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ORIGINAL ARTICLE

Comparison of Infra Orbital Nerve Outcome in Zygomaticomaxillary Complex Fractures Treated Surgically and Conservatively

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ABSTRACT

Introduction: Zygomaticomaxillary complex fractures are second most common facial injuries. These fracture are managed either by open reduction with rigid fixation or conservatively.

Objective: To compare infra orbital nerve outcome in zygomaticomaxillary complex fractures treated surgically and conservatively.

Methodology: The current randomized controlled trial study was carried out at Oral and Maxillofacial Surgery Department, Sandeman Provincial Hospital/Bolan Medical College Quetta from 23/04/2018 to 22/10/2018 after the synopsis approval. Total sample size calculated was 100. 50 patients in Group-A were treated by open reduction and internal fixation technique and 50 patients in Group-B were managed conservatively without any intervention. All the data was recorded in a specialized proforma for this study. Data analysis was done by SPSS.

Results: The overall mean age (SD) of the patient's was 36.2±7.1 years. Most of the patients (n=64, 64.0%) were 31-45 years old. The male patients in our study were 65 (65.0%) whereas female participants were 35 (35.0%). For detection of mechanical threshold, the patients proportion with sensations at 3cm filament length was significantly lower in patients who underwent surgical treatment (78.0% vs. 100.0%; p-value<0.001) as compared to the participants managed conservatively. It was also lower significantly at 5cm and 7cm for Group-A in comparison to Group-B (p-value≤0.05). For detection of heat threshold, the patients proportion with sensation at 32°C was no different between Group-A and Group-B (p-value=0.529). However, proportion of patients with sensations at 35oC (64.0% vs. 100.0%; p-value<0.001) and 37oc (90.0% vs. 100.0%; p-value=0.022) was lower significantly in surgically treated patients. Pain threshold detection was significantly lower in patients who underwent surgical treatment (1.26±0.44 vs. 1.58±0.49; p-value<0.001) in comparison to conservative treatment.

Conclusion: In patients with zygomaticomaxillary complex fractures, infra orbital nerve outcome was superior in patients managed conservatively than those treated with open reduction and internal fixation which advocates evading unnecessary intervention in such cases in future practice.

Keywords: Zygomaticomaxillary Complex Fractures, Conservative Treatment, Infra Orbital Nerve

INTRODUCTION

The major buttress of the facial skeleton is zygomatic bone [1]. The second commonest facial injuries are zygomaticomaxillary complex fractures. It is lying between the zygomatic process of frontal bone and maxilla. The most important contributor to the orbit is zygomatic bone and their role is important in protection of the eyes. The integrity of zygomatic bone is critical in maintenance of normal width of the face and cheek prominence however at the same time this bone more exposed to fracture due to this prominence and convexity [2]. The orbital floor is anteroposteriorly narrow and S-shaped. The infraorbital canal and groove move down the floor while conveying the infraorbital nerve. The anatomy corresponds to the clinical symptoms of facial numbness, dysesthesia or paresthesia following an orbital floor or fractures of zygomatic bone that afflict the ala of anterior teeth, cheek, nose and upper lip [3]. The common treatment modalities used for zygomaticomaxillary complex fracture are open reduction with rigid fixation [4], close reduction via Gilleis temporal approach or keen intraoral approach and conservatively as indicated. Assessment of infraorbital nerve sensory deficit is determined by subjective signs such as diminished sensation in the area innervated by infraorbital nerve called hypoesthesia, altered sensation as dysesthesia and loss of sensation as anesthesia. This sensory deficit can be measured by pain threshold, thermal threshold and mechanical threshold of affected area with control side [5]. Previous studies statistics shows outcome of infra orbital nerve assessed by mechanical, thermal and pain sensations. At the end of six month mechanical sensations were 100% in patients treated surgically which is significantly greater then compared to patients treated conservatively 50%. Thermal sensations were appreciated 80% treated surgically while 83.33% managed conservatively. Pain score on VAS was 1.2± 0.44 for patients treated surgically while 1.5±0.76 managed conservatively at the end of six month [5]. There is limited data available in national literature. The aim of this study is designed to compare two treatment modalities of zygomaticomaxillary complex fracture in relation to their effect on infra orbital nerve outcome and to determine which treatment modality has better clinical outcomes and less neurosensory complications. Therefore, this study will help to achieve the major goal of a more effective treatment method, which will ultimately help the affected individuals.

MATERIALS AND METHODS

The current randomized controlled trial study was carried out at Oral and Maxillofacial Surgery Department, Sandeman Provincial Hospital/Bolan Medical College Quetta from 23/04/2018 to 22/10/2018 after the synopsis approval. Total sample size calculated was 100. 50 patients in Group-A were treated by open reduction and internal fixation technique (100%) [5]. 50 patients in Group-B were managed conservatively without any intervention (80%) [5]. Anticipated population proportion 95%. Margin of error <5%.

Inclusion Criteria: All those patients coming to oral and maxillofacial surgery unit with history of unilateral zygomaticomaxillary complex fractures having sensory deficit of the area supplied by infra orbital nerve of not >6 weak duration were selected of either gender, cast and religion having age 18 years to 45 years.

Exclusion Criteria

1. Associated fractures of other bones like spinal or head injuries which might be life threatening and must be treated first. Time lapse for treatment of such fractures and fiber optic intubation that was not available in our setup excluded such patients from study objects.

2. Bilateral fracture of zygomaticomaxillary complex was not included in the study as one intact sensory side was required for comparison of results.
3. Patient with infected fracture site which might alter the healing process and pain sensation were not be included
4. Patient having allergies to metal or any foreign body were also excluded due to risk of life threatening allergic reactions.

Data Collection Procedure: Permission was taken from hospital ethical committee. Patients fulfilling the above inclusion criteria were selected from OPD. All the patients were divided into two groups, Group-A and Group-B by using lottery method. All the risks and potential benefits were explained to every patient before starting any procedure. Informed written consent was taken from patients. Thorough history and meticulous clinical examination on all patients presenting with trauma to middle third of face was performed but extensive manipulation of fracture segments was avoided so that degree of patient discomfort and nerve damage was minimized.

After recording the personal bio data, X-ray Water's view was advised to demonstrate the zygomaticomaxillary buttress and inferior orbital rim, X-ray Caldwell's posterior anterior view to see the zygomaticofrontal suture, to all subjects suspecting to have zygomaticomaxillary complex fracture. A definite diagnosis of zygomatic fracture with the aid of clinical and radiographic findings was established and recorded accordingly for each case in designed proforma.

Infraorbital nerve function was determined in term of thermal, mechanical and pain stimuli on day 0 and was compared postoperatively at the end of 3rd month recorded accordingly on designed proforma.

After thorough clinical and radiologic examination, patients diagnosed as zygomaticomaxillary complex fracture were divided in two groups

Group-A; open reduction technique with miniplate fixation was undertaken.

Group-B; conservative management without any intervention.

The sensory function of infraorbital nerve was tested as

Mechanical Sensations: It was carried out with the help of 7.0nylon of "3cm, 5cm, and 7cm" length, held with non-toothed forceps at one end and other end free for testing purpose. Stimulation of area bilaterally starting from 7cm length then 5cm and last with 3cm. Three perpendicular stimulations were applied to each site. The patient was instructed to subjectively indicate the spot with a yes or no response while pointing with their index finger and closing their eyes. At the completion of the third month, >2 positive responses were considered to be a normal tactile sensory response.

Thermal Sensations: It was tested by hot water bath held in equal volume at 32oc, 35oc, 37oc. Three sites were tested bilaterally starting from 37oc and the area to be left cool and relax before next test. Yes or no response was noted according to feeling of patient. Normal thermal sensation was considered if positive responses were >2 and were recorded at the end of 3rd month.

Pain Sensations: It was detected by using 32 gauge 1 inch long acupuncture needle and 100 mm "visual analogue scale calibrated 0-10" with "0 being no pain and 10" being agonizing pain. Needle was pushed against selected area of skin until it slightly bent. Any two common numerical results were noted as a pin prick response. All the readings were taken preoperatively day 0 and at the completion of 3rd months, for each group of patient and outcome were displayed as percentage of patient recovered with time.

Data analysis procedure: The data was entered and analyzed with the help of SPSS version 20.0. Quantitative variable presented as mean and standard deviation were age of patients, pain score and duration of fracture. Qualitative variables were gender, heat sensations and mechanical sensations and have been presented as frequency and percentage. Mean pain score has been compared in both study groups using independent sample t-test. P-value of 0.05 or less has been taken significant. Thermal and mechanical sensations at different temperature and length of nylon have been compared in both groups by using chi-square test. P-value of 0.05 or less has been taken significant. Through stratification, effect modifiers including age, gender, and fracture duration have been managed. Independent sample t-test and chi-square test have been used after stratification, with a p-value of 0.05 or less considered significant.

RESULTS

The overall mean age (SD) of the patient's was 36.2±7.1 years with 18 years as minimum age and 45 years as maximum age. Most of the patients (n=64, 64.0%) were 31-45 years old. The male patients in our study were 65 (65.0%) whereas female participants were 35 (35.0%). The fracture duration was ranged from 1 week to 6 weeks with mean duration of 3.1±1.4 weeks. (Table 1) The comparison of mean age, mean duration of fracture, distribution of various age, gender and duration of fracture is given in table 2. For detection of mechanical threshold, the patients proportion with sensations at 3cm filament length was significantly lower in patients who underwent surgical treatment (78.0% vs. 100.0%; p-value<0.001) as compared to the participants managed conservatively. It was also lower significantly at 5cm and 7cm for Group-A in comparison to Group-B (p-value≤0.05). (Table 3) Same significant difference was shown between the two groups as shown in Table 4 to 6. For detection of heat threshold, the patients proportion with sensation at 32°C was no different between Group-A and Group-B (p-value=0.529). However, proportion of patients with sensations at 35oC (64.0% vs. 100.0%; p-value<0.001) and 37oc (90.0% vs. 100.0%; p-value=0.022) was lower significantly in surgically treated patients. (Table 7) Similar difference was shown between the two groups on the basis ofn age, gender and fracture duration of the patients. (Table 8 and 9) Pain threshold detection (with acupuncture needle) was significantly lower in patients who underwent surgical treatment (1.26±0.44 vs. 1.58±0.49; p-value<0.001) in comparison to conservative treatment as shown in Table 11. Similar difference was shown between the two groups on the basis of age, gender and fracture duration of the patients. (Table 12)

Table 1: Baseline parameters of the participants

Parameter	Subcategory	Frequency (%)
Age	18-30 years	36 (36.0%)
	31-45 years	64 (64.0%)
Gender	Male	65 (65.0%)
	Female	35 (35.0%)
Duration of Fracture	1-3 weeks	61 (61.0%)
	3-6 weeks	39 (39.0%)

Table 2: Comparative baseline parameters of both the group

Characteristics	ORIF	Conservative	P value
Age	36.1±7.6	36.3±6.6	0.855
18-30 years	19 (38.0%)	17 (34.0%)	0.677
31-45 years	31 (62.0%)	33 (66.0%)	
Gender			
Male	33 (66.0%)	32 (64.0%)	0.834
Female	17 (34.0%)	18 (36.0%)	
Duration of Fracture (weeks)	3.1±1.4	3.2±1.4	0.777
1-3 weeks	31 (62.0%)	30 (60.0%)	0.838
3-6 weeks	19 (38.0%)	20 (40.0%)	

Table 3: Mechanical Sensations comparison between the two Groups

Mechanical Sensations	ORIF	Conservative	P-value
3cm			
Yes	39 (78.0%)	50 (100.0%)	<0.001*
No	11 (22.0%)	0 (0.0%)	
5cm			
Yes	10 (20.0%)	41 (82.0%)	<0.001*
No	40 (80.0%)	9 (18.0%)	
7cm			
Yes	0 (0.0%)	11 (22.0%)	<0.001*
No	50 (100.0%)	39 (78.0%)	

Table 4: Mechanical Sensations comparison of @ 3cm across various subgroups

	Mechanical Sensations 3cm		P-value
	ORIF	Conservative	
Age			
18-30 years	15/19 (78.9%)	17/17 (100.0%)	0.045*
31-45 years	24/31 (77.4%)	33/33 (100.0%)	0.004*
Gender			
Male	26/33 (78.8%)	32/32 (100.0%)	0.006*
Female	13/17 (76.5%)	18/18 (100.0%)	0.029*
Duration of Fracture (weeks)			
1-3 weeks	24/31 (77.4%)	30/30 (100.0%)	0.006*
3-6 weeks	15/19 (78.9%)	20/20 (100.0%)	0.030*

Table 5: Mechanical Sensations comparison of @ 5cm between the two groups

	Mechanical Sensations 5cm		P-value
	ORIF	Conservative	
Age			
18-30 years	4/19 (21.1%)	14/17 (82.4%)	<0.001*
31-45 years	6/31 (19.4%)	27/33 (81.8%)	<0.001*
Gender			
Male	6/33 (18.2%)	26/32 (81.3%)	<0.001*
Female	4/17 (23.5%)	15/18 (83.3%)	<0.001*
Duration of Fracture (weeks)			
1-3 weeks	6/31 (19.4%)	25/30 (83.3%)	<0.001*
3-6 weeks	4/19 (21.1%)	16/20 (80.0%)	<0.001*

Table 6: Comparison of Mechanical Sensations @ 7cm between the two groups

	Mechanical Sensations 7cm		P-value
	ORIF	Conservative	
Age			
18-30 years	0/19 (0.0%)	4/17 (23.5%)	0.025*
31-45 years	0/31 (0.0%)	7/33 (21.2%)	0.007*
Gender			
Male	0/33 (0.0%)	7/32 (21.9%)	0.004*
Female	0/17 (0.0%)	4/18 (22.2%)	0.039*
Duration of Fracture (weeks)			
1-3 weeks	0/31 (0.0%)	7/30 (23.3%)	0.004*
3-6 weeks	0/19 (0.0%)	4/20 (20.0%)	0.040*

Table 7: Comparison of Thermal Sensations between the two groups

Thermal Sensations	ORIF	Conservative	P-value
32oC			
Yes	19 (38.0%)	16 (32.0%)	0.529
No	31 (62.0%)	34 (68.0%)	
35oC			
Yes	32 (64.0%)	50 (100.0%)	<0.001*
No	18 (36.0%)	0 (0.0%)	
37oC			
Yes	45 (90.0%)	50 (100.0%)	0.022*
No	5 (10.0%)	0 (0.0%)	

Table 8: Comparison of Thermal Sensations @ 32oC between the two groups

	Thermal Sensations 32oC		P-value
	ORIF	Conservative	
Age (years)			
18-30 years	7/19 (36.8%)	5/17 (29.4%)	0.637
31-45 years	12/31 (38.7%)	11/33 (33.3%)	0.654
Gender			
Male	13/33 (39.4%)	11/32 (34.4%)	0.675
Female	6/17 (35.3%)	5/18 (27.8%)	0.632
Duration of Fracture (weeks)			
1-3 weeks	12/31 (38.7%)	10/30 (33.3%)	0.662
3-6 weeks	7/19 (36.8%)	6/20 (30.0%)	0.651

Table 9: Comparison of Thermal Sensations @ 35oC between the two groups

	Thermal Sensations 35oC		P-value
	ORIF	Conservative	
Age			
18-30 years	12/19 (63.2%)	17/17 (100.0%)	0.005*
31-45 years	20/31 (64.5%)	33/33 (100.0%)	<0.001*
Gender			
Male	21/33 (63.6%)	32/32 (100.0%)	<0.001*
Female	11/17 (64.7%)	18/18 (100.0%)	0.006*
Duration of Fracture (weeks)			
1-3 weeks	20/31 (64.5%)	30/30 (100.0%)	<0.001*
3-6 weeks	12/19 (63.2%)	20/20 (100.0%)	0.003*

Table 10: Comparison of Thermal Sensations @ 37oC between the two groups

	Thermal Sensations 37oC		P-value
	ORIF	Conservative	
Age			
18-30 years	17/19 (89.5%)	17/17 (100.0%)	0.169
31-45 years	28/31 (90.3%)	33/33 (100.0%)	0.067
Gender			
Male	30/33 (90.9%)	32/32 (100.0%)	0.081
Female	15/17 (88.2%)	18/18 (100.0%)	0.134
Duration of Fracture (weeks)			
1-3 weeks	28/31 (90.3%)	30/30 (100.0%)	0.081
3-6 weeks	17/19 (89.5%)	20/20 (100.0%)	0.136

Table 11: Comparison of Pain Threshold between the two groups

	ORIF	Conservative	P-value
Pain Threshold (mean±sd)	1.26±0.44	1.58±0.49	0.001*

Table 12: Comparison of Pain Threshold between the two groups

Stratification	Subgroups	Pain Threshold (mean±sd)		P-value
		ORIF	Conservative	
Age	18-30 years	1.21±0.42	1.53±0.51	0.048*
	31-45 years	1.29±0.46	1.61±0.49	0.011*
Gender	Male	1.27±0.45	1.59±0.49	0.008*
	Female	1.24±0.44	1.56±0.51	0.055
Duration	1-3 weeks	1.23±0.43	1.50±0.51	0.026*
	3-6 weeks	1.32±0.48	1.70±0.47	0.016*

DISCUSSION

One of the most frequent causes of trauma, accounting for 45% of all midfacial and 25% of all facial fractures, is the anatomical prominence of the zygomaticomaxillary complex in the facial skeleton [1]. These fractures are treated either conservatively as recommended or by open reduction and rigid fixation [2,3]. Ecchymosis and periorbital edema are frequent symptoms of these fractures. Other symptoms include neurological damage in the infraorbital nerve's distribution, sub conjunctival bleeding with or without lateral limit in all planes, and depression of the malar eminence. A fracture traversing through the infraorbital foramen or canal can cause temporary or permanent infraorbital nerve hypoesthesia or anesthesia due to varying degrees of nerve damage which may or may not recover with time [3].

Different documentations support different theories about management option and nerve outcome. It is hypothesized that nerve recovery occurs more quickly and effectively following closed reduction [6]. In a study, 52% of patients received conservative treatment, and their nerve function fully improved [7]. On the other hand, there is evidence to suggest that internal fixation and open reduction allow for a substantially greater restoration of infraorbital nerve function [8]. After open reduction and internal fixation, it was shown that only 22.1% of patients continued to have nerve dysfunction [9]. However iatrogenic damage during surgery may also delay the recovery on the other side [5]. A recent randomized controlled trial reported better nerve outcome with conservative treatment [5].

In the present study, the mean age of the patients was 36.2±7.1 years. Most of the patients (n=64, 64.0%) were 31-45 years old. A study carried out by Ishaq et al. in 2018 observed similar mean age of 36.5±11.1 years. They also reported similar higher proportion (66.0%) of 31-45 years age group among such patients [10]. Another study done by Noor et al.also reported similar mean age of 37.4±3.8 years in patients presenting at FMH College of Medicine and Dentistry, Lahore [11]. A comparable mean age of 39.5±7.4 years has been reported by Candamourty et al. (2013) in Indian such patients [12]. A higher proportion of 31-45 years age group has also been reported by Balakrishnan et al. (2015) who observed that 61.3% of such patients in India were aged between 31-45 years [13]. Zhang et al. (2018) reported comparable mean age of 33.6±11.4 years in Chinese such patients [14] while Ogata et al. (2013) reported it to be 39.8±17.0 years in Japan [15]. Salinas et al. (2013) observed it to be 40.3±7.9 years in such patients in USA [16].

We observed that there were 65 (65.0%) male and 35 (35.0%) female patients with a male to female ratio of 1.9:1. The findings of our study are in line with the study done by Noor et al. who reported similar male predominance [11]. Ishaq et al. reported similar male predominance (m:f; 2.6:1) in patients with zygomaticomaxillary complex fractures at Mayo Hospital, Lahore [10]. Ogata et al. in Japan and Zhang et al. in China reported similar male predominance [14, 15].

In the present study, we observed that the nerve function was superior in patients managed conservatively as compared to ORIF. Almost same results have been observed by DAS et al. in India [5] who observed that the proportion of patients with sensations at 3cm (80.0% vs. 100.0%; p-value≤0.05) and 5cm (20.0% vs. 83.3%; p-value≤0.05) length of filament was significantly lower in patients who underwent ORIF as compared to those who were managed conservatively. For heat threshold detection, they too reported that proportion of patients with sensation at 32°C was no different between ORIF and conservatively managed patients (40.0% vs. 33.3%; p-value>0.05). However, proportion of patients with sensations at 35oC (60.0% vs. 100.0%; p-value<0.001) was lower significantly in surgically treated patients is almost similar with the findings of our study. They also reported similar significantly lower pain threshold in ORIF group (1.20±0.44 vs. 1.50±0.54; p-value≤0.05) in comparison to conservative group.

In this study, we found that in patients with zygomaticomaxillary complex fractures, infra orbital nerve outcome was superior in patients managed conservatively than those treated with open reduction and internal fixation which advocates evading unnecessary intervention in such cases in future practice. However a very important limitation of this research was that we didn't do a long term follow-up as the original study by Das et al. observed that the outcome improved in the surgical group over time and was superior to conservative treatment at the end of 6 months follow-up. Moreover, surgical treatment gives better cosmetic and functional outcome [5]. Thus there is need for such a study with long term follow-up considering other outcome variables preferably the "cosmesis" and patient's satisfaction to establish better treatment option more clearly.

CONCLUSION

In patients with zygomaticomaxillary complex fractures, infra orbital nerve outcome was superior in patients managed conservatively than those treated with open reduction and internal fixation which advocates evading unnecessary intervention in such cases in future practice.

REFERENCES

1 Miloro M, Ghali GE, Larsen PE, Waite PD. Peterson's principles of oral and maxillofacial Surgery. 3rd ed. PMPH-USA 2012.p. 400- 465.

2 Dakir A, Muthumani T, Prabu NP, Maity A. One point fixation of zygomatic tripod fractures in the zygomatic buttress through keen's intraoral approach. J Pharm Bioallied Sci 2015;7:238-41.

3 Booth PW, Eppley BL, Schmelzeisen R. Maxillofacial trauma & esthetic facial reconstruction. 2nd ed. 2002. p. 160-170.

4 Rana M, Warraich R, Tahir S, Iqbal A, Von Sie C, Eckardt AM, et al. Surgical treatment of zygomatic bone fracture using two points fixation versus three points fixation--a randomised prospective clinical trial. Trials 2012;13:36.

5 Das AK, Bandopadhay M, chatopadhay A, Biswas S, Saha A, Balkrishna UM, et al. Clinical evaluation of neurosensory changes in the infraorbital nerve following surgical management of zygomaticomaxillary complex fractures. J Clin Diagn Res 2015;9(12):54-8.

6 Sakavicius D, Juodzbalys G, Kubilius R, Sabalys P. Investigation of infraorbital nerve injury following zygomaticomaxillary complex fractures. J Oral Rehab 2008;35(5):903-16.

7 Peltomaa J, Rihkanen H. Infraorbital nerve recovery after minimally dislocated facial fractures. EUH Arch Otorhinolaryngol 2000;257(8):449-52.

8 Benoliel R, Birenboim R, Regev E, Eliav E. Neurosensory changes in the infraorbital nerve following zygomatic fractures. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005;99(7):657-65.

9 De Man K, Bax WA. The Influence of the mode of treatment of zygomatic bone fractures on the healing process of the infraorbital nerve. Br J Oral Maxillofac Surg 1988;26(5):419-25.

10 Ishaq Y, Noor M, Anwar MA. Comparison of infraorbital nerve recovery after open and closed reduction of zygomaticomaxillary complex fractures. Int J Otorhinolaryngol Head Neck Surg 2018;4(3):613-7.

11 Noor M, Ishaq Y, Anwar MA. Frequency of infra-orbital nerve injury after a Zygomaticomaxillary complex fracture and its functional recovery after open reduction and internal fixation. Int Surg J 2017;4(2):685-9.

12 Candamourty R, Narayanan V, Baig MF, Muthusekar MR, Jain MK, Babu RM. Treatment modalities in zygomatic complex fractures: a prospective short clinical study. Dent Med Res 2013;1(1):13-22.

13 Balakrishnan K, Ebenezer V, Dakir A, Kumar S, Prakash D. Management of tripod fractures (zygomaticomaxillary complex) 1 point and 2 point fixations: a 5-year review. J Pharm Bioallied Sci 2015;7(Suppl-1):S242-7.

14 Zhang X, Ye L, Li H, Wang Y, Dilxat D, Liu W, et al. Surgical navigation improves reductions accuracy of unilateral complicated zygomaticomaxillary complex fractures: a randomized controlled trial. Sci Rep 2018;8(1):68-90.

15 Ogata H, Sakamoto Y, Kishi K. A new classification of zygomatic fracture featuring zygomaticofrontal suture: injury mechanism and a guide to treatment. Plast Surg Int J 2013;2013:383486.

16 Salinas JB, Vira D, David HU, John MS. Steimann pin repair of zygomatic complex fractures. Int J Otolaryngol Head Neck Surg 2013;2:74-8.