure 17-18). These lines can be used as a simple to interpretation.

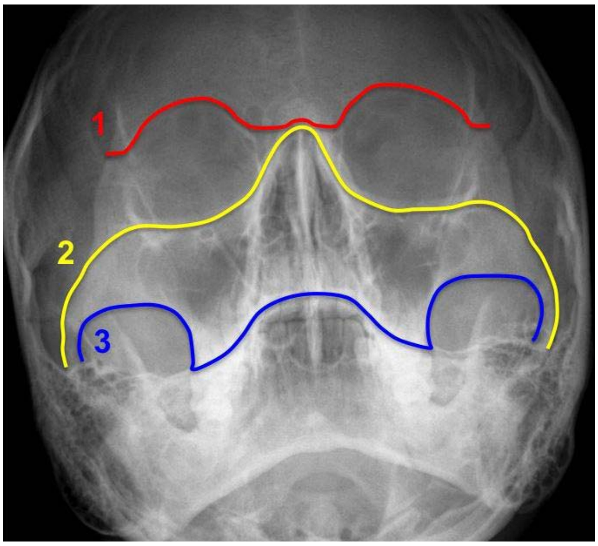


Figure 17: Campbell and McGrigor lines

1: This line is traced from one zygomatico frontal suture to another, across the superior edge of the orbits
2: This line traces the zygomatic arch, crosses the zygomatic bone, and traces across the inferior orbital margins to the contralateral zygomatic arch
3: This line connects the condyle and coronoid process of the mandible and the maxillary antra on both sides

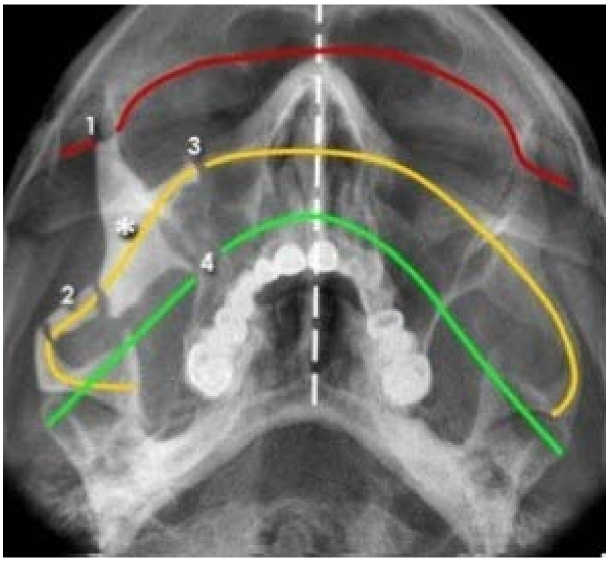
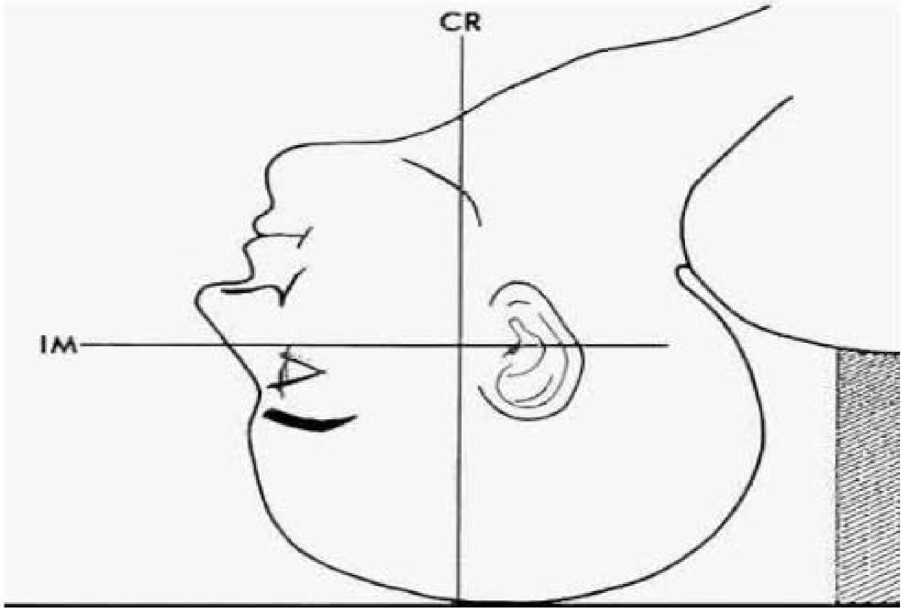


Figure 18: Tripod fracture on Waters view using Campbell and McGrigor lines

1-Zygomatico Frontal suture fracture
2-Comminuted fracture at the zygomatic arch
3-Orbital floor fracture
4-Breach of the lateral wall at the maxillary antrum

b. Submentovertex view: this projection is obtained with the patient's neck extended either in the supine or upright position. The top of the head is placed so that the infraorbitometeal line is parallel with the x-ray cassette. The x-ray beam is directed at right angles to the infraorbtometeal line. This projection gives a good view on the zygomatic arch.(Figure 19)



<u>**Figure 19**: Submentovertex view positionning</u>

CR: Central Ray, IM: InfraorbitoMeteal

2.2. <u>CT SCAN:</u>

Over the years, CT scanning has supplanted plain radiography as the imaging modality of choice. Almost all malar fractures require direct CT scanning in both the axial and coronal planes (<3-mm slice thickness) to categorize the pattern of injury clearly and direct subsequent management [18].

If direct coronal images cannot be obtained, as in the case when neck extension is precluded by possible cervical spine injury, then thin-section axial helical scans can be reformatted to obtain coronal sections [13].

In a non-comminuted ZMC fracture, the zygomatic arch component of the superior transverse maxillary buttress is typically left unfixated, with the remaining buttresses used as a reference for reduction. However, if the buttresses are comminuted, the surgeon may need to expose and reduce the zygomatic arch via a scalp incision to ensure that the zygoma is adequately anteriorly projected. The typical clinical and radiologic deformity of a ZMC fracture is loss of cheek projection and a resultant increase in facial width. A frequently missed ZMC fracture is at the temporal bone portion of the upper transverse maxillary buttress [20].

In severe ZMC fractures, the orbital defect can appear minimal due to impaction of the zygoma. It is important to visualize the defect with the zygoma in its anatomic position to appreciate the true loss of bone support. For orbital floor defects, attention to the shape and position of the inferior rectus muscle on coronal CT scans can provide information regarding the damage to the fascial sling of the globe [20]. CT has made preoperative assessment of the status of the bony orbit possible with a great degree of accuracy. When preoperative CT scans are available, it is no longer necessary to discuss whether the internal orbit should be explored [21].

Feuerbach [22] stated that extensive plain film studies following massive trauma are technically difficult and yield a relatively small amount of information. Using 3D CT areas of clinical interest can be isolated by volume rendering technique from the patient and viewed in a variety of orientations, not possible using other methods and in complex anatomical images such as facial bones. 3D images can make interpretation of an otherwise difficult set of cross-sectional CT images easier and less time consuming [23].

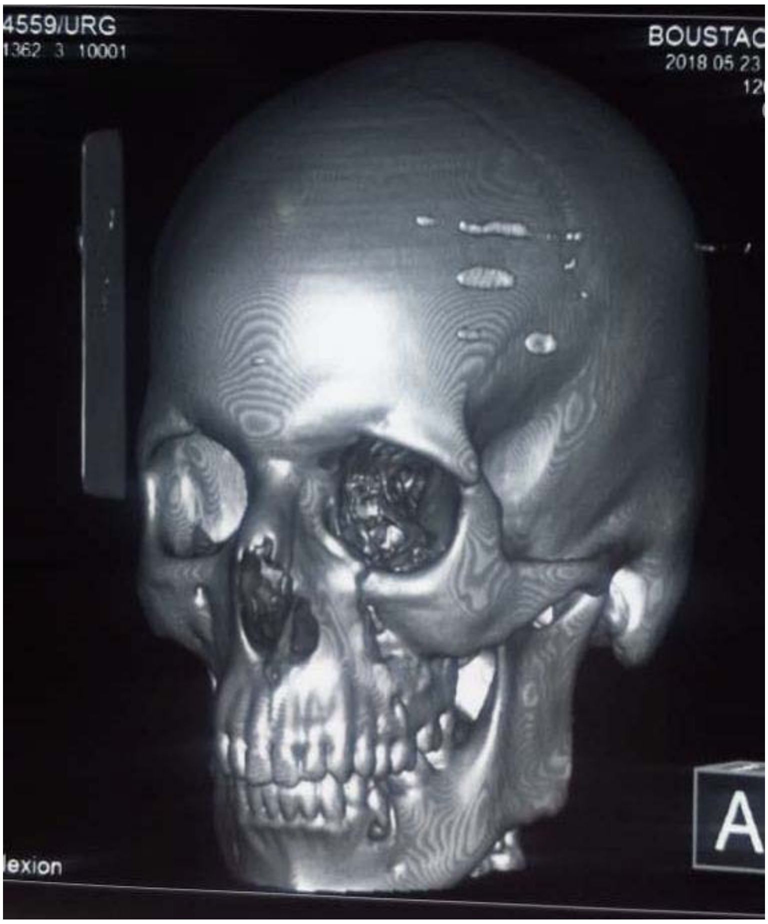


Figure 20: 3D reconstruction showing a left ZMC fracture (Type B)

2.3. Magnetic resonance imaging:

MRI should be considered in severe and extensive cases, where thorough soft tissue evaluation is important. Studies showed its efficiency to assess orbital complications involved in ZMC fractures.

Possible structural herniation or entrapment of the infra-orbital nerve, should consider MRI to assess the involved soft tissues [24]. In fact, Ilankovan et al. [25] found MRI more to be sensitive, in comparison to CT, for the diagnosis of herniation and entrapment of soft tissues in orbital fractures.

However, in more severe and extensive cases, where soft tissue differentiation is essential, high-resolution CT should be preferred over MRI if there is a possibility that a metallic foreign body is present [26].

2.4. Ultrasonography:

Ultrasonography has traditionally been used in orbital and ocular diagnosis, but its role in maxillofacial trauma is less widely recognized. McCann et al. [27] used ultrasound with 85% accuracy in diagnosing fractures of the ZMC. According to Friedrich et al. [28], application of ultrasound is most useful for visualization of the zygomatic arch and the anterior wall of the frontal sinus.

Kim et al. [29] used intraoperative ultrasonography to evaluate alignment of the inferior orbital wall, ZF buttress, and zygomatic arch. Ultrasonography is a valuable visualization tool for both diagnosis and treatment of facial bone fractures [30], [31].

IV. TREATMENT:

1. Aims of treatment:

The goal of all surgical procedures should be to repair function and esthetics deficits:

- Restore normal contour of the face
- Relieve pain
- Precise anatomical reduction of the fragment
- Provide stable fixation of the reduced fragment
- Correct the complications: diplopia, remove any interference in range of mandibular movement, relieve pressure from infra-orbital nerve

2. Indications:

Indications for treatment of ZMC fractures depend on two features: function and esthetics.

The treatment can either be conservative or surgical.

2.1. Conservative treatment:

Conservative treatment is warranted in minimal to non-displaced fractures in which there is no cosmetic or functional deficits, or in medically unstable patients in which undergoing on operation with general anesthetic may be too great of risk [15].

2.2. Surgical treatment:

The decision to intervene surgically in patients with ZMC fractures should be based primarily on whether there is displacement of the malar complex and the existence of functional findings. The necessity of internal fixation is then judged.

a. Reduction without fixation:

For mildly displaced ZMC fractures, especially those involving 1-2 articulations, often times the reduced segments may be stable enough to avoid fixation. It is best to complete the procedure within 2-3 weeks of the initial trauma to avoid early fibrous union of bony segments which can make reduction difficult. This method can be completed via multiple open or closed approaches depending on the fracture location and necessity for direct visualization of the segments to confirm reduction [15].

b. Reduction with fixation:

Open reduction and internal fixation of ZMC fractures is indicated in largely displaced, comminuted fractures, or in mildly displaced fractures in which stable reduction is not achieved following reduction. As described by Ellis et al., anatomically accurate reduction of the ZMC is best obtained by direct visualization of multiple sutures if necessary. Additional fixation is not related to better outcomes if the proper reduction was not completed initially [14], [21].The issue that our study raises is how much fixation is enough fixation?

In our series all of our patients were treated with ORIF with two point fixation in the FZ suture and infra-orbital rim through a lateral eye brow incision and and mid eyelid incision respectively.

3. Contraindications:

- ✓ Fractures of more than 20 days that may require osteostomy
- ✓ Minimally displaced fractures with no symptoms
- ✓ Eldery and medically compromised patients

4. Treatment means:

4.1. Medical treatment:

Medical treatment is prescribed for preoperative preparation of the patients. It can also be the only indicated treatment when surgery is not indicated. It includes:

- ✓ Up right head position to relief the pain and improve the edema resolution
- ✓ Analgesia
- ✓ Corticosteroids for resolution of edema
- ✓ Antibiotics: Amoxicillin clavulanicacide 3g/day for 7 days

In our study, prophylactic antibiotics were prescribed for all our patients for sinus coverage since we considered ZMC fractures to be open fractures. For Lee et al. [18] antibiotics are not indicated in non-displaced fractures. Andreasen et al. [32] concluded in their systematic review that infection rates were so low in isolated zygomatic fractures that prophylactic antibiotics were not recommended.

Corticosteroids are initiated by many surgeons to minimize swelling and further damage to the optic nerve. In addition, surgery is delayed until vision has stabilized or improved [33], [34], [35].

4.2. Surgical treatment:

Surgical treatment in generally indicated for displaced fractures should be surgically reduced and stabilized. The degree of displacement can be easily checked by assessing the status of the normal articulations of the ZMC with the craniofacial skeleton on CT scan.

a. Adequate time for surgery:

Surgery is indicated when there is impairment of function —that is, limited mouth opening—and/or when the patient complains of an aesthetic problem— that is, a flattening of one side of the face. It is not specifically indicated for parasthesia. Surgery is often best deferred until the swelling has settled and the patient can be assessed fully [36].

Hwang et al [6] carried out their surgical procedure on a an average of 6.4 days after injury, and most had surgery within 1 week (58.2%). Yamsani et al. [37] treated the majority of their patients 7 days after their reporting. For some authors, the adequate time depends also on existing neuropathy: surgery is delayed until vision has stabilized or improved [33], [34], [35].

In our series, the average time of surgical intervention was of 9,5 days, most patients were treated after the 8^{th} day, to give enough time for the edema to be resolved. The surgery is then performed under satisfactory local conditions to have better approaches and promote better healing.

b. Surgical techniques:

They should be individualized according to severity of the fracture and associated injuries, but it should always focus on anatomical reduction of the malar position and the orbital anatomy.

The treatment should be as minimally invasive as possible to avoid multiple surgical approaches, consequent potential infections, additional scars, and nerve palsy and should provide precise physical stability of the zygoma.

b.1. Surgical approaches:

The ideal surgical approach to treat fractures of the ZMC should provide enough exposure of the fractured segments, ensure less potential for further injury to facial structures, and allow for good cosmetic results. Ideas differ sharply as to the surgical approach from a surgeon to another.

The aesthetic appearance is very important in maxillofacial surgery. Placing an incision on the face does not only take under consideration the surgical requirements, but also many aesthetic criteria.

Usually, the skin incisions should be made parallel to the Langer lines found throughout the body skin and whose orientation of collagen fibers in the dermis, and are generally parallel to the orientation of the underlying muscle fibers. As wrinkles become more and more visible with age, it is recommended to place incisions directly in or alongside future wrinkles. These incisions are made to expose the fracture sites and allow solid fixation after anatomical reduction.

This chapter will discuss the different fixation sites in ZMC fractures and the possible surgical approaches to each one.

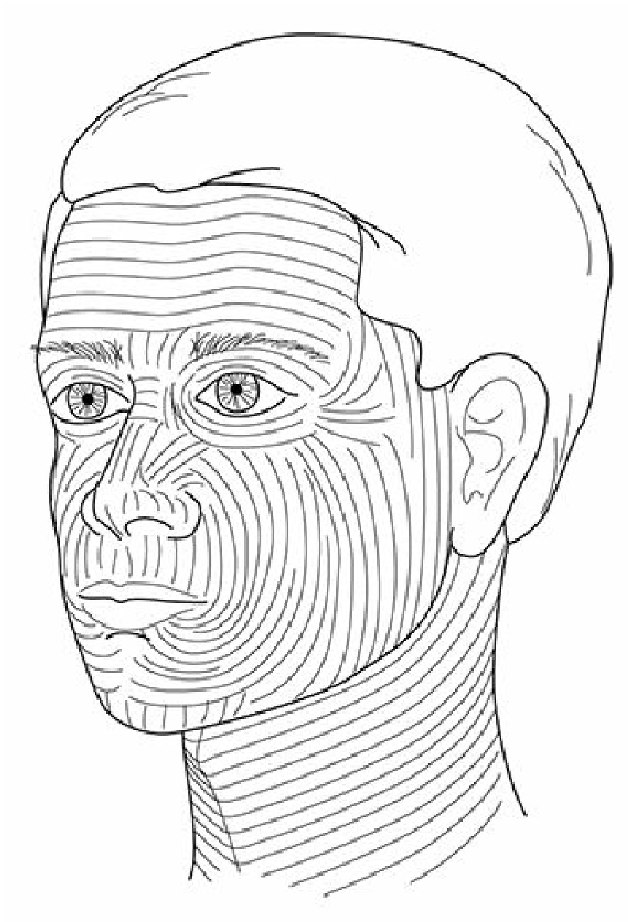


Figure 21: Langer's lines [38]

➜ Extra oral approach :

✓ Superolateral approach :

In most cases one of these approaches will be the only incision necessary for treatment, given the relative strength of the ZF pillar, which typically makes it the last buttress to be displaced. If indeed this displacement is seen on the preoperative CT scan, then consideration can be given to making a lateral eyebrow or upper-lid incision to visualize this buttress [18].

- Supraorbital approach : lateral eyebrow

The lateral eyebrow approach provides simple and rapid access to the FZ suture and lateral orbital rim. No functionally important neurovascular structures are at risk in this approach. As long as the incision is not placed within the eyebrow hairs the resulting scar is usually well concealed according to our experience. The location of the lateral brow incision should be over the fractured segments and placed within or in close proximity to the eyebrow for some authors [15]. Sharp incision is carried directly down to bone, and subperiosteal dissection is performed to expose the frontozygomatic and down the medial lateral orbital wall to visualize the zygomatico sphenoid suture.

Hwang el al. [39] used this approach on 14 patients; they were all satisfied with their postoperative appearance. Thangavelu et al. [40] concluded that in this technique, a visible scar is seen in the lateral orbital region; however, in all displaced fractures fixation at lateral wall of orbit is a must. For Kung et Kanaban [41], this approach was seen as an advance in treatment because it allows good access to the FZ suture, however the resultant scar is often perceptible in poorly planned incisions, in patients with eyebrow hair loss, and in those who do not have eyebrows extending laterally and inferiorly along the orbital margin.

- Upper eyelid approach

The upper eyelid approach, also known as blepharoplasty or supratarsal approach, offers greater versatility and enhanced accessibility to the superolateral rim compared to the lateral eyebrow approach. The soft tissues of the upper lid are thin, resilient, so that the incision site can be easily maneuvered onto the bony surfaces. In addition the incision can be extended laterally across the lateral orbital rim above the lateral canthus insertion without aesthetic drawbacks. Particularly the lower portion of the lateral rim is exposed more readily and the lateral orbital wall can be inspected more widely.

The upper eyelid incision is placed half way between the upper lid and brow within a natural crease. Incision is made through skin and orbicularis oculi and carried superiorly to the orbital rim. Dissection of the periosteium with elevation will provide wide exposure of the lateral orbital wall [15].

Kung et Kaban [41] concluded that in addition to providing excellent exposure, the upper eyelid approach produces a superb cosmetic result with a well-hidden scar in the skin folds of the upper eyelid without the risk of brow alopecia that accompanies the lateral brow approach as mentioned Susarla and Peacock [42]. Abouchadi et al.[43] agreed on this theory concluding that lateral orbital approach by eyelid crease incision allows a good exposure, an invisible scar and a light postoperative course. It constitutes a good alternative to the supero-lateral approach.

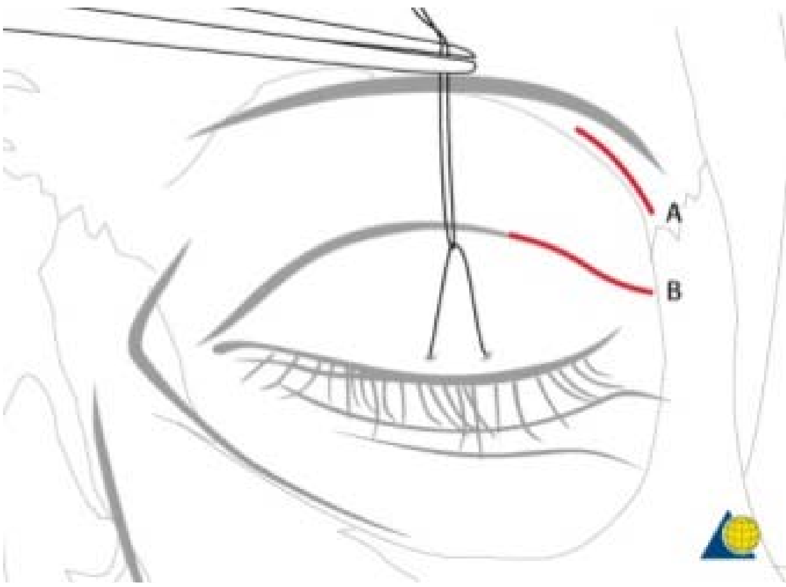


Figure 22: Superolateral approaches [44]

A: Lateral eyebrow approach
B: Upper eyelid approach

✓ **Lower eyelid approach:**

There are three basic approaches through the external skin of the lower eyelid to give access to the inferior, lower medial, and lateral aspects of the orbital cavity:

- **Subciliary** (lower blepharoplasty), it can be extended laterally to gain access to the lateral orbital rim.
- **Subtarsal** (lower or mid-eyelid)
- **Infraorbital** (inferior orbital rim)

The course of the incisions is aligned to the slope of the natural skin creases which become more apparent with age. The skin of the eyelid is the thinnest in the human body. It has little or no dermis and almost no subdermal fat. Hypertrophic scarring and keloid formation is very uncommon following lower lid skin incisions. In general, the scars become inconspicuous with time. They also give good acess the orbital floor and permit its revision, and allow reconstruction when needed.

As effective as the lower eye lid approach seem to be, many studies noted, that it is not without significant risks, such as the possibility of lower-lid malposition and external lid scarring [45], [46]. It also has been demonstrated that eyelid asymmetries from scleral show, lid retraction, ectropion, etc. occur in up to 42% of surgical approaches to the infraorbital rim/orbital floor, whether the incision is placed through (subciliary, subtarsal) or behind (transconjunctival) the lower eyelid [21],[47], [48], [49].

Suspensory suture (Figure 24) for lower eyelid was described and achieved in order to avoid these complications. It is a mattress suture through the Gray line of the lower lid and is applied at the end of the operation. It lengthens the lower eyelid when it is taped to the forehead. This creates traction for several days until the wound healing has passed its first critical phase.

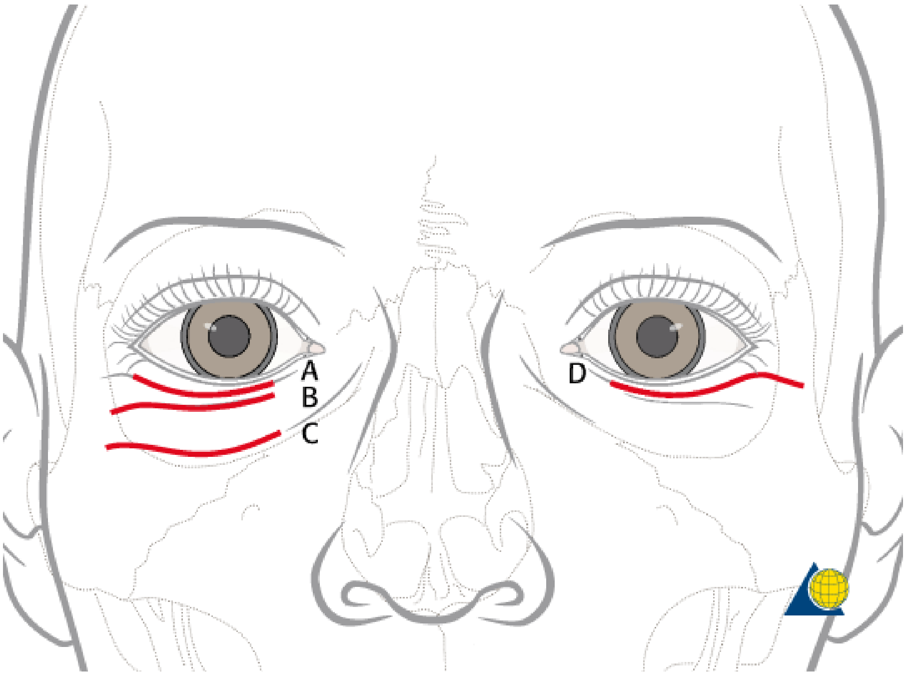


Figure 23: Lower eyelid approaches [44]

A: Subciliary (lower blepharoplasty)
B: Subtarsal (lower or mid-eyelid)
C: Infraorbital (synonym: inferior orbital rim)
D: The subciliary approach can be extended laterally to gain access to the lateral orbital rim

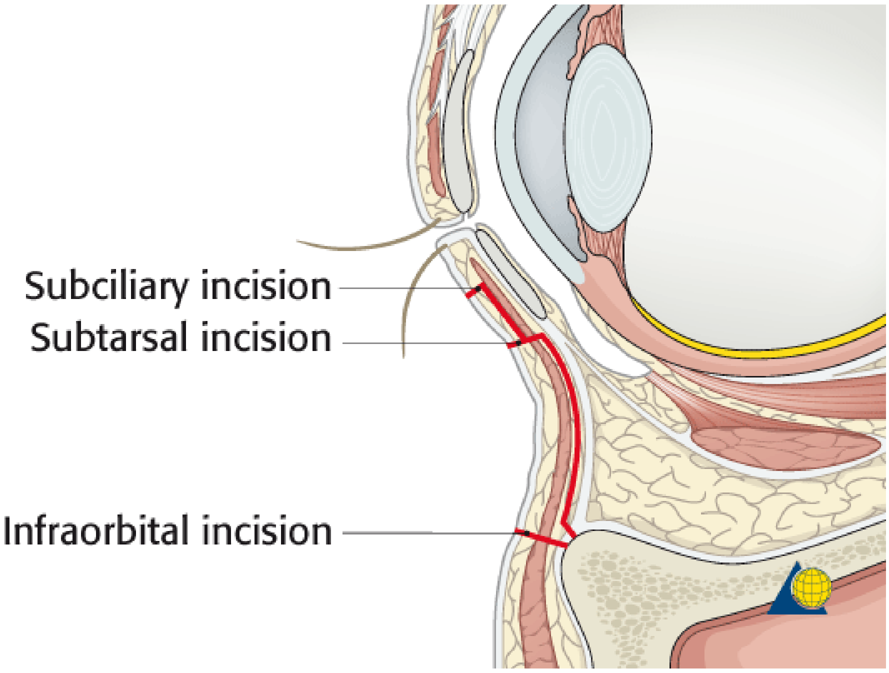


Figure 24: Lower eyelid approaches [44]

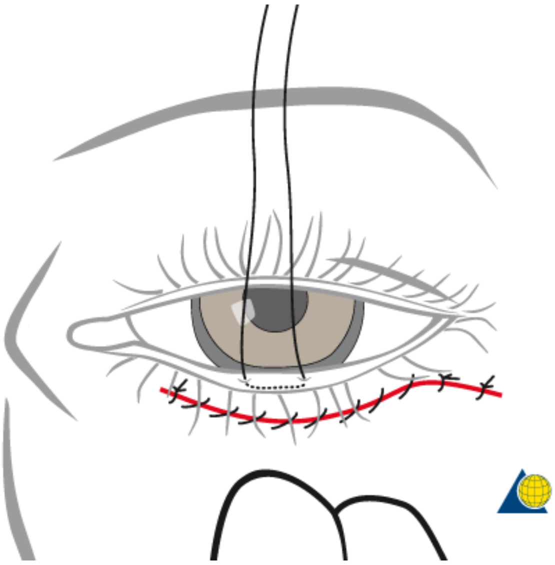


Figure 25: Suspensory suture [44]

- **Infraorbital approach**

Infraorbital incisions lie at the transition between the thin eyelid skin and the thicker cheek skin, going along with the infra-orbital rim. They are therefore predisposed to edema and increased visibility of the scars, even when the incision runs curvilinear within the resting skin tension lines. This might explain why this approach has lost its former popularity.

Figure 26: Per operative image showing the infra-orbital approach

- **Subtarsal approach**

The incision is diagonally oriented and starts medially about 2-3 mm below the lid margin and courses in a latero-caudal direction.

A comparative study has found the mid-lower eyelid incision showed the give best results, with an impairment frequency well below those of the other two approaches. This approach seems to combine the advantages of the infraorbital incision with the unnoticeable scar formation associated with the subciliary incision [27].

In our series we used the mid lower-eyelid -approach for all of our patients, for the good exposure of the infraorbital rim and orbital floor that it gives on one hand and for the satisfactory aesthetic results on the other hand.

- **Subcilary /infracillary approach (lower blepharoplasty)**

The skin incision is made just below the eyelashes. Subsequent to the skin incision there are three optional pathways for the dissection down to the orbital rim:

- Subcutaneous
- Deep to the orbicularis oculi muscle
- Step dissection or layered Converse technique

Subciliary approach is the traditional transcutaneous approach to the infraorbital rim and floor. The location of the incision through the skin of the lower eyelid is the same as what one might do for a cosmetic blepharoplasty. Studies showed that when used for skeletal surgery, the subciliary approach has a significant rate of complications. These involve ectropion, scleral show, palpebral asymmetries, etc [50].

- **Transconjunctival approach**

The typical inferior fornix transconjunctival approach can use two different routes to access the infraorbital rim:

- Retroseptal
- Preseptal

These two approaches vary in relation to the orbital septum on the pathway to the infraorbital rim. Controversy exists on the advantages and disadvantages of these two surgical routes.

Multiple comparative studies have shown that the lower-lid transconjunctival approach is associated with fewer eyelid complications than with the traditional subciliary approach [50].

This approach can permit access to FZ suture in addition to infra-orbital rim when extended to the lateral canthus according to lee et al. [51].

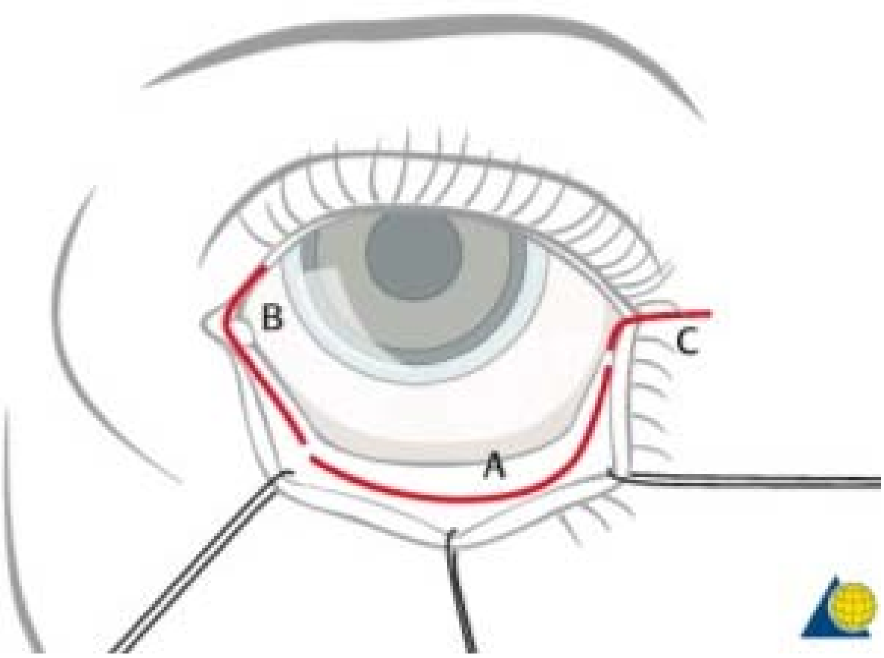


Figure 27: Tranconjonctival approach can be performed in several ways [44]:

A: Transconjunctival (retro or preseptal)
B: Transcaruncular (medial transconjunctival)
C: Transconjunctival with lateral extension (Lateral canthotomy)
D: Combination of A and B
E: C shaped incision: Combination of A, B and C

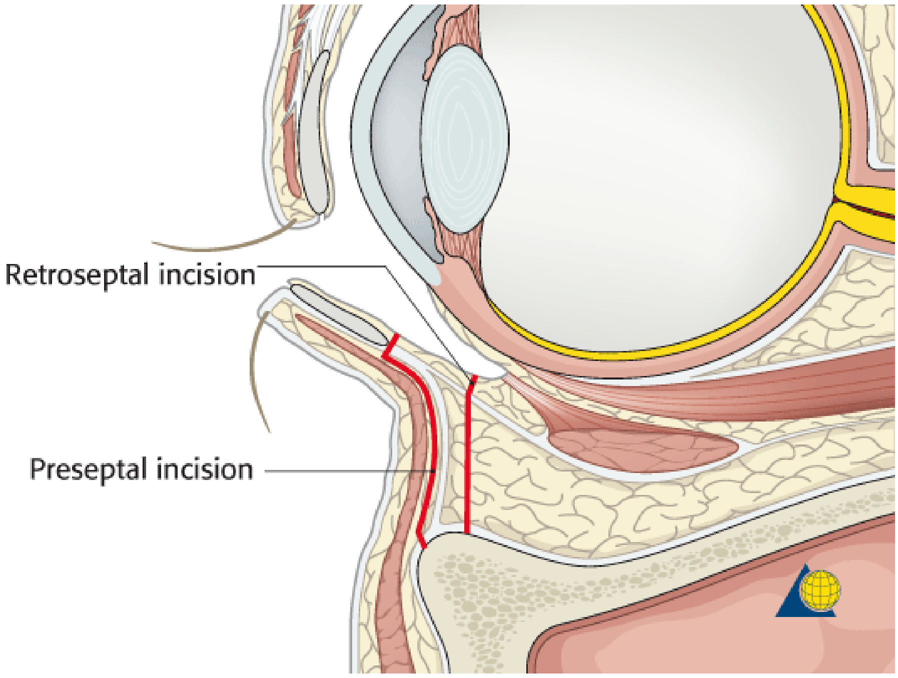


Figure 28: Transconjunctival approach: Retroseptal and preseptal incision [44]

✓ **Percutaneous approach**

This approach is suitable for displaced ZMC fractures with high stability after reduction using a hook or a screw.

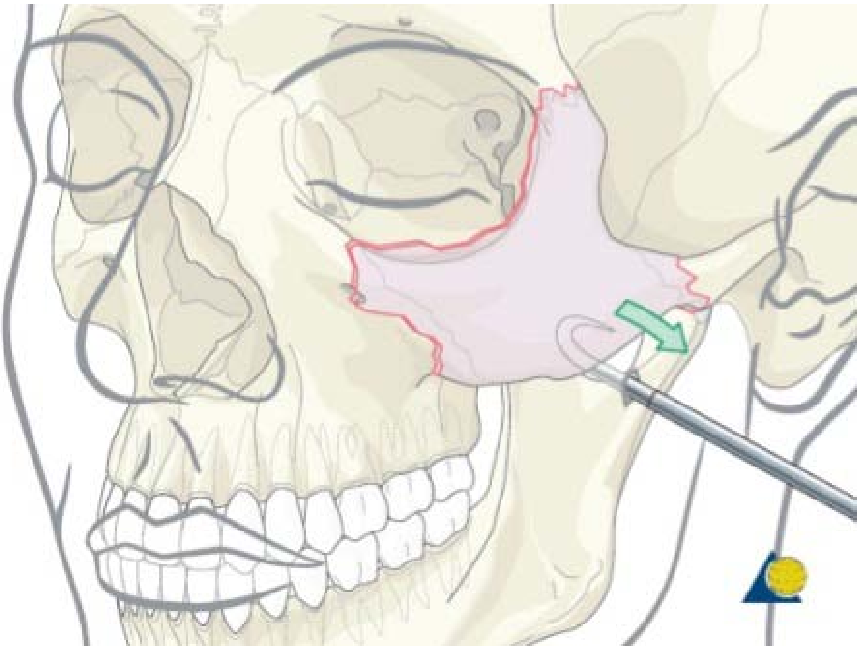


Figure 29: Percutaneous approach using a Stacey bone hook [44]

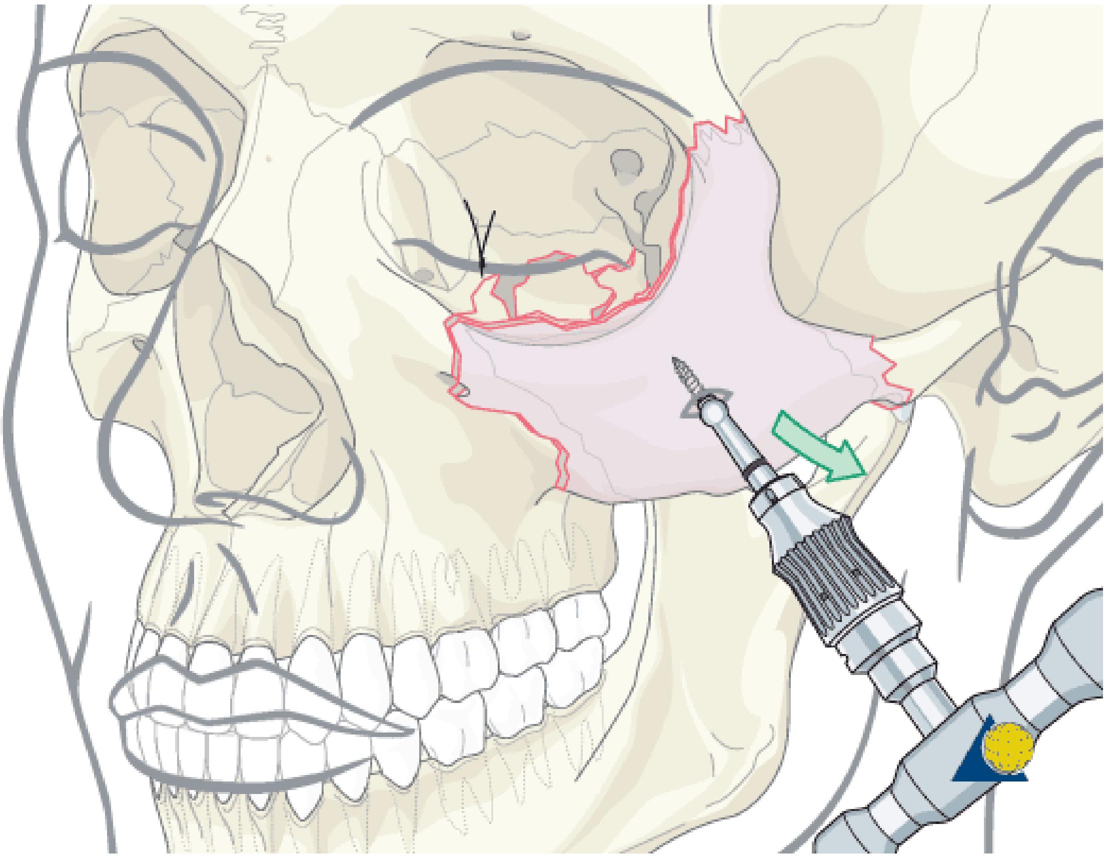


Figure 30: Percutaneous approach using Carroll-Girard screw [44]

- ✓ **Hemicoronal approach :**

This approach is used to expose the anterior cranial vault, the forehead and the upper and middle regions of the facial skeleton. The coronal incision is well described for access to the zygomatic complex especially the zygomatic arch [52]. With excellent exposure of the temporal and infratemporal spaces as well as the superior, lateral, and medial orbital walls, it has become the approach of choice for the late correction of major zygomatic deformities that require osteotomies or bone grafting [53]. However, it results in significant scar alopecia and can also be associated with complications of temporal hollowing and possible risk of injury to the temporal branch of the facial nerve.

In many instances, the negative sequelae of the coronal approach are worse than the benefit achieved from direct exposure of the arch [54]. As a result, many surgeons prefer indirect exposures for reduction of the zygomatic arch.

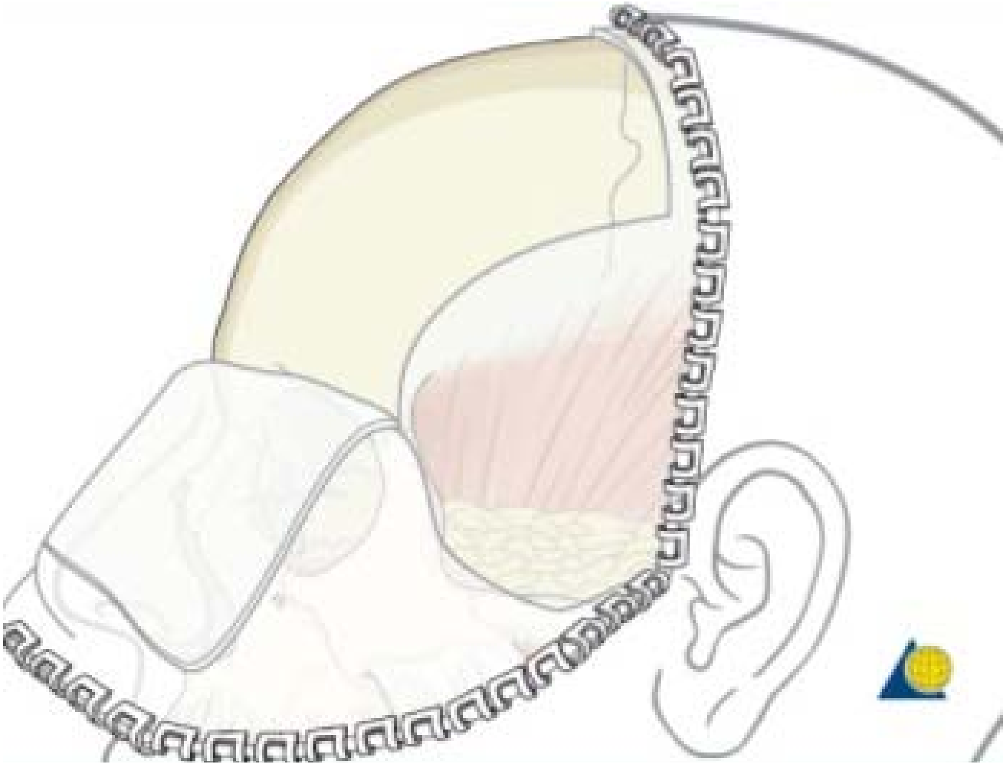


Figure 31: Hemicoronal approach [44]

✓ **Temporal (Gillies) approach** :

The temporal approach is a common indirect approach for reduction of the zygomatic arch. The Gillies technique describes a temporal incision (2 cm in length), made 2.5 cm superior and anterior to the helix, within the hairline. The incision should be made carefully to avoid the superficial temporal artery.

It is used for pure zygomatic arch fracture, where the zygomatic complex itself remains non-displaced. These types of fractures were not included in our study.

Some authors found that the upper buccal sulcus approach has a number of advantages over the Gillies temporal approach, the latter being effective, [55] and widely practiced [54]. These are no skin scars, closer and more precise application of force by the operator, placement of bone plates at the buttress possible through the same incision, minimal bleeding, simplified antral bone harvest if required, and simple mucosal closure [56].

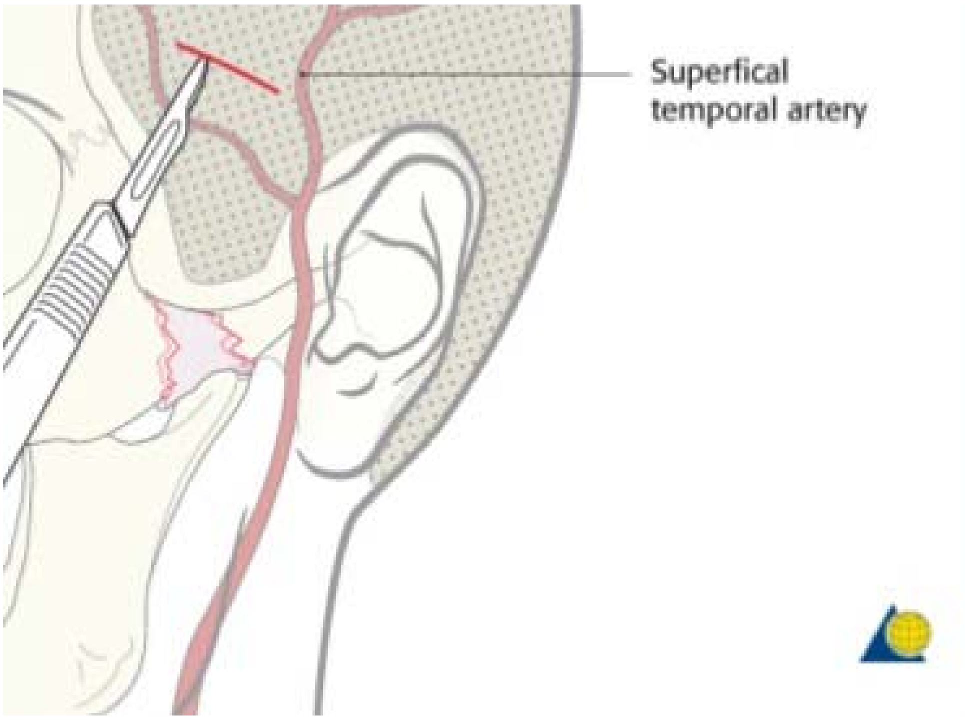


Figure 32: Temporal approach [44]

Intra-oral approach

These techniques offer the advantages of avoiding any skin incision, thereby avoiding any visible scaring. They allow minimal dissection and an excellent vector for reduction; however, they may result in increased rates of infection by introducing oral flora into the infra temporal fossa [57].

✓ Transoral : maxillary -vestibular

The transoral (Keen) approach provides the most direct access to the zygomatic arch. It allows for an intraoral incision, and therefore does not have the risk of scar alopecia that will result from other approaches. It is by far the approach that offers the best cosmetic results since the scar is not visible at all.

A 2 cm lateral maxillary vestibular incision (upper gingival buccal incision) is made with a scalpel or a cautery device just at the base of the zygomatico maxillary buttress. The incision is made through mucosa only; therefore the patient will have no visible scar.

In the majority of cases, this approach can be the first and only incision necessary as it allows the exposure of the ZMB, which is also the most commonly affected buttress of the ZMC [10]. Another study confirms this theory by demonstrating that 1 point fixation at the ZMB through a gingivobuccal incision was effective for tripod fractures without comminution of lateral orbital rim fractures. If the lateral and inferior orbital walls are adequately reduced, this surgical technique results in a successful outcome [29]. However this approach is not empty of risks, it can cause damage to the parotid papilla, which is typically located adjacent to the first or second maxillary molar, and damage to the infraorbital nerve [42].

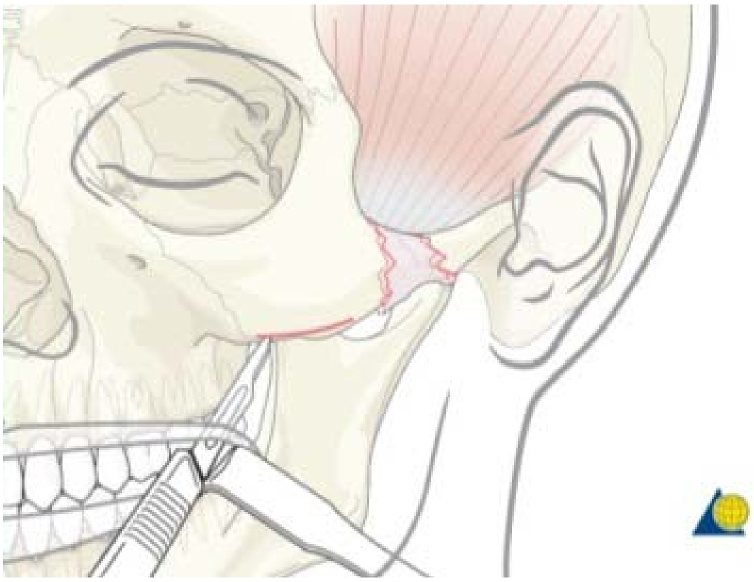


Figure 33: Transoral (Keen) approach [44]

✓ **Endoscopic approach** :

More recently, endoscopic technique has been used successfully at various centers in the management of zygomatic arch fractures via small periauricular incision [58], [59]. This minimally invasive approach negates the need for coronal incisions and appears to be a promising tool that augments, rather than replaces, the time-tested principles of adequate skeletal exposure, accurate fracture reduction, and appropriate internal fixation. However, endoscopic technique requires a steep learning curve and special equipment. Moreover, the long-term data on outcomes is lacking [18].

b.2. Choice of the surgical approach

While treating ZMC fracture, the surgeon can choose more than one of the previously mentioned approaches to reduce, stabilize and fixate the ZMC. This choice depends on the fracture type, the existence or not of functional signs, the hospital's protocol or the surgeon's habits and experience.

In the absence of intra operative CT scan imaging _as is the case in our center_ , the key step to choose an approach for Ellis et al. [60] is the need of orbital reconstruction or not according to preoperative CT scan imaging. If no internal orbital reconstruction is needed the reduction can be performed "closed" in a number of ways, including a Gillies temporal approach, a transcutaneous hook or bone screw (Carroll-Girard), etc. If the displaced fragment reduces and resists displacement using digital pressure applied to the malar eminence, the surgery is over. If the fragment is not well reduced or if internal orbital reconstruction is needed, ORIF is essential.

Figure 34: 7 days post-operative assessment treated through subtarsal incision and lateral eye brow incision

b.3. Reduction:

The first step is accurate reduction of the fracture body. It can be done indirectly using the temporal approach, the Keen's approach or the percutaneus approach as it is the case in our series; where we used Ginstet hook to reduce the fractured fragment. It can also be done directly through the earlier explained approaches (open reduction).

Figure 35: Per operative image showing reduction using Ginstet hook

b.4. Exposure of the fracture site:

The fracture sites (FZ suture, Infra-orbital rim, ZMB, ZA) are exposed through the previously mentioned approaches. Whichever approach is used, the periosteum over the fracture is incised sharply and elevated from the fracture site. During this maneuver, care should be taken not to damage the oculomotor muscles and the infra-orbital vasculo-nervous bundle.

In case of an old fracture, the incarcerated elements are taken by fibrosis and adhere to the periosteum, sometimes with the presence of flanges inside the fat and the intra-orbital muscles.

b.5. Fixation:

Fixation can be achieved in 1 to 4 fracture sites in the ZMC, with different combinations. Multiple methods are described in literature. This varies according to the experience of the surgeon, the associated clinical findings and the available technology in the operating room (intraoperative CT, navigation, etc.).

- 1 point fixation:

According to literature one point fixation is usually used when no orbital reconstruction is needed, for displaced simple non-comminuted fractures. It is a less invasive technique if fragment "snaps" into place with reduction.

ZMB is the most popular fixation site, as it is the most commonly affected buttress of the ZMC[13][10].It is the most used when it comes to only inserting one point fixation and that through a gingivobuccal sulcus incision [29].

The reason that this surgical approach is chosen as the first point of exposure is two-fold. First, the scar is hidden within the oral cavity so the chance of an iatrogenic deformity is nil. Second, the ZMB is a key point for alignment of the displaced zygoma [60].

A study that compared 1 point fixation in the ZMB area to 2 point fixation in the ZMB and FZ area in selected patients with tripod fractures, showed that 1 point fixation at the ZMB avoid unsightly scars and give high satisfaction with surgical outcomes [61].

For other authors, the adequate first point fixation is the FZ suture, as is the case for the Academic Centre for Dentistry of Amsterdam team's protocol [9].

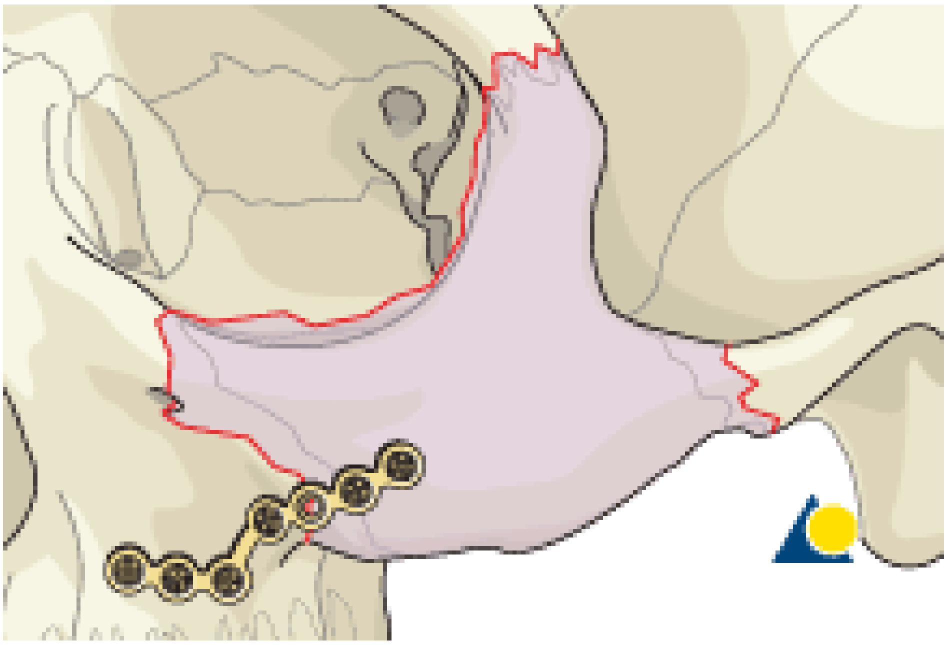


Figure 36: 1 point fixation on the ZMB [44]

- 2 point fixation:

2 point fixation is used when anatomic reduction cannot be confirmed using one point. It allows the visualization of an additional fracture site and a better stabilization to the ZMC.

- ZMB+ ZF

Zhang et al.[19] used these two areas for fixation in all of their patients. Additional incisions were added only when necessary. This means in most patients lateral eyebrow incision plus maxillary vestibular incision was enough to accomplish reduction and fixation.

- ZMB+infraorbital rim

When the ZMC is considered unstable after placing a titanium miniplate along the fracture line at the ZMB or if this area is grossly comminuted then a plate may be placed extraorally through the skin incision at the infra orbital rim as it would also provide orbital floor revision according to Courtney et al. [56].

- ZF+infraorbital rim

Lee et al. [51] used a single transconjunctival approach to access both the ZF suture and infraorbital rim, they believe it is a very useful technique for the treatment of zygomatic complex fracture which is not severely comminuted, because it provides excellent exposure and postoperative stability of the zygoma with a lower incidence of complications, including visible scarring and ectropion.

For Shumrick et al. [62], the infraorbital rim is rarely a major contributor to the ultimate stability of a ZMC or midface fracture as stability comes from the ZMB, ZF suture, and zygomatic arch.

In our series we used these two areas to fixate the ZMC through the lateral eyebrow approach and the subtarsal approach. We believe that these two points provide a 3-plane fixation in space to ensure the stability of the ZMC with good exposure to the orbital floor and lateral orbital wall in case reconstruction is needed.

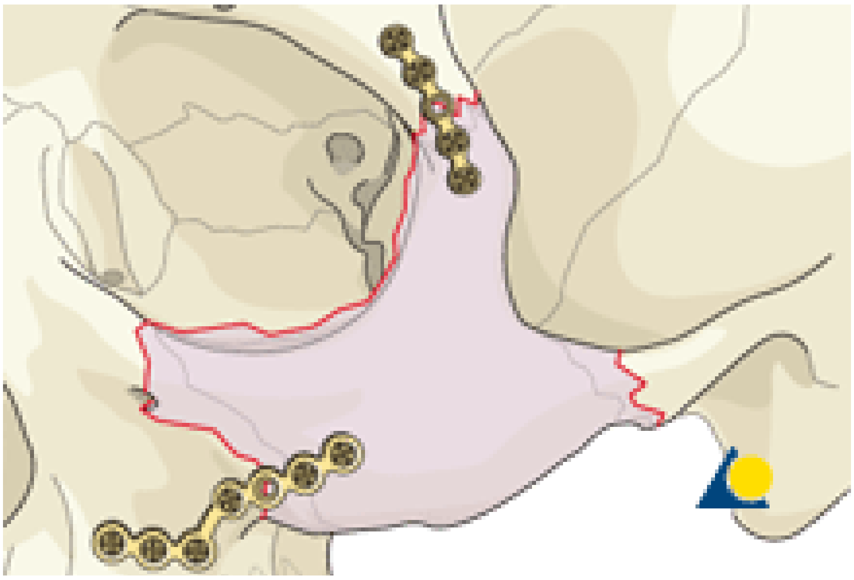


Figure 37: 2 point fixation on the FZ suture and the ZMB areas [44]

Figure 38: Per operative image showing miniplate fixation at the infraorbital rim

- 3 point fixation:

3 point fixation is mainly indicated when the fracture is displaced and/or comminuted requires more than 2 point exposure to verify reduction and need for orbital reconstruction.

According to the biomechanics of the facial skeleton's investigation discussed by Rudderman and Mullen [63], fractured zygomatic segment has six possible directions of motion: translation across x, y and z axis; rotation about x, y and z axis. Therefore, the most favorable fixation situation can be created by choosing three fixation points that are not collinear. Pearl [64] agreed to this theory and concluded that it is essential to reposition the zygoma at a minimum of three locations to achieve correction in three dimensions. He further opined that reduction at the FZ suture and inferior orbital rim can still leave persistent lateral rotation in the region of the anterior maxillary buttress leading to intra-orbital volume expansion behind the axis of globe.

In an experimental study, Davidson et al. [65] analyzed different combinations of miniplate fixation for stabilizing fractured zygoma in human skulls. They found that 3 point fixation at ZF suture; inferior orbital rim and ZMB conferred maximum stability against forces matching physiological stresses. Similar results were found by O'Hara et al [66] in another experimental biophysical study.

The main concern when 3 point fixation is indicated is the visible scaring. However, if the incisions are properly made using the option of transconjunctival incision for orbital rim (which leaves no obvious scar), upper eyebrow incision for FZ suture (minimal scar that can hide under eyebrow) and intraoral buccal sulcus incision for ZMB (no visible scar), the 3 point fixation can give us great esthetics results [67]. Moreover, it provides the possibility to access the orbital floor for revision and possible reconstruction.

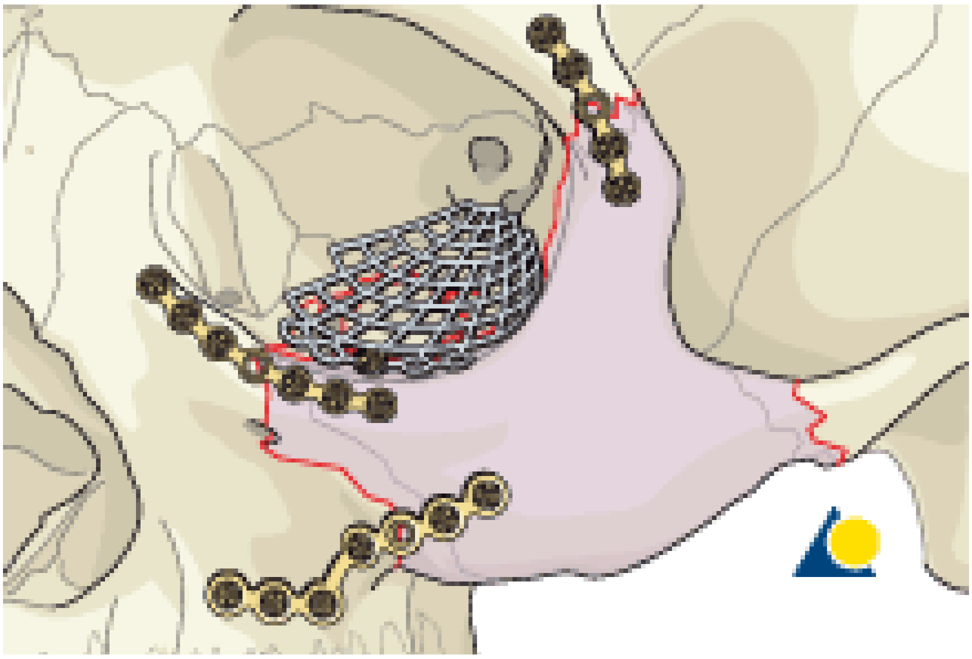


Figure 39: 3 point fixation with orbital reconstruction [44]

- 4 point fixation:

4 point fixation is indicated for complex zygomatic fractures where exposure of the ZA is necessary to ensure proper reduction of the ZMC.

The ZA is considered to be the fourth point upon the reduction. ZA destruction due to trauma changes the antero-posterior direction of the zygomatic body and expands the facial area [68]. Thus, appropriate diagnosis of the relationship of the ZA with the basal skull posteriorly and with the facial center anterior is considered most important in the treatment of midfacial trauma, posttraumatic disfigurement, and a ZMC fracture [4], [69].

The fourth point is used as an extensible approach to fixing the ZA via a coronal incision using the incision line behind the hairline. The exact reduction of the ZA area showed good outcomes in patients with a ZMC fracture. However, complications such as a longer scar on the scalp, extended hair loss of the incised site, injury of the temporal branch of the facial nerve, numbing or tingling of the supraorbital and supratrochlear nerves, and atrophy of the temporal fat pad may occur. Furthermore, a longer operation time and hospitalization period may be required [70].

Choi et al. [71] demonstrated that using the preauricular approach is more useful than the conventional method that uses the coronal approach when adopting 4 point fixation.

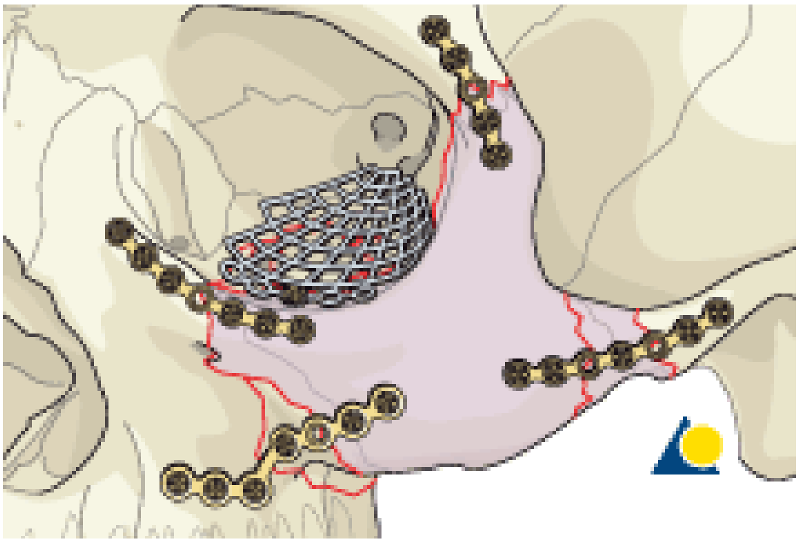


Figure 40: 4 point fixation with orbital reconstruction [44]

Table IV: Advantages and disadvantages to different approaches

Fixation Number	Fixation sites	Advantages	Disadvantages	Authors
1 point fixation	ZMB	Minimal incision	-Difficult assessment of proper reduction	Olate et al. [9]
	FZ			Forouzanfar et al. [8]
2 point fixation	IOR+FZ	Orbital revision	-Difficult assessment of proper reduction	Lee et al. [51]
	ZMB+FZ	Minimal incision		Zhang et al. [19]
	ZMB+IOR	Orbital revision		Courtney et al. [56]
3 point fixation	ZMB+ZF+IOR	-Better stability of reduction -Orbital revision	-Difficult assessment of ZA reduction	Davidson et al. [65]
4 point fixation	ZMC+ZF+IOR+ZA	-Optimal stability of reduction -Orbital revision	-Visible scar -Time consuming -Risk of temporal hollowing -Risk of injury to temporal branch of the facial nerve	Choi et al. [71]

b.6. Orbital floor exploration and reconstruction:

Postsurgical enophthalmos usually results from not reconstructing the orbital floor/walls when indicated, or doing so inadequately [72], [73]. Studies have shown that post-traumatic enophthalmos is most commonly caused by an increase in the size of the bony orbit [74]. Lateral positioning of the ZMC is one of the most common methods for increasing orbital volume because of the cross-sectional area of the orbit at the level of the displaced ZMC. However, concomitant fractures of the orbital floor or medial wall, which often accompany ZMC fractures, can also increase orbital volume. Any patient with presurgical enophthalmos should be suspected of having orbital disruption; hence the need for adequate orbital reconstruction.

Indications for orbital floor exploration and repair include extraocular muscle entrapment with limitation of upward gaze, comminution of the floor, enophthalmos more than 2 mm, defects posterior to the axis of the globe, or floor defects 5 to 10 mm on computed tomography [75].

- **Biomaterials**:

  - ✓ Bone graft

Bone autografts

They are taken from the patient himself and constitute the safer method for several authors thanks to their capacity of osteo-induction and osteo conduction demonstrated by Urist et al [76] in 1952 in their bone graft implantation experiments. They constitute a material of choice for orbital reconstruction [77]. The two surgical procedures, including the removal and placement of the graft, must be performed in a single time, during the same surgical session [76], [78], [79].

Krastinovaet al. [80] emphasize in their study series the use of non-synthetic parietal bone graft material, split skull and conchal cartilage.

- Parietal graft

The operative techniques consist of a cortico-cancellous bone removal at the parietal level. This bone consists of a relatively thick outer cortex (2 mm) located in contact with the scalp and an internal cortex located in contact with the meninges. Between these two layers is a more fragile bone: the diploe [77].

The parietal removal provides a large volume of cortico-cancellous bone with good resistance to resorption. This bone has the same nature as that of the area to be grafted. The implementation is relatively easy and the after-effects are painless, which reduces the duration of hospitalization. The scar is not very visible [81].

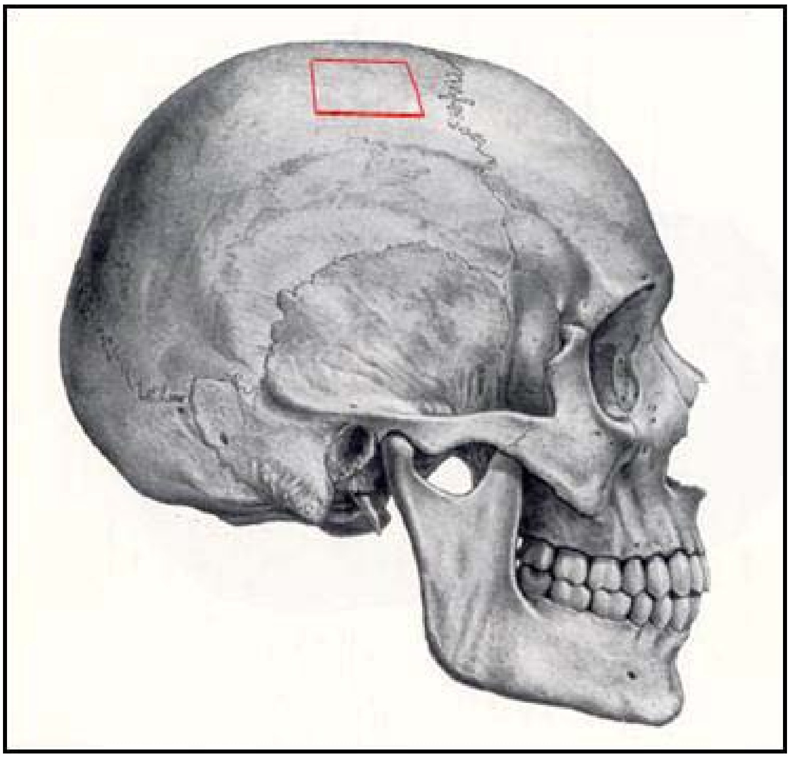


Figure 41: Calvarial bone graft [78]

- Iliac graft

The iliac bone graft will be of interest for reconstructions of large areas, requiring a relatively large amount of bone [84]. Spongy bone (available in large quantities) makes it possible to fill the gaps and to avoid any dead space that will cause complications [82].

The operative technique will depend on the surgeon. The surgical approach used is either located at the posterior iliac crest, or more usually, at the anterior crest. A large graft is then removed with a large amount of cancellous bone.

Nowadays, the current tendency of many surgeons is to abandon this site in favor of the parietal because this graft's resorption is strong and can reach in the months following the transplant 40 to 60%.

Risto et al. [78] have shown in a retrospective study that autogenous iliac graft is the material of choice for orbital reconstruction.

In our study, the iliac bone graft was the only bone graft method used when needed (2 cases). It is a rapid simple technique with eligible esthetic results.

- Other sites of bone grafts

Sources of free non-vascularised bone grafts include calvarium, rib, ilium, tibia, fibula, scapula and radius[83]. Their usefulness have, however, been limited by early bone resorption and infection[84]. Vascularised grafts are now the state-of-the-art for bone replacement in the maxillofacial region[85], as they are reliable, resistant to radiation and infection, and allow the placement of dental implants. Their disadvantages include high cost, the need for specialized training and equipment as well as significant donor site morbidity[86],[87].

Donkor et al. successfully used free autogenous rib on 29 patients to reconstruct defects in the maxillofacial region. The results were satisfactory 90% of the patients healed uneventfully [88].

Kosaka et al [89]reported in a recent study that included 75 patients, the advantages of bone grafts taken from the outer cortex of the mandible for the reconstruction of the orbital walls compared to other donor sites.

Bone allographs

Nineteenth-century surgeons were unaware of immunological reactions and did not differentiate between autografts, allografts, and even xenografts. Calf bone grafts were the most commonly used [90], [91].

Beziat et al [92], report in a series of studies, the results of the use of cranial vault grafts retrieved during the treatment of craniosynostosis and sterilized by gamma rays to reconstruct the orbital walls. They describe the practical details of this technique on 26 cases that did not result in any incident or complication.

However, the use of allograft faces two difficulties: their antigenicity and the risk of transmission of infectious agent which tend more and more to be discarded. The same is true for heterografts because of the frequency of immunological rejections[82].

The autologous bone graft then becomes the material of choice and security available to the surgeon to resolve bone loss [78], [93].

✓ Cartilaginous graft

Wersenbauch and Bell [94]used the autologous cartilaginous graft to repair orbital fractures in 1973.

Nowadays, the repair of bone deficits is most often used with septal cartilaginous grafts [95].

The advantage of septal cartilage is that it is a totally hidden sampling site, it is located on the same surgical field as the implantation site; the engraftment is easy and fast and without any risks of complication the need for nasal packing is the only disadvantage.

Sparfel et al.[95]proved in their study that septal cartilage is a good alternative thanks to its good tolerance, its low cost and the good functional and aesthetic results it gives.

➢ **Non-resorbable synthetic osteoconductive implants:**

Ceramics are materials made from the compaction of a powder under a pressure effect associated with a thermal process (sintering). Ceramics are nonorganic mineral materials [96], [97].

We mainly distinguish: Tricalcium phosphates (TCP), hydroxyapatite (HA) and biphasic ceramics (BCP).

- **Metallic implants**

They have benefited greatly from the latest advances and research both in terms of adaptability and long-term tolerance, reducing or eliminating the risk of complications such as extrusion or infection [98].

Metal implants offer a rigid, thin and malleable support. They exist in the form of mini-plates and microplates or titanium grid, vitallium or lattice [98], [99], [100]. The grids can be cut and bent to fit the confines of the orbit [101], [102]. Implant fixation is sometimes necessary; it can either be performed by periosteal suture or by steel wire or mini-plates.

- **Resorbable implants**

They serve as a support to an osteo-fibrous callus. After an initial period of fracture support, the implant resorbs as bone neo-genesis progresses [43].

The polydioxanone plate is easy to cut and is relatively inexpensive, its tolerance is excellent, however, its resorption rate (2 to 3 months) and the flexibility of the limits its use in the correction of small bone loss [103].

Vicrylmesh was used for the correction of small losses of substance in the early years. Currently it is less used because of the inflammatory reactions generated [104].

Ethisorb is a semi-flexible matrix composed of PDS (polydioxanone) and Vicryl that causes less inflammatory reaction than those due to PDS [104]. Jank et al [105] have recently shown in their study of 435 patients that there is no difference between the use of PDS, Ethisorb and long-term lyophilized dura patches, the surgeon is free to choose equaly between the three.

- **Inert implants**

The silastic: this material is abandoned by many authors [95], because of the risk of foreign body reaction, sometimes 20 years after their implantation.

The porous poly-ethylene: is a flexible material, easily malleable and of great stability. The pore size varies between 100 and 200 µm. Ellis et al. [75] insisted that porous polyethylene does not cause bone resorption, unlike other non-rebsorbable inert implants. Yee J et al. [106] they insist that this material should be reserved for situations where the bone loss is very wide.

Teflon: like silicone, it presents risks of migration and extrusion. It is available in three sizes: Small, medium, large. The long-term results of various studies show little complications when using this type of implants.

Figure 42: Silastic implant

Cranioplast: in the form of a paste, instantly prepared in the operation room by combining a liquid monomer and powder. It allows reconstructing the walls of the orbit and orbital rims as well as the correction of enophthalmos.

The increasing sophistication of reconstruction techniques requires each plastic surgeon's intervention to strive for excellence, which puts him in perplexity when it comes to choosing material.

In general, the material is essentially chosen according to the intraoperative findings. Surgeon’s habits also play a significant role in this choice.

It is recognized today that the reconstruction of orbital defects is based on the principle of the interposition of material between the orbital tissues reintegrated into the bone cavity and the sinus. Many solutions have been suggested over time, autografts, allografts, heterografts or biomaterials. At the same time, the real knowledge of the long-term complications of some of them makes it possible, for example, rejection of silicone and silastic implants, since there are more and more publications reporting re-intervention for infection or extrusion of implants.

In our series we used Prolene mesh for small bone defects. This choice is due to the absence of other options, but it gives a good outcome according to our experience.

In the end, we believe that the best choice can be made between resorbable biomaterials and bone autografts [107].

Figure 43: Implementation of Prolene mesh for orbital reconstruction

Figure 44: Post operative Water's radiographic control of 2 point fixation at IOR and ZMB

V. Complications:

1. Intraoperative complications:

Perioperative complications, haemorrhages, and secondary hematomas, that can cause ocular and optic nerve compression, can take place. Lacrimation and optic nerve involvement may also occur [108].

In our study, there were no intraoperative complications as all patients underwent general anesthesia and controlled hypotension.

2. Post-operative complications and sequealea:

Complications of zygoma fractures may occur in the acute postoperative period or in the delayed postoperative period. The most common ones are listed below:

- ✓ Infection
- ✓ Trismus
- ✓ Diplopia/enopthalmus
- ✓ Facial nerve deficits
- ✓ Malunion/nonunion
- ✓ Malar projection asymmetry
- ✓ Hardware dehiscence

The single most important factor in managing complications is through prevention with sound surgical technique, along with the proper patient education pertaining to postoperative rehabilitation and follow up [15].

2.1. Sensitive disturbance:

Many patients will experience numbness of the cheek overlying the malar fracture secondary to nerve damage. A total of 24 percent of patients in Zingg et al.'s [72] series experienced this problem.

Although the infraorbital nerve is the most frequent source of the symptoms, involvement of the zygomatico facial or zygomatico temporal nerves may further contribute to numbness. As long as the nerve is seen to be intact at the time of the fracture reduction, sensation usually improves and the patient should be counseled accordingly.

In the occasional persistent cases, mechanical impingement of the nerve should be suspected and the patient should be offered nerve decompression [13].

In our study, sensitive disturbances persisted in 9 patients from 16 (56,25%) who had preoperative hypoesthesia. At the one year follow up: 1 patient did not fully recover from infraorbital hypoesthesia and 2 cases progressed to neuralgia. Yang et al. concluded in a cohort study that individuals with ZMC fractures have increased risk of trigeminal neuralgia, particularly within 2-years follow-ups after injury [109].

2.2. Diplopia :

Diplopia is the one of the most common complications along to enophtalmos and sensitive disturbance. The incidence of persistent, residual or treatment-induced diplopia after ZMC fractures varies between 2% and 17% [6], [7], [37].

The confrontation of clinical examination, medical imaging, Lancaster test and a forced duction test makes it possible to specify the mechanism of oculomotor disorder [108]:

- Inadequate extrication;
- Neurogenic or direct muscle damage that can resolve or stabilize after 6 months;
- Periorbital fibrosis and interposition of reconstruction material;

Diplopia can be transient or persistent. It depends on the mechanism and circumstances of the surgical treatment. Either the surgical procedure was well done, the diplopia is often transient and secondary to muscle paresis with an implant placed near the orbital apex and impeding muscle contraction.

If it persists beyond 3 months, we suggest a revision of the orbital floor with removal of the implant.

On the other hand, if the fracture has not been well treated and the diplopia persists, surgical intervention is necessary, especially when it is associated to other signs; if diplopia persists alone and the forced duct test is normal; it means only the oculomotor muscles are affected. If forced duction is abnormal and radiological images show incarceration, orbital exploration is essential [110].

In our study , 1 patient had persistence of his diplopia post-operatively 2,22% at the 3 months follow up, then disappeared at 6 month and 1 year follow up (2 patients had preoperative diplopia).

2.3. Enophthalmos:

Enophthalmos is perhaps the most troubling complication after surgery for orbito zygomatic fractures. When enophthalmos is seen in the postoperative period, a repeated computed tomographic scan should be performed. If the orbit needs correction, it should be reconstructed accurately in a second surgical procedure. Most frequently, the problem is caused by implants or grafts being placed straight back into the maxillary antrum, rather than superiorly into the orbital cone with the natural inclination of the orbital floor [13].

The best method of managing enophthalmos remains prevention of the complication itself because no effective solution exists to truly manage the complication postoperatively.

Early diagnosis of the complication is greatly facilitated if the surgeon routinely obtains immediate postoperative CT scans of the patient [18].

In our study, at the 1 year follow up enophtalmos persisted in 1 case (2,22%) from 3 that suffered from it preoperatively (33,3%). None of our patients presented post-operative enophthalmos.

2.4. Projection defaults:

These esthetic sequealae that include asymmetries and malar projection defaults are usually due to late or inadequate reduction and fixation of ZMC fractures [111], [71].

In our study, 6,66% suffered from loss of malar projection at long term follow up.

2.5. Infection:

Although postoperative infection rates are theoretically higher for a number of reasons[112], it has been our experience that postoperative systemic antibiotics coupled with adequate hygiene and antibacterial mouth rinses result in infection rates similar to other modalities used to treat ZMC fractures. In fact, a systematic review concluded that infection rates were so low in isolated zygomatic fractures that prophylactic antibiotics were not recommended [32].

2.6. Scleral show:

Literature has described a number of cases with permanent scleral show [45], [113]. But these cases are rare and are generally due to the patients' age. In the study held by Lee et al. [51], only one patient (1.9%) had persistent scleral show. This case was a 78 yr-old patient who had lid laxity preoperatively and showed ectropion postoperatively, which may be due to scar contracture. Canthal reattachment procedure (canthopexy) with release of the scar was performed.

Table V: Comparison of different series' results

Author	Inclusion criteria	Number of point fixation	Fixation site	Reposted complications at long term follow up			
				Diplopia	MOL	SD	Asymmetries
Chen et al.[114]	-Isolated -Displaced -Non comminuted	1	ZMB	_	2,4%	35,7%	16,6%
Hwang et al.[6]	_	2 (73,3%) 3 (15,1%) 1 (12%)	ZF:82,2% IOR:70% ZMB:32%	17%	12,5%	56,8%	1,1%
Zhang et al.[19]	_	2 to 4	ZF+ZMB (66%) ZF+ZMB+ZA (23,2%) ZF+ZMB+IOR (6,4%) ZF+ZMB+IOR+ZA (4,4%)	_	7,2%	15,78%	2,63%
Yamsani et al.[37]	-Isolated -Unilateral -No orbital floor fracture	3	ZMB+IOR+ZF		10%	22%	_
Our series	-Isolated -Unilateral -Non comminted	2	ZF+IOR	0%	11,12%	2,22%	4,45%

VI. Recommendations

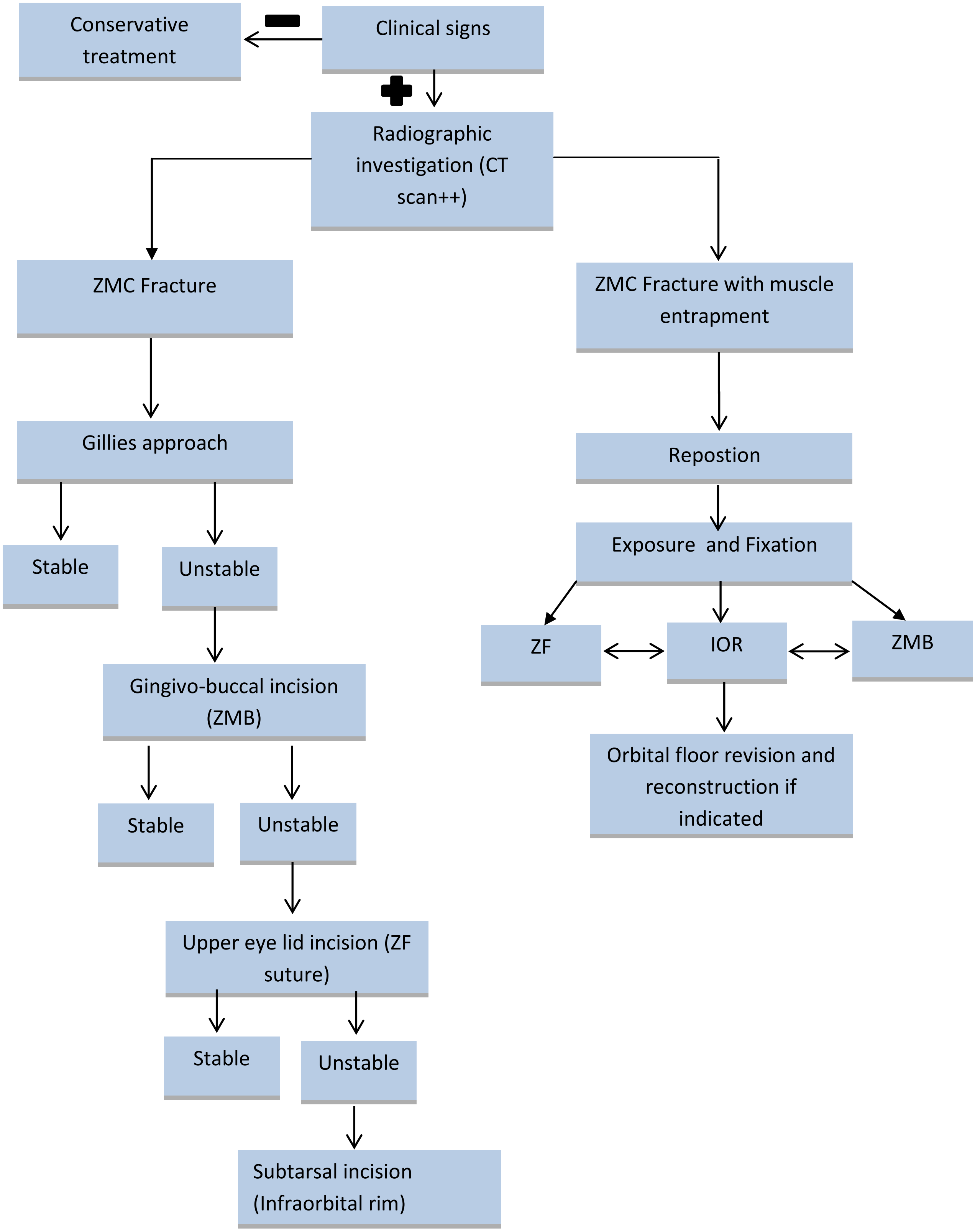
There is considerable information available on the epidemiology and mechanism of injury for zygomatic bone fractures, however, there is a lack of information regarding treatment protocols and there is still no consensus on the treatment of these fractures.

A retrospective analysis was performed in Amsterdam by Forouzanfar et al.[9] to investigate their department's protocol. However extraoral approach remains questionable if the same results can be achieved using an intraoral approach.

At the end, ZMC should be surgically treated based on both clinical and radiographic signs, with minimal incisions to avoid unnecessary scaring. Thus intra oral incisions should be prioritized, for the solidity of ZMB and nonexistence of scars. If stability isn't achieved an upper eye lid incision should be made to expose the FZ suture. Then a third point at the infraorbital rim through subtarsal incision, to achieve optimal stability when it's not achieved by the 2 first points.

All previous results from different studies taken under consideration, we suggest the following protocol.

Suggested protocol:



CONCLUSION

The zygomatic region is the most prominent region of the face, which predisposes it to bearing the brunt of facial injuries. The zygoma, a major buttress of the facial skeleton, is the principle structure of the lateral mid face.

The most common etiologies are road traffic accidents and aggressions. Masculine predominance is very remarkable among all series.

When the oral and maxillofacial surgeon faces a ZMC fracture, he is asked to clinically assess injuries of the face based on both physical and radiographic exam, then decide the adequate treatment approach that includes incision sites, fixation areas and the necessity or not of an orbital reconstruction. The ultimate goal in treating zygomatic complex fracture is to obtain an accurate, stable reduction and 3-dimensional restoration of the original configuration of the zygomatic complex while minimizing external scars, other esthetic issues and functional deformity.

Appropriate management depends on an accurate diagnosis, focusing on the physical examination and data from computed tomography scans. One must pay particular attention to the orbital component of this injury, as it is from this that so much of the morbidity relating to these fractures is incurred.

A variety of techniques can be used to produce a satisfactory outcome. Based on our approach's results and a review of the literature, recommendations for treatment are suggested. We must point out that surgical technique must be subjected to continuous quality control to minimize future problems for the patients in question.

The purpose of this study was to assess post-operative complications of different surgical approaches and fixation sites in ZMC fractures, criticize our own study's approach and come up with recommendations that take the whole under consideration.

APPENDIX

APPENDIX 1

Anatomic review

(Os Zygomaticum; Malar Bone)

The zygomatic bone is small and quadrangular, and is situated at the upper and lateral part of the face: it forms the prominence of the cheek, part of the lateral wall and floor of the orbit, and parts of the temporal and infratemporal fossæ. It presents a malar and a temporal surface; four processes, the fronto sphenoidal, orbital, maxillary, and temporal; and four borders.

The zygomatic bones form the cheeks and the lateral walls of the orbits. They are also commonly referred to a as the cheekbones or malar bones.

- **Surfaces:**

The malar surface (Fig. 45) is convex and perforated near its center by a small aperture, the zygomatico-facial foramen, for the passage of the zygomatico-facial nerve and vessels; below this foramen is a slight elevation, which gives origin to the Zygomaticus.

The temporal surface (Fig. 46), directed backward and medial ward, is concave, presenting medially a rough, triangular area, for articulation with the maxilla, and laterally a smooth, concave surface, the upper part of which forms the anterior boundary of the temporal fossa, the lower a part of the infra temporal fossa. Near the center of this surface is the zygomatico temporal foramen for the transmission of the zygomatico temporal nerve.

- **Processes:**

The fronto sphenoidal process is thick and serrated, and articulates with the zygomatic process of the frontal bone. On its orbital surface, just within the orbital margin and about 11 mm. Below the zygomatico frontal suture is a tubercle of varying size and form, but present in 95 per cent of skulls.

The orbital process is a thick, strong plate, projecting backward and medial ward from the orbital margin. Its antero-medial surface forms, by its junction with the orbital surface of the maxilla and with the great wing of the sphenoid, part of the floor and lateral wall of the orbit. On it are seen the orifices of two canals, the zygomatico orbital foramina; one of these canals opens into the temporal fossa, the other on the malar surface of the bone; the former transmits the zygomatico temporal, the latter the zygomatico facial nerve. Its postero-lateral surface, smooth and convex, forms parts of the temporal and infra temporal fossæ. Its anterior margin, smooth and rounded, is part of the circumference of the orbit. Its superior margin, rough, and directed horizontally, articulates with the frontal bone behind the zygomatic process. Its posterior margin is serrated for articulation, with the great wing of the sphenoid and the orbital surface of the maxilla. At the angle of junction of the sphenoidal and maxillary portions, a short, concave, non-articular part is generally seen; this forms the anterior boundary of the inferior orbital fissure:

occasionally, this non-articular part is absent, the fissure then being completed by the junction of the maxilla and sphenoid, or by the interposition of a small sutural bone in the angular interval between them. The maxillary process presents a rough, triangular surface which articulates with the maxilla. The temporal process, long, narrow, and serrated, articulates with the zygomatic process of the temporal.

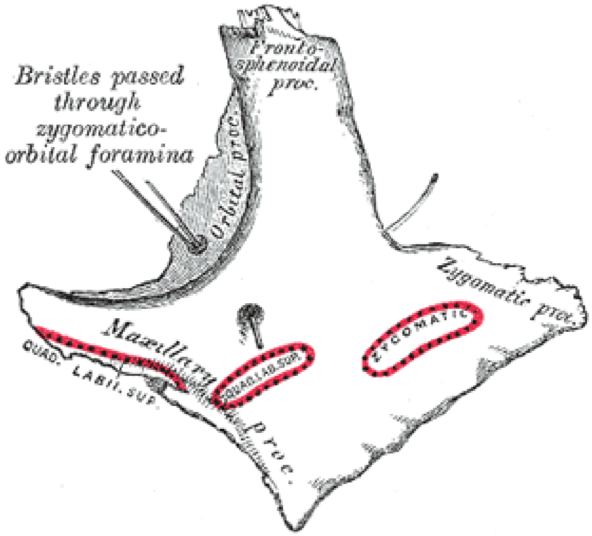


Figure 45 : Left zygomatic bone, Malar surface

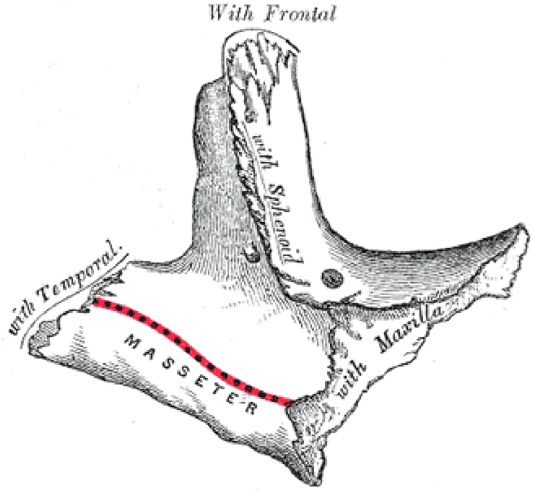


Figure 46 : Left zygomatic bone, Temporal surface.

- **Borders:**

The antero-superior or orbital border is smooth, concave, and forms a considerable part of the circumference of the orbit. The antero-inferior or maxillary border is rough, and bevelled at the expense of its inner table, to articulate with the maxilla; near the orbital margin it gives origin to the Quadratus labii superioris. The postero-superior or temporal border, curved like an italic letter f, is continuous above with the commencement of the temporal line, and below with the upper border of the zygomatic arch; the temporal fascia is attached to it. The postero-inferior or zygomatic border affords attachment by its rough edge to the Masseter.

- **Articulations**:

Each zygomatic bone articulates with the temporal bone, frontal bone, maxilla, and sphenoid bones.

- **Markings of the Zygomatic bone**:

Frontal view: (figure 47)

1. Frontal process (or frontosphenoidal process) - projection that articulates with frontal and sphenoid bones.
2. Orbital process - projection that forms lateral wall (and part of floor) of orbit.
3. Maxillary process - projection that articulates with maxilla bone.

Lateral view: (figure 47)

1. Frontal process (or frontosphenoidal process) - projection that articulates with frontal and sphenoid bones.
2. Temporal process - projection that articulates with zygomatic process of temporal bone to form zygomatic arch.
3. Maxillary process - projection that articulates with maxilla bone.

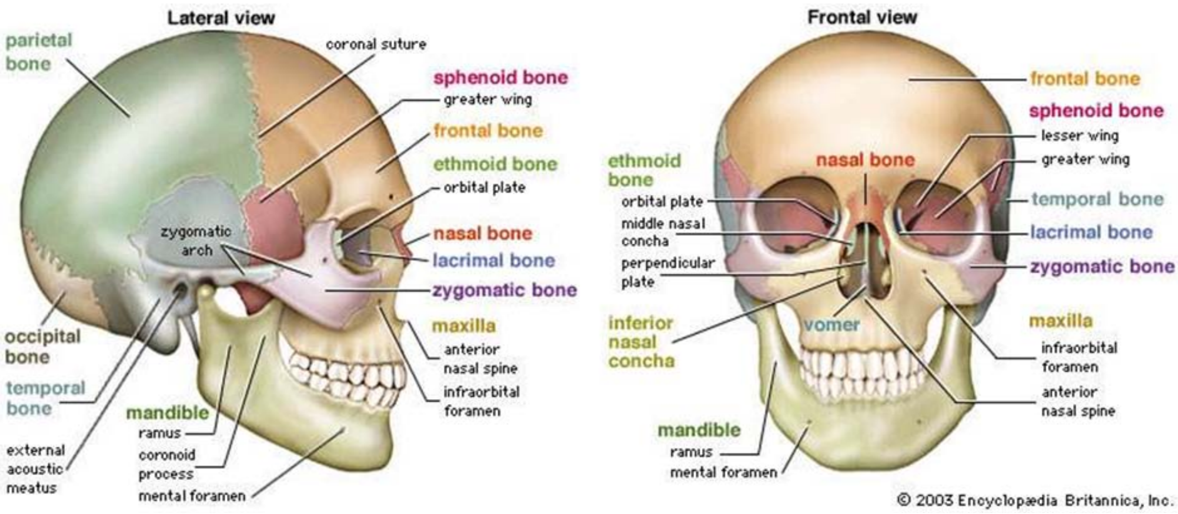


Figure 47: Lateral and frontal view of the skull

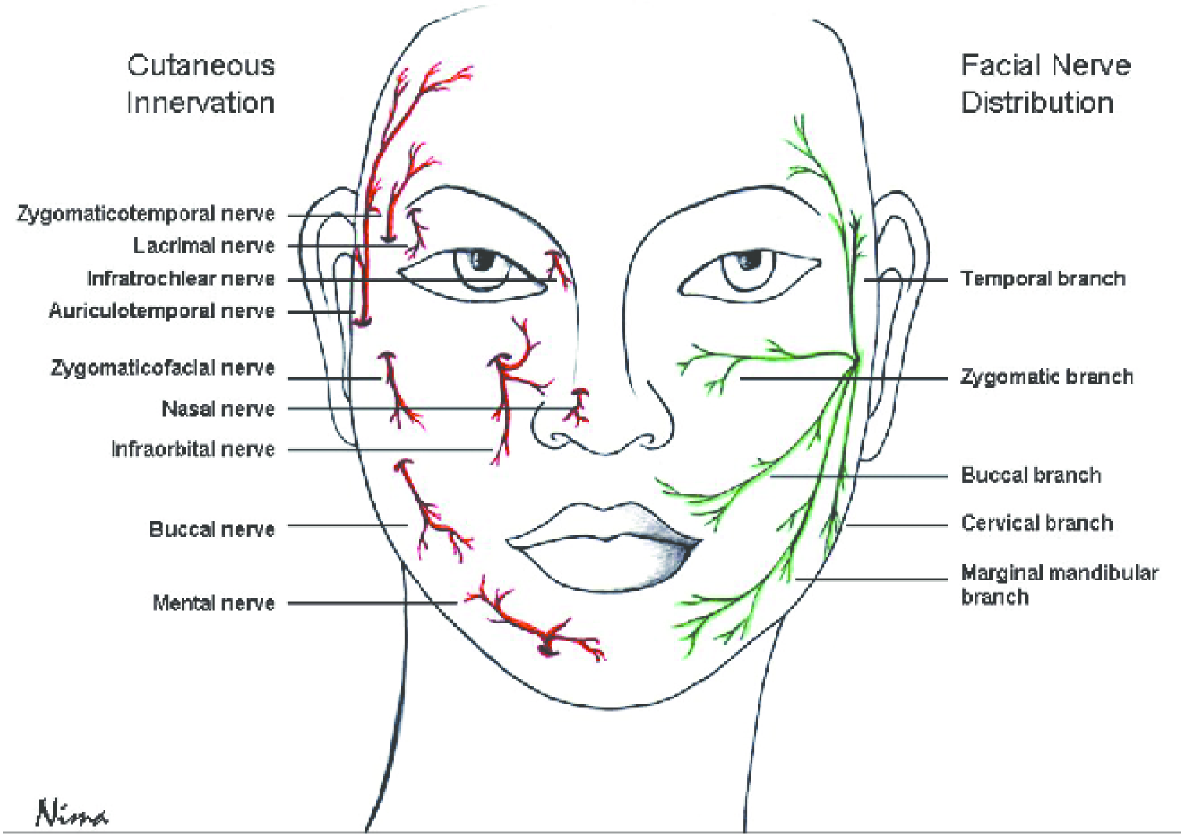


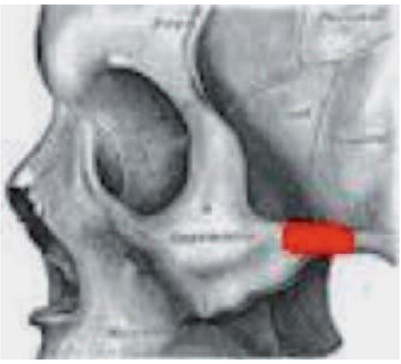
Figure 48:Facial innervations

APPENDIX 2

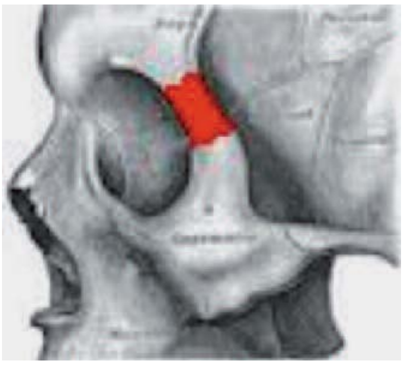
Zingg's classification of zygomatic fractures

We adopted Zingg's classification (Figure 49) as a reference[72] to zygomatic fractures.

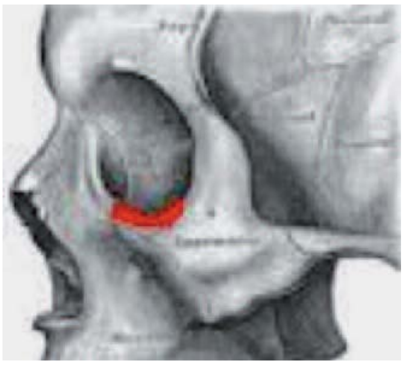
- Category A: Isolated fracture of one of the three processes of the zygomatic bone:
  - The temporal process, which forms the zygomatic arch
  - The frontal process, which forms the lateral orbital wall
  - The maxillary process, which forms the infraorbital rim
- Category B: Fracture of all three processes, detaching zygomatic bone from facial skeleton leading to a classic tripod fracture, but anatomically these fractures are actually tetrapod, because the frontal process of zygoma also communicates with greater wing of sphenoid, which also requires to be disrupted to technically render zygoma free.
- Category C: Same as type B but with fragmentation including the body of zygoma.



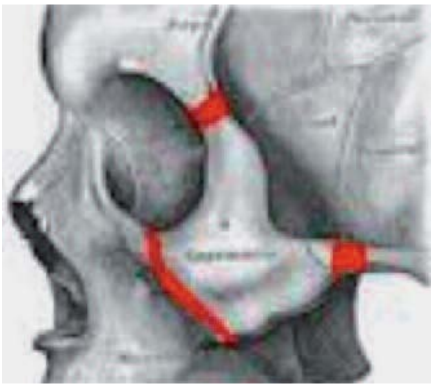
A1: Isolated fracture of the Temporal process



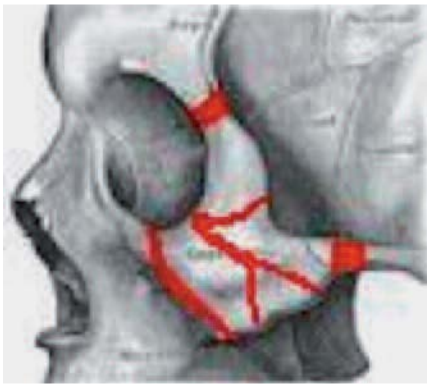
A2: Isolated fracture of the Frontal process



A3: Isolated fracture of the Maxillary process



B: Tetrapod fracture



C: Communitive fracture

Figure 49: Zingg's Classification

APPENDIX 3

Lancaster Test

It is a graphical survey of oculomotricity at different gaze levels:

The paralyzed eye has a smaller frame than normal (by hypo action of the paralyzed muscle).

The contralateral eye has a larger frame than normal (by hyper action of the contralateral agonist according to Hering's law).

This test makes the diagnosis of oculomotor paralysis possible, determines the side of this paralysis, and objectifies the paralyzed muscle(s). It also allows following the evolution of the paralysis by successive surveys [35].

In case of isolated deficit of the elevation, elevators limitation is found on the fractured side, along to the lack of contracture of the ipsilateral antagonists and a hyper action of the contralateral synergists which is explained by the law of Hering. This aspect applies the achievement of a CT scan even when of radiological sign on standard radiography are absent.

The isolated deficit of the lowering is observed during posterior fractures of the orbital floor with muscular incarceration.

The associated deficit of elevation and lowering is the result of significant musculo-aponeurotic incarceration. In this case the forced ducting test is positive.

Association of vertical and horizontal deficit can be observed during an intra-orbital hematoma with exophthalmia. The horizontal deficit often reflects a neurogenic lesion such as paresis or paralysis of an oculomotor nerve.

SUMMARY

Abstract

Zygomatico Maxillary fractures are common among our population. They represent 45 % of midface fractures.

This is a retrospective study of 45 cases of fractures of the zygomatico maxillary complex, operated in the maxillofacial surgery department of the Avicenne Teaching Military Hospital of Marrakech between January 2011 and December 2017. The data was collected from medical records analysis: clinical, para-clinical and therapeutic data.

A masculine predominance of 82,2% was found. The most common etiologies are road traffic accidents 64,4% and aggressions 15,5%. The right side was the most frequently injured (53,34%). The major clinical signs were: mouth opening limitation, enophthalmos, diplopia, sensory disorders, flattening of the malar prominence. Standard imaging and CT scan were achieved in all our patients for good diagnosis. Our surgical approach was based on exploration through lateral eyebrow incision and subtarsal incision, reduction using Ginstet hook and fixation on the exposed areas. Orbital reconstruction was needed in 06 patients from whom 4 had a Prolene mesh and 2 iliac bone grafts. Post-operative clinical assessment found at the one year follow up: hypoesthesia 1 patient (2,22%) ,neuralgia in 2 (4;44%),none had diplopia; enophthalmos persisted in 1 case (2,22%) and 6,66% suffered from loss of malar projection. Subtarsal scar was not visible in any of our cases and 75,5% of lateral eye brow scars were invisible

At the end, ZMC should be surgically treated based on both clinical and radiographic signs, with minimal incisions to avoid unnecessary scaring. Thus intra oral incisions should be prioritized, for the solidity of ZMB and nonexistence of scars. The purpose of this study is to assess post-operative complications of different surgical approaches and fixation sites in ZMC fractures, criticize our own study's approach and come up with recommendations that take the whole under consideration.

Résumé

Les fractures zygomatico maxillaires sont fréquentes dans notre population. Elles représentent 45% des fractures de la face.

Il s'agit d'une étude rétrospective de 45 cas de fractures du complexe zygomatico maxillaire, opérés dans le service de chirurgie maxillo-faciale de l'Hôpital militaire Avicenne de Marrakech entre Janvier 2011 et Décembre 2017. Les données ont été recueillies à partir d'analyse des dossiers médicaux : des données cliniques, para cliniques et thérapeutiques.

Une prédominance masculine de 82,2% a été notée. Les étiologies les plus courantes sont les accidents de la route 64,4% et les agressions 15,5%. Le côté droit est plus souvent fracturé (53,34%). Les principaux signes cliniques sont: la limitation de l'ouverture buccale, énophtalmie, diplopie, troubles sensoriels et affaissement de la pommette. L'imagerie standard et la tomodensitométrie ont été réalisées chez tous nos patients. L'abord chirurgical a été fait à travers une incision à la queue du sourcil et une autre sous-palpébrale haute, la réduction par un crochet de Ginstet puis la fixation. Une reconstruction orbitaire a été nécessaire chez 6 patients dont 4 par mèche de Prolène et 2 par greffe iliaque. L'évolution clinique après un an trouve : une hypoesthésie chez 1 patient (2,22%), névralgie chez 2 (4; 44%), aucun malade n'a présenté une diplopie; l'énophtalmie a persisté dans 1 cas (2,22%) et 6,66% ont souffert de défauts de projection. La cicatrice sous-palpébrale n'était visible dans aucun de nos cas et 75,5% des cicatrices latérales des sourcils étaient invisibles.

Le traitement du complexe zygomatico maxillaire se base sur les signes cliniques et radiologiques .L'abord chirurgical doit être minimal pour éviter les cicatrices inutiles. Ainsi, les abords intra-buccaux devraient être privilégiés. Cette étude est faite pour évaluer et critiquer les différentes conduites chirurgicales dont la nôtre et de formuler des recommandations qui prennent en compte les résultats de la littérature.

ملخـص

أصبحت كسور مركب العظم الوجني الفكي العلوي أكثر شيوعا، إذ تمثل % 45 من مجموع كسور الوجه.

لاحظنا هيمنة الذكور بنسبة %82,2 مع معدل عمر يناهز 43 عاما، و تعتبر حوادث السير السبب لأول لكسور مركب العظم الوجني الفكي العلوي بنسبة %64,4 تليها الاعتداءات بنسبة %15,5. كانت الجهة اليمنى الأكثر إصابة، فكانت تمثل %53,34. العلامات السريرية المهمة تمثلت في : الخوص، ازدواجية النظر، تسطح البروز الخدي و الإضطرابات الحسية بمناطق العصب تحت الحجاج.

و قد ساعدت الأشعة العادية والمقطعية المحورية للوجه في وضع التشخيص الموجب و الاستراتيجية العلاجية. النهج الجراحي المعتمد كان عبر فتحة الحاجب الوحشي و أخرى تحت الجفن. وتمت إعادة إعمار أرضية الحجاج لدى أربع مرضى بألواح البرولين فيما تم استخدام الطعم الذاتي العظمي كمادة أساسية لإعادة البنيان لدى مريضان. تم تقييم المرضى سريريا بعد الجراحة وقد توصلنا إلى النتائج التالية : بقاء الاضطرابات الحسية لدى 3 مرضى، خوص في حالة واحدة %2,22، فيما لم يظهر أي مريض ازدواجية النظر. أما فيما يخص التقييم الجمالي، فلم تكن أية ندوب مرئية على مستوى تحت الجفن. و الحالة هذه بالنسبة ل%75,5 من ندوب الحاجب الوحشي.

يجب على النهج المتخذ لعلاج كسور مركب العظم الوجني الفكي العلوي أن يقام بأقل الفتحات الممكنة مع الحفاظ صلابة التثبيت الجراحي. كان الهدف من هذه الدراسة هو الخروج بتوصية تأخذ بعين الاعتبار الدراسات التي أجريت في هذا المنحى.

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قسم الطبيب

أقْسِم بِالله العَظِيم

أن أراقبَ الله في مِهْنَتِي.

وأن أصُونَ حياة الإنسان في كآفّةِ أطوَارهَا في كل الظروف والأحَوال باذلة وسْعِي في إنقاذها مِن الهَلاكِ والمرَضِ والألَم والقَلَق.

وأن أحفَظَ لِلنَاسِ كرَامَتهُم، وأسْتر عَوْرَتهُم، وأكتمَ سِرَّهُمْ.

وأن أكونَ عَلى الدوَام من وسائِل رحمة الله، باذلة رِعَايَتي الطبية للقريب والبعيد، للصالح والطالح، والصديق والعدو.

وأن أثابر على طلب العلم، وأسَخِّرَه لِنَفْعِ الإِنْسَان لا لأذَاه.

وأن أُوَقّرَ مَن عَلَّمَني، وأُعَلّمَ مَن يَصْغرَني، وأكون أختاً لِكُلِّ زَميلٍ في المِهنَةِ الطِّبِّيَة مُتعَاونِينَ عَلى البرِّ والتقوى.

وأن تكون حياتي مِصْدَاق إيمَاني في سِرّي وَعَلانيَتي، نَقِيَّة مِمّا يُشينهَا تجَاهَ الله وَرَسُولِهِ وَالمؤمِنين.

والله على ما أقول شهيدا

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سنة 2018 أطروحة رقم 189

كسور مركب العظم الوجني الفكي العلوي. أي تثبيت؟1، 2، 3 أم 4 نقط للتثبيت.

الأطروحة

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من طرف

الآنسة هند توفيق

المزدادة في 12 دجنبر 1992 ب أيت ملول

طبيبة داخلية بالمستشفى الجامعي محمد السادس

لنيل شهادة الدكتوراه في الطب

الكلمات الأساسية:

نقط التثبيت - تثبيت داخلي - كسر- مركب العظم الوجني الفكي العلوي

اللجنة

السيدة	**ن. منصوري حطاب** أستاذة في جراحة و تقويم الوجه و الفكين	**الرئيسة**
السيد	**ع. أبو شادي** أستاذ مبرز في جراحة و تقويم الوجه و الفكين	**المشرف**
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