Evaluation of intraoral Two-point fixation in Monobloc Zygomatic Complex Fractures

Original Article

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ABSTRACT

Backgroud: esthetics could be as important as function in many patients suffering from zygomatic complex fractures. We aimed to evaluate a modified intraoral approach for treating isolated monobloc zygomatic complex fractures with two-point fixation at the zygomaticomaxillary buttress and infraorbital rim.

Method: This is a single armed (non-controlled) clinical trial carried on twelve patients who were assigned to our study (n=12) with unilateral isolated zygomatic complex fracture. Treatment was evaluated clinically and radiographically using three-dimensional computed tomography, infraorbital nerve function assessment was done through mechanical, thermal and pain thresholds detection. Evaluation was done preoperatively, two-days, one week, one-month, two-months and three-months postoperatively.

Results: Study showed male predominance over females (12:0). The aged ranged from 1852- with a mean of 33. 11 out of the twelve patients had the left side affected. Road traffic accidents was the major cause. Infraorbital nerve function was completely restored within two-months postoperatively. Infraorbital nerve paresthesia completely disappeared within two-months in 11 of our patients, one case reported persistent transient infraorbital nerve paresthesia.

Conclusion: the modified intraoral approach although technique sensitive, provides excellent esthetic and functional results. Allowing the use of two-point fixation through a single incision avoiding any scars or postoperative complications to the eye from using the extraoral approaches.

Key Words: zygomatic complex fractures , approaches to the infraorbital rim , modified keen's approach , two-point fixation.

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INTRODUCTION

The zygomatic bone is predisposed to a substantial number of craniofacial injuries, owing to its prominence and position. It is the second most common mid-facial bone fractured following the nasal bone and would represent 13% of the overall craniofacial fractures[1].

According to the severity of the injury and degree of displacement, the management may vary between no surgical intervention, closed or open reduction with internal fixation (ORIF) [2] .

ORIF using miniplates has widely been used for treating zygomatic complex (ZC) fractures,[3] there has been a controversy on the number of points of fixation, areas of fixation and the surgical approach to achieve the best functional and esthetic outcome [4] .

Three-point fixation ensures the maximum stability, although it involves more incisions, increasing the chances for post-surgical scars, increased surgical cost from the increased hardware and longer operative time [1].

In vitro [5] and in vivo [6] studies had shown outstanding results for the use of two-point fixation at the zygomaticomaxillary buttress (ZMB) and infraorbital rim (IOR) in terms of stability which was comparable to the three-point fixation.

In terms of esthetics, the use of the zygomaticofrontal suture (ZF) through the lateral eyebrow approach would result in postoperative scars [7], gaining access to the IOR through the subcilliary, subtarsal, infraorbital and transconjunctival with lateral canthotomy approaches all combined carry the risks for the eyelid including ectropion, entropion, in addition to postoperative scars.

Access to the IOR and ZMB through a single intraoral incision was possible, [8] and since esthetics is usually a major concern for patients, [6] we aimed in our study to evaluate both clinically and radiographically, the efficacy of two-point fixation in monobloc ZC fracture via the intraoral approach.

METHODS

A total of 12 patients were included in this study who

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sustained monobloc ZC fracture. Patients were recruited from the outpatient clinic of Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Tanta University.

Inclusion criteria included unilateral ZC fractures, non-comminuted displaced monobloc zygomatic complex fractures and no history of undergoing any previous mid-face surgery.

While exclusion criteria included Fractures that require orbital floor reconstruction, infraorbital nerve sensory disturbances on the non-affected contralateral side (for comparison purpose), an ASA (American Society of Anesthesiologists) score greater than 2, any relevant craniofacial anomaly previous skeletal or soft tissue craniofacial injuries. All patients were males, the age was 18 to 52, 11 patients had left side ZC fracture while one patient had right ZC fracture.

Clinical examination was performed preoperatively and compared with the postoperative results at one-week, one, two, three and six-months follow-ups. Extraoral parameters measured were skin lacerations, periorbital edema, periorbital ecchymosis, subconjunctival hemorrhage, pain at injury site, enophthalmos, epistaxis, flattening of the malar prominence, diplopia and eye movement, infraorbital nerve paresthesia, step deformities and crepitations.

Intraoral parameters included maximum mouth opening, dental occlusion, ecchymosis and lacerations. Infraorbital nerve was checked for paresthesia and function. Function assessment was divided into mechanical, thermal and pain threshold detection, a method suggested by Das AK et al [9]

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A) Mechanical threshold detection (A-beta fibers):

70- nylon monofilament were cut into three lengths of 3cm, 5cm and 7cm, held at one end, other end being free for purpose of testing. Threads were held in a perpendicular fashion applying enough force to induce slight bending of the filament with the patient’s eye closed indicating the site with the index finger with the eyes closed as well as subjectively asserting ‘yes’ or ‘no’. More than two positive responses were taken as normal tactile sensory function.

B) Thermal threshold detection (A-delta & C-fibers):

A hot water bath was used to achieve study temperatures of 32°C, 35°C and 37°C and room temperature. Stainless steel tubes with a temperature indicator were used to detect the thermal thresholds. Sites were stimulated in the test area bilaterally. The responses were taken as ‘yes’ and ‘no’. More than two positive responses were taken as positive sensation.

C) Pain threshold detection (A-delta & C-fibers):

Pain threshold detected using a 27-gauge, one inch length needle. Visual Analog Scale (VAS) calibrated 010-. The needle was pushed against the patient’s skin until it is slightly bent with the patient's eye closed. Any two common numerical findings to be recorded as a reaction to pin prick.

Radiographic

Radiographic CT scans with 3D reconstruction was done pre, immediate and six months postoperative for evaluation.

Surgical Technique

All procedures performed under general anesthesia intranasal intubation. According to Carvalho et al.,[8] the modified Keen’s approach was used. After the identification of Stensen’s duct, an incision was made horizontally in the buccal sulcus through the maxillary vestibular mucoperiosteum approximately 35-mm above the mucogingival junction, extending from the first permanent molar extending to reach the lateral incisor.

Incision was carried down through the mucosa, submucosa, underlying facial muscles and periosteum onto the bare bony surface taking care of the infraorbital nerve. A full thickness mucoperiosteal flap was raised using a Freer periosteal elevator exposing the zygomatic process of the maxilla to gain access to the fracture sites. Dissection was kept subperiosteal to avoid buccal fat pad herniation.

Dissection was extended posteriorly behind the ZMB into the region of the maxillary tuberosity. The infraorbital nerve was protected and dissected to tunnelize the IOR approach above the infraorbital foramen.

Reduction: Carried out using zygomatic hook or elevators. ZC reduced to its original position, was visually checked for accuracy of reduction and decompression of the infraorbital nerve. Fixation: Miniplates were bent and adapted precisely in all planes to achieve a passive bone-plate fixation.

In all cases, fixation was achieved using titanium miniplates with space size of 2 mm with at least 4 holes, 2 on each side, the insertion of the miniplate was as high as possible accesses a better quantity and quality of bone. Self-drilling mini screws,

2 mm in diameter and 5 -7 mm in length were used.

(Figure 1 and 3) Miniplates were checked for stability and position accuracy, then sutured using 4.0 vicryl.

Postoperative medications were prescribed according to our hospital regimen and patient instructions were given.

RESULTS

This study was conducted on 12 adult patients with monobloc ZC fracture (11 patients on the left side 91.7% and 1 patient on the right side 8.3%). Patient's age ranged from 18 to 52 with a mean of 33.08 and a standard deviation (SD) ±9.43, all twelve patients were males. The time lapse between the time of injury and the surgical procedure presented with a mean of 9.75 days and ranging from 6 -14 days.

Periorbital edema: Two days postoperative, scores ranged (2 - 4) with a mean of 3.5. The edema was decreased one week postoperatively in all patients giving a range (0 - 3) and a mean of 1.7. Periorbital ecchymosis: Immediately postoperative, the periorbital ecchymosis ranged (2 - 4) with a mean of 3.5. Ecchymosis decreased in all patients at one-week postoperatively ranging from (0 - 3) with a mean of 1.8. By one-month complete healing occurred for both signs. (Figure 4 A,4 B and 4C)

Subconjunctival hemorrhage: Six patients presented with subconjunctival hemorrhage preoperatively which subsided one week postoperatively. Pain at surgical site: pain completely subsided by one month in all patients.

Infraorbital nerve paresthesia: all patients reported the presence of paresthesia preoperatively which was still present at the one-week postoperative follow-up, two patients felt an increase in paresthesia post-surgery. All patients reported a decrease in the severity of the paresthesia after one-month. One patient reached NO at one-month postoperative, ten patients reached NO at two-months. No diplopia, enophthalmos or infection was present in any of the patients.

All patients showed flattening of the malar prominence at the affected side preoperatively, at two days postoperative the vision was obscured by edema which was improved at the one-week postoperative follow-up in all patients. (Figure 5A, b)

All patients presented with a limitation in the mouth opening preoperatively, ranged from 2.8 to 3.7cm with a mean of 3.28. The maximum range of mouth opening was reached by one-month postoperatively in all patients, ranging from 3.4 to 4.3cm, with a mean of 3.88.

Infraorbital nerve function assessment

A) Mechanical Threshold

Preoperatively, all patients showed no response to the tests in addition to one week postoperatively where the infraorbital nerve paresthesia was still persistent. comparison showed no statistical significance (*P*-value=1).

At one-month postoperative, there was improvement in infraorbital functions as the tests showed a positive response (YES) in all patients using the 3cm nylon filament.

The 5cm and 7cm test showed variances in response, where at 5cm 66.7% responded YES while 33.3% showed NO response. At 7cm 25% responded YES while 75% responded NO.

By comparing this with the preoperative results, there was high statistical significance (*P*-value=0.000**) at the 3cm and 5cm tests, and (*P*-value=0.001*) at the 7cm test. Results coincided with the decrease in the severity of the infraorbital nerve paresthesia.

At the two and three-months postoperative follow-up, all patients responded YES to all lengths used in the mechanical threshold test, during the same period where infraorbital nerve paresthesia completely subsided in all patients except one patient (yet reported a decrease in severity).

By comparing the results at the two and three-months follow-up with the preoperative results, there was a high statistical significance (*P*-value=0.000**) for all the lengths used (3, 5 and 7cm). While compared to the one-month follow-up the results varied. The 3cm test was non-significant (*P*-value=1), at the 5cm test the results were non-significant (*P*-value=0.064) while at the 7cm test the results were statistically significant (*P*-value=0.028*).

B) Thermal threshold

Preoperatively, all patients showed a negative sensation response to the thermal threshold test at all temperatures (32□, 35□, 37□ and room temperature) in addition to one week postoperatively, there was no statistical significance (*P*-value=1).

At the one, two and three-months follow-up visits, all patients responded positively giving a YES result (100%) to the thermal threshold test at all the temperatures, which coincided with the decrease and resolution of the infraorbital nerve paresthesia. By comparing the test results of the one, two and three months with the preoperative results, a high statistical significance was present (*P*-value=0.000**) in all the temperatures used.

C) Pain Threshold:

Patients did not show any response to the infraorbital nerve pain threshold tests preoperatively on the day of admission and one week postoperatively giving a score 0 VAS. The results showed no statistical significance (*P*-value=1). For all patients, positive pain sensation started at one month postoperatively and a gradual increase was noted up to 3 months postoperatively. At one-month the scores ranged from 2 to 7 with a mean of 4.67, at two-months the scores ranged from 6 to 8 with a mean of 7.25.

The statistical results from both periods were highly significant (*P*-value=0.002*) compared to the preoperative and one-week postoperative results. At three-months all patients gave a score 10 VAS except one patient who gave a score 9 with a mean of 9.92.

The statistical results were highly significant compared to the previous follow-up periods. (*P*-value=0.001*) to the preoperative and one-week postoperative follow-ups, (*P*-value=0.002*) to the one and two-months follow-up periods. The infraorbital nerve function assessment showed no statistical significance between the three and six-months follow-up results.

Radiographic results

The height and projection of the ZC [6] were measured from 3D CT radiographs taken from all subjects imme diately postoperative and compared with measurements taken after six months post operatively.
(Figure 6A, 6B and 6C).

Height of the ZC

A statistical analysis of the calculated VD ratios between the affected and non-affected sides showed a mean of 0.97 and SD ±0.03 immediately postoperative, and a mean of 0.96 and SD ±0.02 six months postoperative. There was no statistically significant difference between the immediate and six months postoperative measures (*P*-value=0.347) (Figure 7A,B).

Projection of the ZC

A statistical analysis of the calculated HD ratios between the affected and non-affected sides showed a mean of 0.96 and SD ±0.07 immediately postoperative, and a mean of 0.94 and SD ±0.06 at six-months postoperative. There was no statistically significant difference between the immediate and six months postoperative measures (*P*-value=0.46) (Figure 8A, B).

Figure 1 : Showing the intraoral approach exposing the ZMB and IOR. Notice the compressed infraorbital nerve with the fracture line

Figure 2 : Showing the second miniplate used at the IOR Straight plate 6-hole without stem was curved and cut into 5 holes for adaptation.

Figure 3 : After wound closure.

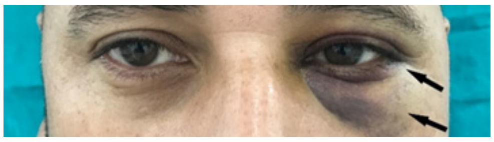

Figure 4A: Immediate postoperative photograph (two-days post-surgery) of case No.7 showing grade 2 periorbital edema and grade 4 periorbital ecchymosis (black arrows).

Figure 4B : One-week postoperative photograph of case No.7 showing the minimal grade 1 periorbital edema and grade 3 periorbital ecchymosis extending past the pupil (black arrows).

Figure 5A: Case No.7 photographed behind the patient's head preoperatively showing the restoration of the malar prominence of the left ZC compared to the right unaffected side, flattening of the left malar prominence was obscured by edema.

Figure 5B: Six-months postoperative showing complete resolution of edema and restoration of the malar prominence.

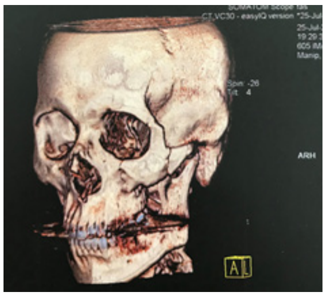

Figure 6A : Preoperative coronal view 3D CT showing fracture of the left ZC at the ZMB and IOR.

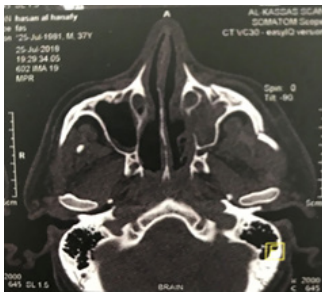

Figure 6B : Preoperative axial view CT showing lateral rotation of the left ZC.

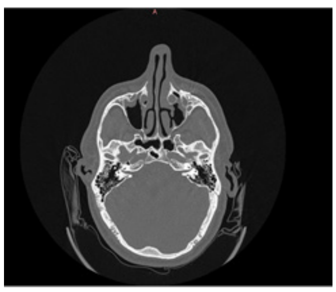

Figure 6C : Postoperative axial view CT showing restoration of the ZC.

Height of the ZC

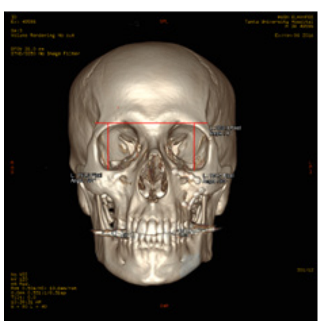

Figure 7A : Six-months postoperative coronal view 3D CT for case No.7 measuring the VD ratio.

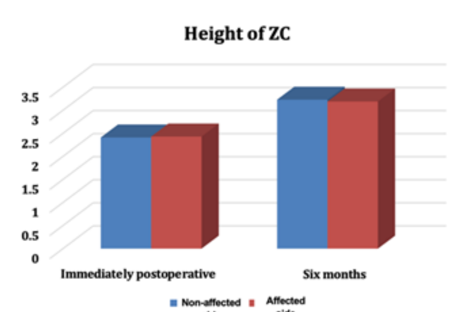

Figure 7B : Bar graph showing the height of the zygomatic complex at the follow-up periods (immediately & six months postoperatively).

Figure 8A : Six-months postoperative axial view 3D CT for case No.7 measuring the HD ratio.

Projection of ZC

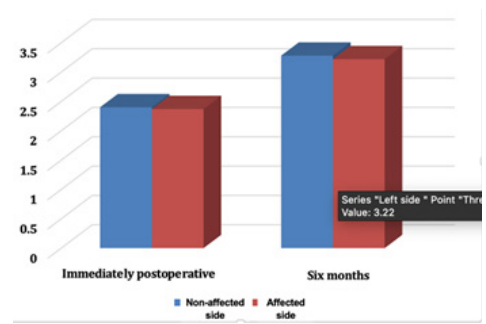

Figure 8B : Bar graph showing the projection of the zygomatic complex at the follow-up periods (immediately & six months postoperatively).

DISCUSSION

Zygomatic complex fractures differ in their degree and severity, different treatment approaches have been implemented [4] where according to Lee et al., [10] the precise physical stability of the zygoma with respect to the number and location of the miniplates applied is unknown as in each case it would depend on the fracture anatomy, extent and the degree of displacement.

Davidson et al., [5] mentioned the efficacy of two-point fixation at the ZMB and IOR using miniplates to provide a stable fixation. Rinehart et al., [11] stated that two-point fixation across the ZF and ZMB was sufficient to withstand static and oscillating loading similar to physiologic masticatory forces. Despite stating that three-point fixation provides maximum stability, both studies supported the use of two-point fixation to provide comparable stability in simple monobloc ZC fractures.

Kim et al., [7] highlighted the low satisfaction rates shown from the patients treated with two fixation points at the ZF and ZMB due to the unsightly scars resulted from the lateral eyebrow incision used.

The use of the IOR through transcutaneous incisions (including the subtarsal, subciliary, infraorbital) show considerable postoperative drawbacks including scleral show and ectropion that could persist for years without resolution according to Bähr et al [12].

The use of the transconjunctival approach offers the advantage of less complications rate, yet the limited access would still require a lateral canthotomy for adequate access and thus could yet leave the patients with unwanted scars. [13] Accordingly evaluated the use of the intraoral technique introduced by Carvalho et al., [8] using a modified Keen's approach exposing the ZMB and the IOR, allowing the use of the two fixation points.

The most common cause for ZC fracture in our study was road traffic accidents where all 12 patients were males. In Tanta, males often drive more and are exposed to higher risk from different jobs with unsafe machines with low safety measures, which was the case in 92% of the patients in our study. Furthermore, 83% of the patients were younger than 40 as younger ages are offered more driving and higher risk jobs than the older ages.

In our work, the use of the intraoral approach easily exposed the zygomaticomaxillary buttress and despite providing direct visualization as claimed earlier [8], yet limited access to the IOR was encountered.

Further dissection of the infraorbital nerve and retraction of the surrounding tissues were required. From our experience, within the 2-weeks the later treatment allowed more soft tissue recovery, which in turn allowed better tissue retraction. Accessibility to the IOR for plate fixation using drill was challenging owing to the position of the infraorbital nerve. To avoid any possible nerve injury a nerve hook was used for retraction and mini self-drilling screws were used for plate fixation which gave the advantage mentioned by Bolm et al., [11] in offering an alternative in areas where drilling was not possible.

Extensive manipulation showed an evident immediate postoperative response in the periorbital edema and ecchymosis state with both giving a high mean of score 3.5. One patient (8.3%) showed complete improvement after one-week while the remaining eleven patients (91.7%) experienced complete improvement by one-month postoperatively. In our study all patients experienced varying degree of paresthesia of the infraorbital nerve preoperatively, with the infraorbital nerve present in the line of fracture. According to Beigi et al., [14] the presence of persistent paresthesia is likely caused by compression of the infraorbital nerve in a collapsed canal, sharp bony fragments causing nerve irritation (which was observed in our study) or adhesional bands.

Good visibility of the infraorbital nerve for decompression and removal of any sharp bony spicules, enabled the complete healing of the nerve. Only one patient (8.3%) reported faint sensations of paresthesia at the three months postoperative follow-up. Vriens, Moos [15] outlined the presence of neurosensory deficits following orbitozygomatic injuries varying from 10-50% on the long-term according to previous studies.

Das et al., [9] discussed the importance of avoiding stretching the infraorbital nerve during the IOR fixation to minimize nerve injury. In our work the limited access required nerve retraction for plate fixation at the IOR. As a result, infraorbital nerve paresthesia was highly evident immediately postoperative in all cases for a temporary period as all patients reported the significant decrease in paresthesia within the first month postoperatively which agreed with Carvalho et al., [8] in their study. Additionally, the high postoperative edema was a result of high manipulation and wide retraction area at the surgical site using the modified intraoral approach.

Infraorbital nerve took about one month postoperatively to gradually improve in all patients taking about two months for complete restoration of mechanical sensations. The thermal threshold test showed restoration of thermal sensations of the infraorbital nerve took one month. During the first month despite the positive readings, sensations were faint or weaker compared to the normal contralateral side.

In the pain threshold test, positive pain sensation started at one month and a gradual increase was noted up to 3 months where total restoration of pain sensation was felt in all our study group except in one patient who gave a score 9. The infraorbital nerve tests showed outstanding results agreeing with Kotrashetti et al., [16] about the necessity of decompression of the infraorbital nerve for healing. Additionally, our results correlated with Das et al.,[9] study which reported a 94% success rate in neurosensory function improvement in patients receiving surgical treatment for ZC fractures.

The post-surgical stability of the ZC was evaluated through 3D CT images on quantitative basis a method used by Taehee Jo, Junhyung Kim [6]. According to our results, there was no statistical significance observed between the sound and affected sides over the postoperative six months period, indicating the effectiveness of two-point fixation of the ZC at the ZMB and IOR. From our experience, reduction of the ZC and fixation was convenient in all cases where the ZF showed no comminutions and presented with minimal or no displacement.

In one subject the ZC was unstable at the ZF and stability post reduction was difficult to achieve, for which it was mandatory to place a fixation point at the ZF via the lateral eyebrow incision which disqualified the patient from our study.

CONCLUSION

The intraoral modified Keen's approach when applicable, would be an excellent choice in terms of the patient's benefit due to the excellent esthetic results and elimination of the postoperative complications risk faced when using the extraoral approaches.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

RECOMMENDATION

Further studies on larger number of patients for longer period of follow-ups are recommended.

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