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IP Indian Journal of Anatomy and Surgery of Head, Neck and Brain

Journal homepage: https://www.ijashnb.org/

Review Article

Fixation of Zygomatic fractures using Mini-plates: An overview

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ARTICLE INFO

Article history:
Received 12-03-2021
Accepted 24-03-2021
Available online 21-04-2021

Keywords:
Zygomaticomaxillary complex
Fracture
Internal fixation

ABSTRACT

Zygoma is a major buttress of the midfacial skeleton, which is frequently injured because of its prominent location. Despite the high frequency of the zygomaticomaxillary complex fractures, there is no consensus among facial reconstructive surgeons regarding the best surgical management; thus, surgical choise for ZMC fractures is still challenging. 9 patients were treated with open reduction and internal fixation using two point fixation technique at frontozygomatic suture and zygomaticomaxillary buttress. Miniplate for fixation of fractured fragments are very useful. However, titanium plates, as they are easily adaptable. Two point fixation modality for displaced ZMC fractures is effective method in fixation and prevents postreduction rotation with significant lower cost.

1. Introduction

The bones of the middle third of the facial skeleton present a superficial appearance of strength but they are, in fact comparatively fragile and they fragment and comminute easily. The fact that they articulate and interdigitate in a most complex fashion, it is difficult to fracture one bone without disrupting it'neighbours.[1]

The zygoma or malar bone, referred to in the vernacular, as the "cheek bone" is a strong buttress in the lateral portion of the middle third of facial skeletan. Because of this buttress like position, it is frequently fractured bone, either singly or in conjuction with fractures involving the maxilla.

Fractures of the middle third area have also been called Upper jaw fracture or fractures of the maxilla, but bones adjacent to the upper jaw are invariably involved in such injuries, with varying degrees of involvement of neighbouring structures as the eyes, nasal airways, paranasal sinuses, tongue and brain.[2]

The zygoma is the second most frequently fractured facial bone. When fractured, it may rotate around a longitudinal or vertical axis and may be displaced medially, laterally, posteriorly, or inferiorly.[3] Between 60-70% of middle third fractures are the fractures of zygomatic complex.[1]

Previously a term 'tripod fracture' was given to specific type of zygomatic fracture which is now considered a misnomer since along with frontal, maxillary, temporal articulations, the orbital extension of zygoma has a broad abutment against greater wing of sphenoid, thus rendering it a tetrapod. This surface of zygoma constitutes most of the lateral orbital wall and also forms part of the orbital floor lateral to infraorbital groove. Therefore, a displaced zygomatic fracture is also anorbital floor and lateral wall fracture.[4]

Because of the impure nature of zygomatic fractures, other terms are also used in describing these like zygomaticomaxillary complex, zygomatic complex, malar fractures, zygomaticomaxillary compound, zygomaticoorbital, trimalar fractures.[5]

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https://doi.org/10.18231/j.ijashnb.2021.001

Treatment of zygomatic fractures varies from no treatment, simple reduction without fixation[5–7] to reduction followed by fixation. Various fixation means have been used, external pins[8,9] lag screw,[10] K wire,[11] Transosseous wires,[12–14] mini DCP, miniplates[12,13,15–17] and microplate.[14,18] of the stainless steel, titanium and bioresorbable[8,19] material all have been used. Point of fixation is not fixed some used one point fixation.[16] some used two. Other used three[20] or four point fixation.

2. Aims and Objectives

The aim of present study was to assess the efficacy of bone plates in the stability of zygomatic complex fractures following surgical reduction. In the proposed study indigenously built stainless steel mini bone plates and titanium mini plates were used. The objective of the study was to critically compare and to evaluate the results obtained following use of two types of mini bone plates. The advantages, merits and various complications of mini bone plates for the management of zygomatic complex fracture was evaluated.

3. Materials and Methods

All the patients with facial trauma having zygomaticomaxillary complex fractures reporting to the department of Oral and Maxillofacial Surgery were examined clinically and radiologically. Cases involving fractures of zygomatic complex were included in study. All together 9 patients with zygomaticomaxillary complex fracture diagnosed clinically and radiologically were included in the study irrespective of caste, creed, colour, race or sex. The following criteria are followed for present study.

For patients to be selected:

1. All the patients had to be medically fit.
2. All the patients required surgical reduction and stabilization of zygomaticomaxillary complex fractures.
3. Four reference points were chosen to select the patient in study, these were, frontozygomatic suture, infra orbital rim, zygomatic buttress and zygomatic arch. Selected patints had disruption of either two or more of reference points.

Criteria for exclusion from study:

1. Either concomitant head or spinal injury.
2. Aged below 18 years.
3. Any other fracture other than ZMC fracture.
4. ZMC fracture more than a month old.
5. Severe displacement of ZMC fracture.
6. If patient had visual disturbance due to ZMC fracture.

3.1.

3.1.1. Selected patients were placed randomly in two groups A and B.

Group A: It included patients with zygomatic fractures in whom after reducing the fracture by Gillies temporal approach, indigenously built stainless steel plates were used for fixation. 4 holes ‘C’ shaped for frontozygomatic suture and 4 holes ’L’shaped for 3 zygomatic fractures.

3.1.2. In present study, 4 patients were included in group B.

Two types of mini bone plates were used in the study. One was indigenously built stainless steel and other was of indigenously built titanium mini bone plate. 4 holed ‘C’ and ‘L’ shaped plates of either type were chosen. In each patient, depending on the group, either stainless steel or titanium ‘C’ shaped plate was used for frontozygomatic suture and ‘L’ or reverse’L’ for zygomatic buttress ‘L’ shaped for right zygomatic buttress and reverse ‘L’ for left zygomatic buttress.

Screws used were 5 mm length and 2mm in thread diameter. They were self-taping and monocortical. Drill bit was 1.6 mm in diameter and was motor driven.

Surgical procedure: All selected patients were checked for medical fitness to undergo the surgical procedure under general anaesthesia. It involved the routine blood examination, serum urea, creatinine, chest x-ray and ECG. All medically fit patients were given antibiotic coverage before surgical procedure. Head was shaved before operation. In case of male patients facial hair were also shaved but not eyebrows. Patients were given general anaesthesia with nasoendotracheal tube in place. Eye towards the side of ZMC fracture was not covered.

Technique for Reduction of ZMC fracture: In all patients Gillies temporal approach was used for reduction of ZMC fractures.

Incision: Firstly superficial temporal artery was located and incision line marked at the bifurcation of it. It was at an angle of 45^0 to the upper limit of attachment of external ear and parallel to anterior branch of temporal artery. It was 2.5 cm in length and 2 cm above and 2 cm in front of external ear.

After incising the skin blunt dissection was done to expose temporalis fascia. When fascia was exposed it was incised to expose the temporalis muscle. Firstly Howarth’s periosteal elevator was placed in downward and forward direction upto the deep aspect of zygomatic bone. There was no obstruction to it’s passage which showed it was in correct plane. Some times the handle had to be pushed laterally so that tip moving in lateral direction, reaches the deep aspect of depressed zygomatic bone. After checking the plane, periosteal elevator was withdrawn until the tip was under the fascia, which acted as guide to the placement of Rowe’s zygomatic elevator.

One hand was placed on Rowe's zygomatic elevators with wrist fully pronated and palmer surface placed over the handle at the end of the blade which was to be inserted deep to temporalis fascia. This was used as a guide to the proper positioning of the instrument and to hold the instrument steady during elevation. Other hand was placed, with wrist supinated, and palmer surface underneath the lifting hand. By closing the hinge of the instrument, the handle was brought close to skin to check the position of instrument. Assistant steadied the head.

For elevation force was applied in outward and upward direction. To protect the skin under the Rowes zygomatic elevator gauze packs were given between skin and elevator. When the fracture was reduced a click sound was heard. After reduction the ZMC was checked at frontozygomatic suture and infraorbital rim to feel for step at these sites. If step was there another attempt of reduction was undertaken. Suturing was done after plating at frontozygomatic suture region and zygomatic buttress region was completed, till that time a pack was placed at the surgical site. Suturing was done in layers. Inner layer of temporalis fascia was sutured by 3-0 catgut and outer skin by 3-0 mersilk. Closed dressing was given after suturing which was changed after every 48 hours. Alternate sutures of skin were removed on 4^{th} postoperative day and open dressing was given afterwards. Total removal of sutures was done on 7^{th} postoperative day.

3.1.3. Technique for plating at frontozygomatic suture region

Incision: After reducing ZMC fracture a separate incision was given at lateral one third of eyebrow to expose the frontozygomatic suture. Eyebrows were not shaved and incision was given parallel to hair follicle to avoid damage to them. Incision was curved and about 2 cm in length made on bony orbital rim. Incision passed through skin, orbicularis oculi and periosteum. Incision did not extend beyond outer canthus of eye so that lymphatic drainage of eye was not disrupted. After exposing frontozygomatic suture by subperiosteal dissection a 4 holed'C' shaped plate was adapted at the suture. After adaptation of the 'C' shaped plate it was fixed using 5 mm long screws with 2 mm thread diameter, self taping and monocortical type. Firstly hole near the fracture line on either side of it, was drilled under continuous irrigation with saline. Screw was applied but not tightened fully. After this, hole towards the fracture line on the opposite side of the first one, was drilled and screw applied and tightened, first applied screw was also tightened. After this, holes away from the fracture line, were drilled. Screws were applied and tightened fully. Through this procedure of plating at frontozygomatic suture, eye was checked periodically to see if there was bubconjunctival haemorrhage if it was not there at the time of operation or if it was there, has it increased. After thorough irrigation with normal saline the site was sutured in layers. Inner layer of periosteum and muscle was sutured with 3-0 catgut. Outer skin layer was sutured using 3-0 mersilk. Closed dressing was given which was changed every 48 hours.

3.1.4. Technique for plating at zygomatic buttress region

Incision: For plating at buttress region, an intraoral horizontal incision was given, about 2 cm in length given. After subperiosteal dissection the buttress was exposed loose fractured bony pieces separated from periosteum, Adaptation was done with concavity on between because of the buttress. For right side 'L' shaped plate and left side reverse 'L' shaped plate was used. After adaptation hole was drilled towards the fracture line on buttress under continuous irrigation. Screw 5 mm in length, 2 mm in thread diameter, self tapping, monocortical type was applied but not tightened completely. Next hole near the fracture line towards the alveolar process was drilled taking care not to damage root of nearby teeth and screw applied and tightened. Now screws away from fracture line towards the alveolar process was drilled. Screw was applied and tightened fully. Now last hole, away from fracture line towards alveolar process was drilled and screw applied and tightened fully. During plating procedure, a counter pressure was applied by Rowe's zygomatic elevator placed in correct plane between temporalis fascia and temporalis muscle. After irrigation site was sutured using 3-0 mersilk. All intraoral sutures were removed on 10^{th} postoperative day. Following parameters were checked in every patient.

Surgical time, Difficulties encountered during fixation of bone plates, Ease of manipulation of bone plates. Post operatively antibiotics were given for seven days. Antral regimen consisting of antiallergics and nasal decongestants was given till 4^{th} postoperative day.

Recording of data: Post operatively each patient was evaluated for six months both clinically and radiographically. Data were collected on 1^{st},3^{rd}, 7^{th},15^{th},90^{th} and 180^{th} day postoperatively on clinical basis. Radiographic data were collected from two radiographs PNS and OPG on 7^{th},90^{th} and 180^{th} day post operatively. Clinically each patint was examined for:

1) Periorbital echymosis, 2) Subconjunctival hemorrhage, 3) Periorbital hematoma, 4) Periorbital edema, 5) Movement of eye in 9 gazes, 6) Hooding of eye, 7) Diplopia in 9 gazes, 8) Swelling, 9) Echymosis and hematoma in zygomatic arch area, 10) Steps at frontozygomatic suture, infraorbital rim and zygomatic arch, 11) Tenderness at frontozygomatic suture, infraorbital rim and zygomatic arch.12) Flattening of cheek, 13) Abnormal mobility of fractured fragments, 14) Deformity or tenderness at palatal region, 15) Echymosis, laceration, discharge at buccal sulcus, 16) Step or tenderness at buccal sulcus, 17) Deviation or restriction of mandibular movements, 18) Anterior or posterior open bite, 19) Occlusal derangrment.

Radiologically visible discontinuity at

1. Frontozygomatic suture.
2. Infraorbital margin.
3. Zygomatic arch,
4. Haziness of maxillary antrum.
5. Body of zygoma and frontomaxillary suture were examined in PNS.
6. Zygomatic arch and zygomatic buttress were examined in OPG.

Two types of plates used were thus compared for the parameters accounted above.

4. Conclusion

In the present study 9 patients were selected according to the laid down criteria and were then randomly divided in 2 groups. In group A stainless steel minibone plates were used as fixation means. A total of 5 cases were included in group A. In group B indigenously built titanium mini bone plates were used as fixation means. A total of 4 cases were included in group B.

All the patients had the reduction of zygomaticomaxillary complex fracture using Gillies temporal approach. Following reduction plating was done at frontozygomatic suture region and zygomatic buttress region. All the patients were evaluated clinically and radiologically and data were taken upto 6 months postoperatively. Results obtained were analysed statistically and are given in results sections and conclusion drawn.

The following conclusions can be drawn from the present study:

1. 2-point fixation following reduction of ZMC fractures at frontozygomatic suture and zymatic buttress region is an effective means of fixation.
2. The incidence of complications associated with lateral eyebrow incisions are minimal. Plating at frontozygomatic region through lateral eyebrow approach is safe both from surgical and esthetic point of view.
3. Miniplate for fixation of fractured fragments are very useful. However, titanium plates, as they are easily adaptable, mau be preferred.
4. Exposer of zygomatic buttress region needs a delicate approach as fragmentation of bone on this region was observed.
5. The present study included a small sample size; further studies are required with a bigger sample size to come at a definite conclusion.

5. Review of Literature

5.1. Epidemiology

Mallett (1950) reviewed 2124 cases of jaw fractures treated at Boston City Hall Hospital from 1919-1948. Harrisch (1960) collected 532 fractures between1952-57. Lindstrom (1960) reviewed 649 patients from 1948-58. Schuchardt and others (1966) studied 1566 fractures from 1946-57 and 1335 cases from 1958-63. 774 cases were of mid third of face.[1]

Rowe and Killey (1968)[21] collected 1500 facial fractures,out of which 501 were of mid third of face and 128 of both mandible and mid third.

Killey and Harrigan (1975)[1] analyzed 3324 patients with facial fractures and out of 4317 fractures only 594 involved middle third of face.

In a study by Haider (1977-78)[22] studied 108 cases. N.E.Steilder et al (1980)[23] studied 240 patients.

P.M.Ferley et al (1984) studied 147 cases of zygoma fracture. Edward Ellis III[13] studied 2067 cases (1985) of ZMC fractures. Richard H.Haug et al (1994)[24] studied 39 patients out of 882 patients. These 39 patients had both facial and cranial fractures.

5.2. Age and Sex

Out of 108 cases studied by Z Haider (1977-78)[18] 91 were males and 17 were females. Ratio was 5.35:1. Age range was 15-40 years. By N.E.Steidler et al (1980)[23] 65% of patients they studied were aged 10-29 years with a peak in 20-29 years. Males constituted 83.3% and only 16.7% were females.

Edward Ellis III[13] studied 2067 cases (1985) of ZMC fractures, males accounted for 80.2% of all cases and females 19.8%. Age range for male was 10-40 years with peak incidence in 20-3- years. Peak incidence for female was between 30-40 years.

According to Peter Jungell et al (1987)[25] of the 68 patients mean age was 36 years. No account has been given on sex ratio.

Study of Christopher P.Thompson et al (1994)[26] showed male female ratio was 4:1.,most common in second and third decades.

In 39 patients studied by Richard H.Haug et al (1994)[24] males outnumbered females by ratio of 6:1. 16-30 year age group was most frequently affected.

Walfgang P. Piotrowski et al (1995)[27] studied 101 patients with orbital roof fractures. Peak age group was 29-30 years. Male female ratio was about 9:1.

Edward Ellis III et al (1996)[13] studied 48 patients with ZMC fractures. Of these 23% were females and 71% were males. Mean age was 34 years. Most males were in fourth decade and females in third decade. Jurjen Schortinghuis et al (1999)[18] studied 44 patients. In this series 7 were females and 37 males. Age range was 41.9_+14.7 years.

Analyses of Dan De Angelis et al (2001)[28] shows males are 4 times more commonly afflicted. Most common in second to third decades of life.

According to E.Bradley Strong et al (2002)[29] ZMC fractures occur in males (80%) more than in females (20%) with peak age between 20-30 years.

5.3. Etiology

Z Haider (1977-78)[22] says assault and fight was major cause, 36.1%, RTA in 19.4%, fall due to other reason was third major cause.

RTA caused fracture in 80.8% of patients studied by N.E.Steidler et al (1980).[30]

According to P.M. Finley et al (1984)[9] RTA was the cause in 43 cases they reviewed, followe by sports,23 patients; industrial accidents in 13 cases, assault in 5 cases, fall in 27 cases and other reasons in 9 cases.

Alleged assault accounted 46.6% of fractures treated by Edward Ellis III (1985),[13] falls 22.4%, motor vehicle accidents 13.3%.

Most common cause of fractures was assault 44%, followed by RTA 25%, falls 18%, sports 6%, work 6% and other 1% by Peter Jungell et al (1987).[25]

80% of the fractures analyzed by Christopher P. Thompson et al (1994)[26] were caused by RTA and remaining 20% by altercations and falls.

In study of Richard H Haug et al (1994)[24] motor vehicle accident was most common cause and only cause in females.

Wolfgang P.Piotrowski et al (1995)[27] claim road accident to be the main cause of ZMC fractures. About 49%, fall 23%, sports 15%.

According to Edward Ellis III et al (1996)[13] altercations accounted for 54% of ZMC fractures, RTA 38%, fall 6%, sports 2%. In females M.V.A was most common cause, in males altercation was most common cause.

In 44 patients studied by Jurjen Schortinghuis et al (1999),[18] 23 ZMC fractures were because of RTA, 11 caused by fights and 5 each from fall and sports.

According to Dan De Angelis et al (2001)[28] main cause of ZMC fracture is blow to the side of face from fist, object or secondary to motor vehicle accident.

E Bradley Strong et al (2002)[29] states ZMC complex fractures occur mostly because of personal altercations, falls, motor vehicle accidents and sports injury. In 25% of patients, other facial fractures were also present.

Fracture patterns and classification

Schjelclerup (1950)[5] was the first to classify zygomatic fractures. He divided fractures into 5 types-

Type I: Occurred when displaced zygomatic bone hinged on maxillary and frontal attachments

Type II: Occurred when displaced zygoma hinged on maxillary attachment.

Type III: Occurred when displaced zygoma hinged on frontal Attachment

Type IV: If zygoma is detached en block.

Type V: Grossly comminuted.

Knight and North (1961)[5] classified the zygomatic complex fractures determining post reduction stability. They divided ZMC fracture in 6 groups and 4 sub groups.

Group 1- Undisplaced fractures.

Group 2- Isolated displaced arch fractures.

Group 3- Displaced but unrotated fractures.

Group 4- A: Medially rotated; outward at malar buttress.

B: Medially rotated; inward at frontozygomatic suture.

Group 5- A: Laterally rotated; upward at frontozygomatic suture.

Group 6- Additional fracture line across main fragment.

Handerson (1963)[5] gave a classification. He divided the ZMC fractures in 7 divisions

1. Non displaced fractures
2. Isolated zygomatic arch fractures
3. Zygomatic complex fractures in which there is displacement but the frontozygomatic suture is non-distracted
4. Zygomatic complex fracture in which there is displacement and distraction of frontozygomatic suture
5. Pure blow out fractures
6. Fractures of orbital rim only
7. Comminuted or multiple fractures

Frontozygomatic suture was used in this classification as it was considered a key to determining the need for fixation following reduction.

Rowe and Killey (1968)[2] classified ZMC fractures according to the displacement of the complex-

Type 1: No significant displacement.

Type 2: Isolated fractures of zygomatic arch.

Type 3: A- Rotated around vertical axis internally.

B- Rotated around vertical axis externally.

Type 4: A- Rotated around longitudinal axis medially.

B- Rotated around longitudinal axis laterally.

Type 5: A-Displacement of complex en block medially.

B- Displacement of complex en block inferiorly.

C- Displacement of complex en block laterally.

Type 6: A- Displacement of orbital floor inferiorly.

B- Displacement of orbital floor superiorly.

Type 7: Displacement of the orbital rim segments.

Type 8: Complex comminuted fractures.

Type 4A, 4B, 5A, 5C and type 8 were unstable fractures frequently require fixation. A separate classification of orbit was also given Rowe and Killey (1968).[2]

Bruno W.Kwapis (1969)[14] classified malar fractures in 6 classes-

1. Non displaced fractures
2. Arch fractures
3. Unrotated body fractures
4. Medially rotated body fractures
5. Laterally rotated body fractures
6. Comminuted fractures

Spiessel and Schroll (1972)19 classified the zygomatic complex fractures based on treatment consideration-

Type 1: Isolated zygomatic arch fractures.

Type 2: Fracture with no significant displacement.

Type 3: Fractures partially displaced medially.

Type 4: Fractures totally displaced medially.

Type 5: Dorsal displacement.

Type 6: Inferior displacement.

Type 7: Comminuted fractures.

Yanagisawa (1973)[5] classified the ZMC fractures using three x-rays waters view, Caldwell's view and submentovertex view. It was a modification of Rowe and Killey classification. He added post en-block displacement to type 5 of the classification as 5d.He omitted type 6.

Larsen and Thomson (1978)[5] classified the ZMC fractures in simple yet practical classification and grouped them into stable and unstable fractures. There were three groups-

Group A: Fractures with minimal or no displacement and hence Intervention required.

Group B: Fractures with great displacement and disruption at Frontozygomatic suture and comminuted fractures.

These require reduction as well as fixation.

Group C: Fractures of all other kinds which require reduction but no fixation.

Fuji and Yamashiro (1983)[5] classified zygomatic complex fractures using cross sectional C.T., by post traumatic position of zygoma

Type 1: No evidence of displacement.

Type 2: Isolated fracture of zygomatic arch.

Type 3: Fractures in body of zygomatic complex rotation in A.P. direction, fractured segment was displaced in posteromedial direction (inward)

Type 4a: Axis of rotation at base of the arch.

Type 4b: Axis of rotation at zygomaticomaxillart suture.

Type 4c: Fractures involving zygoma; main body of maxilla and the palate.

Classification by Rowe and Williams(1985)[2]

i) Fractures stable after elevation

(a) Arch only (medially displaced)

(b) Rotation around vertical axis

- Medially
- Laterally

ii) Fractures unstable after elevation

(a) Arch only (inferiorly displaced)

(b) Rotation around horizontal axis

- Medially
- Laterally

(c) Displacement en block

- Inferiorly
- Medially
- Posterolaterally

(d) Comminuted fractures

Zingg et al in 1992[4] gave a new classification-

Type A: Incomplete zygomatic fractures- Low energy injuries frequently cause isolated fractures of only one zygomatic pillar.

A1: Isolated zygomatic arch fracture.

A2: Lateral orbital wall fracture.

A3: Infraorbital rim fracture.

Displacement does not occur because remaining pillars are intact.

Type B: Complete monofragment zygomatic fracture. All four pillars of malar bone are fractured and displacement may occur.

Type C: Multifragment zygomatic fractures.

5.4. *Radiology*

John E.Bowerman(1969)[31] advocated PA view with 20^0-25^0 tilt. This throws the petrous bones clear of the orbits.

Bruno W. Kwapis (1969)[14] used PA oblique,submental and PA views.

Rod J.Rohrrich et al (1992)[32] in their study found submentovertex, water's, Caldwell and lateral views are required with Caldwell to be most accurate.

S.N.Rogers et al (1995)[33] are of view of using single occipitomental view either standard or 30^o.

Russel P.Spinazze et al (1996)[34] used water's.submentovertex and caldwell's view and CT scans.

Antheny Pogrel et al (2000[35] consider single 30o occipitomental view supplemented by CT

Dan De Angelis et al (2001)[28] have put stress on CT examination.

E.Bradley Strong et al (2002)[29] used plain films like submentovertex, which was considered best view for zygomatic arches, townes, AP, Water's view and CT was considered a necessity for accurate diagnosis and for treatment plan.

5.5. *Clinical Signs and Symptoms*

D.P.Von Arx and M.Gilhooly (1983)[36] have reported a case which presented intermittent periorbital swelling, diagnosed as emphysema, seven years after he suffered the trauma

K.de Man et al (1991)[12] have reported influence of age on management of blow out fractures of orbital floor. According to them limited eye movement, positive forced duction test and blow out fracture on CT should be operated as soon as possible.

M.R.cope and K.F.Moos (1991)[37] examined 45 children with blow out fracture and found diplopia was more persistent in children aged 0-9 years.

Peter Jungell and Christian lindqvist (1987)[25] evaluated effects of ZMC fracture and various treatment modalities on paresthesia of infraorbital nerve. Out of 50 operated cases 42% had some degree of paresthesia. No significant disturbance in outcome was found between method of reduction. In 10 patients transosseous wiring was used at infraorbital rim had persistent hypoesthesia.

In study by N.Zahariades et al (1990)[38] 52 patients with ZMC fracture with infraorbital nerve involvement were evaluated. Those with minor or no displacement showed complete recovery. Early treatment was associated with better results. Results appeared to be better if lateral orbital approach was used.

J.P.M.Vriens et al (1995)[39] evaluated 50 patients with unilateral ZMC fracture for morbidity of infraorbital nerve. Highest incidence of neurosensory deficit occurred in undistracted FZ suture. They recommended miniplate osteosynthesis as opposed to wire fixation in unstable ZMC fractures.

In another study by same authors[40] studied effects of various treatment modalities on infraorbital nerve function.According to them, sensory disturbance was most pronounced and severe in patients who had closed reduction and no fixation and least in patients who had open reduction with mini plate fixation.

Stefan Schultze-Mosgau et al(1999)[3] analysed post traumatic and post treatment sensory disturbance of inferior alveolar and infraorbital nerves following mandibular and mid face fracture. They found post traumatic disturbance in 65% of mid face fractures and post surgical disturbance in 15% of cases.

5.5.1. Approaches to ZMC

L.C.Manganello-Souza et al (1997)[41] used transconjuctival approach to zygomatic and orbital floor fractures in 40 patients.

Chung Hoon Lee et al (1996)[42] repaired fractured zygoma using endoscopic assistance in cadavers which was later used in patients successfully.

5.6. Methods of Reduction

Kruger (1959)[43] and vero (1968)[5] recommended elevation ZMC intra-orally through buccal sulcus and fixation was done by pins.

JFC Schentler (1990)[44] reduced ZMC fractures under local anesthesia intraorally. No fixation was done.

Poswillo (1976)[45] described exact location of stab incision for percutaneous approach.

According to Reny and Stricker (1969)[5] there is danger of instrument into infraorbital foramen, if instrument is not kept close to bone in percutaneous approach.

De Man (1988[12] repositioned fractured zygoma using percutaneous bone hook

Edward Ellis III et al (1996)[13] used carrol-gizard screw for reduction of ZMC fractures.

Enislidis et al (1998[8] used volkman repositioning hook to reduce the ZMC fractures

Nicholas –Zachariades et al (1998)[38] used Roger-Anderson pins in 180 cases.

5.7. Indirect Fixation

Brown et al (1942-52), Fordyce (1960), Dingman and Natvig (1964), Zaydon and Brown (1964) used internal pin fixation for treating facial fractures.

Steidler et al (1980[30] used cranio-maxillary and internal pin fixation in 80 2% of their cases.

Brownand Barnard (1983)[11] recommended use of transnasal wiring using K-wire.

P.M.Finley et al (1984)[9] used antral packs and external pins in the treatment of unstable ZMC fractures.

Jones and Speculand (1986)[46] used splint for unstable zygomatic arch fractures.

Direct external pin fixation of maxillary fractures were done using premaxillary pins by T.R.Flood (1987)[47]

5.8. Direct Fixation

Bruno W.Kwapis (1980)[14] used three surgical sites for fixation: Frontozygomatic suture, zygomaticomaxillary suture and infraorbital rim.

Richard M.Carr et al (1997)[15] treated 36 patients with two point fixation at FZ suture and infraorbital rim. 2 patients had miniplates at zygomatic buttress and 6 had at FZ suture.

Nicholas Zachariades et al (1998)[38] used transosseous wiring in 89 out of 1150 patients.

Leon A.Assael et al (1994)[10] used autogenous bone graft to reconstruct the orbital floor and used lag screw for fixation.

Roberts (1964) introduced 3/4th inch long mandibular bone plates.

Special miniplates were described by Michelet et al (1973).

K De Man (1988)[12] did fixation using miniplates at FZ suture in 72 patients and used wiring in 40 patients.

Gregory C.Rinehart et al (1989)[44] compared stability of malar fractures after application of 3,2 and 1 miniplates.3 plates provided firm fixation without movement,2 and 1 provided firm fixation with slight movement whearas transosseous wiring showed fixation failure.

P.Reher et al (1994)[17] conducted an anatomical study of miniplates at FZ suture. Risk of penetrating anterior cranial fossa, orbit and temporal fossa was measured while drilling the holes. At points upto 15 mm above the suture, risk of penetrating the orbit was high. Risk of penetrating anterior cranial fossa begins when drilling at 10 mm from FZ suture. Taking this into consideration, they had set a limit for the length of screws to be used for fixing plates at FZ suture. At point 15 mm above FZ suture, 6 mm screw; upto 10 mm, 5 mm screw should be used. At point upto 10 mm below FZ suture, 7mm long screw; upto 15 mm below FZ suture, 5mm long screw should be used.

Mc.Vicar et al (1995)[19] used self reinforced polyglycolic acid membrane in reconstruction of orbital floor in 12 patients.

Daniel D O'Hara et al (1996)[48] studied role of microfixation in malar fractures.

Edward Ellis III et al (1996)[13] used one point fixation in 31.2%, two or three point fixation in 27.1% and four point fixation in 10.4% of their patients. Bone plates were used in all cases except for two cases in which wires were used. Bone plates were mini dynamic plates, microplates and miniplates.

Nicholas Zachariades et al (1998)[38] studied 1277 patients of ZMC fractures. Surgery was performed in 1150 cases and plates were used in 322 patients.

J.Schostingluis et al (1999)[18] used microplates and miniplates in 44 patients with maxillofacial trauma. After reduction 1.0mm and 1.5 mm titanium microsystem was used for fixation.

Zachary Segal et al (2002)[49] in his article stated that post operative stability of reduced zygoma is better after 3 point fixation however at times 2 point fixation is adequate.

5.9. Complications

Zachary Segal (2002)[49] considered, failure to reduce fractures properly and malunited fractures to be most common cause of enopthlmos.

Zingg et al (1991)[7] reported 3-4% of incidence of enopthalmos.

In a study by steidler NE et al diplopia was the most common orbital complication; occurring in 8% of their patients.

In the series by Ellis et al diplopia was accounted for 12% of patients.

Barday reported 8.4% incidence of diplopia; 60% were transitory.

Ord (1981),[50] stated that postoperative retrobulbar hemorrage and blindness was present in 0.3% of patients.

Rowe and Killey (1970)[2] reported two cases, Blindness associated with reduction of zygomatic complex fractures has also been recorded by Gordon and Macrae (1950), Penn and Epstien(1957), Magoon (1963), Varley et al(1968). Nicholson and Ggak (1971) and Long Ellis(1971).[2]

Anderson et al (1982) recommend megadose of steroids.[2]

Approach to intra conal space has been advised by Moriarty (1982).[2]

Varely et al used combined medical and surgical procedure(1986).[51]

Paracentesis of the anterior chamber is also recommended.[2]

Wood (1989) studied a case of delayed retrobulbar hemorrhage occurring about 72 hours after initial injury.[2]

EWB Varley et al(1968)[51] reported a case in which there was acute retinal aterial occlusion following rduction of a fractured zygoma. Immediate decompression of the orbit via maxillary antrum and intra arterial infusion of central retinal artery with papaverine was done successfully.

GD Wood (1968)[52] presented two cases of blindness following fracture of zygomatic bone.

Ira R Lederman (1981)[53] has commented on loss of vision following surgical treatment of orbital froor fracture.

RA Ord et al (1986)[50] studied a case with bilateral retrobulbar hemorrhage following trauma.

Mario G Gonzaly (1990)[54] reported a case of optic nerve blindness following malar fracture.

Superior orbital fissure syndrome was described by Hirschfeld by about 1858 and later described by Badal and Fromaget in 1894. Term, superior orbital fissure syndrome, was given by Rochon Duvigneaud in 1896.[2]

Bowerman et al(1986) has reported 2 cases of superior orbital fissure syndrome.

Hollows et al (1999)[55] has commented about a case of life threatening hemorrhage from nose after elevation of fractured zygoma which was managed by external carotid ligation.

De Man and Bax found 80% of their patient had dysestesia. Norgard noted sensory disturbance in 96% of their patient. Jungell and Lindquist found 81%patient had paraesthesia of infraorbital nerve. Majority of patients recovered but 42% of their patients had permanent change.[5]

Ptients treated with rigid fixation had fewer sensory deficit. Champy and associates, de Man and Bax, Zingg and Coworkers and associated state that reduction and fixation are important factor in the recovery from sensory disturbance.[5]

N E Steidler et al (1980)[30] found persistent infraorbital sensory defects occurred in 22% of patients.

Peter Jungell (1987)[25] studied 68 patients of ZMC fracture out of which 56 patients had sensory disturbance of infra orbital rim. No significant difference was there when different types of indirect reduction methods were used.

N Zachariades et al (1990)[56] found when there was minimal displacement of ZMC, complete recovery of nerve function. Early treatment gave better results.

JPM vriens et al (1995)[39] found greatest sensory disturbance occurred with undistracted frontozygomatic suture. Open reduction offers better results and miniplates were recommended for recovery of sensory function of infraorbital nerve JPM Vries et al (1998)[40] in another study recommended open reduction and miniplate fixation rather than close reduction and wire osteosynthesis for return of sensation of infraorbital nerve.

Dec. To Zingg (1991,1992)[4]found persistent sensory dysfunction ranges from 22-65% for closed reduction.[29]

Zing(1991)[7] reported 7% incidence of maxillary sinus a pacification after ZMC fracture only 1.6% patients were symptomatic.[29]

Ostrofsky and Lownie showed bony ankylosis in a patient who didn't seek treatment for ZMC fracture.[5]

Findlay found primarily fibrocartilagenous fusion[5]

J Schortinghuis et al (1999)[18] used two types of screw 1mm and 1.5 mm and found preoperative complications to be 1.2% for 1mm screw and included screw breakage, stripping of threads, injury to tooth root. Post operative complication was 0.8%. In 1.5 mm screw system no complication was found. In a study of 55 patients who had fixation devices removed, orringer et al found palpable plates and screws to be most common reason (35%) followed by pain, infection or loosening (abount 25%)

Heckler and co-workers reported 6% incidence; Manson, Dyfresne and colleagues noted 10% incidence Lacy; pospisil found 18% incidence of ectroption in their patients. Bahr and co-workers found it to be 18.8% in their patients. They all used subciliary incision with skin muscle dissection.[5]

Appling (1993) sited 28% incidence with subciliary approach and 3% incidence with trans conjuntival approach.

According to Bradly strong (2002)[29] ectropion results from injury to inner lamella and occurs most commonly with trans conjunctival approach.

A study by Z achariades et al (1998)[38] found patients treated with rigid internal fixation of ZMC with trans osseous wiring resulted in a greater rate of infection than bone plate. 4.5% of their patients suffered from infection.

J.Cornal (1983)[57] reported a case who presented with lower lid abscess dehiscence and discharge from temporal wound and prolapsed of necrotic temporal fascia following ZMC fracture reduction.

Atul Parashar, Ramwsh K Sharma, Surinder Makker (2007) Concluded that vertiacal dystopia, enopthalmos, malar projection and malar height shows statistically significant enhancement in outcome attesting to better inherent stability of three point fixation. Subjective assessment of aesthetic sequelae shows better results with three point fixation though they do not acieve statistical significance in the present study, this could be because of the sample size of this study. They recommended that three point fixation with mini plates for management of displaced zygomatic fracture.

Ashish Chakrranarayan, Thapliyal GK, Sinha R, et al(2009) were conducted prospective study over 30 patients with zygomatic complex fracture which were managed by open reduction and internal fixation using titanium mini bone plate and screws at the frontozygomatic and zygomatic buttress region and they were concuded that stable fixation and immobilization of isolated zygomatic complex can be achieved with two point fixation using titanium mini plate and screws at frontozygomatic and zygomatic buttress region of zygomatic complex fracture. Post operative complications like scarring, ectopion and neurological deficit can be avoided by not using infraorbital rim as the third point of fixation.

Palik Kwon Lee, Jung Ho Lee, Yoon Soek et al presented their xperiences with a single transconjunctival incision and two point (inferior orbital rim and frontozygomatic suture) fixation in 53 patients with zygomatic complex fracture which were not comminuted. All patients had transconjunctival approaches with lateral canthal extensions, and 6 out of 53 patients had an additional small (about less than 2 cm) gingivobuccal incision to achieve an accurate reduction. There were 3 minor complications, and the overall esthetics and functional results were satisfactory with a long term follow-up. Our method has the following advantages in the reduction of zygomatic complex fracture; it leaves only an inconspicuous lateral canthal scar. In addition,it provides excellent simultaneous visualization of the inferior orbital rim and frontozygomatic suture area. Hence, two point fixation through a single incision can be performed with a satisfactory stability.

Seon Tae Kim, Doo Hyun Go, Joo Hyum Jung et al (2011) were conducted retroactive study on 30 patients which were devided into 2 groups. Group 1 was composed of 14 patients (1 with bilateral tripod fracture and 13 with unilateral tripod fracture) who underwent open reduction with 1-point (ZM area) internal fixation through a buccogingival incision, and group 2 was composed of 16 patients who underwent open reduction with 2-point (ZM and FZ areas) internal fixation through buccogingival lateral eyebrow incisions. Of 16 patients in group 2, 10 (63) complained of unsightly scars in the lateral eyebrow incision site whereas none of the patients in group 1 complained of external scarring. None of the patients complained of bony movement and pain in the FZ area in either group. In groupm 2, 4 of 16 patients (25%) complained of palpability in the FZ area, whereas none in group 1 complained of palpability. Two patients underwent surgery for plate removal in group 2. None of the patients in group 1 complained of any cosmetic problems, with no fixation in the FZ area. And they concluded that one point fixation in the ZM area in zygomatic tripod fractures can avoid unsightly scars and give high satisfaction with surgical outcomes in selected patients with tripod fractures

6. Conflicts of Interest

All contributing authors declare no conflicts of interest.

7. Source of Funding

None.

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Cite this article: Sajjan A, Shahapur R, Chincholi R, Patil A. Fixation of Zygomatic fractures using Mini-plates: An overview. *IP Indian J Anat Surg Head, Neck Brain* 2021;7(1):1-11.