One-point versus two-point fixation of tripodal zygomatic fractures

Mohammed Safwat Shahine[a], Salah El-Dein Gaber Shaltout[a], Mohammed Hasan Osman[a], Mohamed Gamal Thabet[a], Mohamed Abdel-Tawab[b], Hamdan Saadi Abbas[a]

[a]General Surgery Department (Maxillofacial Unit), Assiut University Hospitals, Egypt, [b]Department of Radiology, Assiut University Hospital, Egypt

Corresponding author. Hamdan Saadi Abbas, General Surgery Department (Maxillofacial Unit), Assiut University Hospital, Egypt.
E-mail: hamdansaadi@aun.edu.eg

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Background
The zygomaticomaxillary complex (ZMC) fractures are highly frequent injuries. There is a variety of operative techniques for fixation of ZMC fractures, with no consensus about the best technique. We aim to compare one-point versus two-point fixation of tripodal zygomatic fractures.
Patients and Methods
This prospective randomized controlled clinical trial was carried out on 68 patients admitted to the trauma unit in Assiut university hospital, in the period from September 2019 to March 2021. Patients were divided into two groups (group 1; one-point fixation, and group 2; two- point fixation).
The degree of success of reduction and fixation was evaluated by measuring the diastasis of ZMC fracture at the inferior orbital (IO) rim on postoperative CT scan; and by clinical evaluation of symmetry between zygomatic eminences.
Results
Post-operative diastasis between the fracture ends was 1.20 ± 0.80 mm in the one-point fixation group, and was 0.99 ± 0.64 mm in the two-point fixation group; (*P*=0.40). Malar symmetry was detected in (94.1%) of patients in the one-point fixation group, and in (97%) of patients in the two- point fixation group; (*P*=0.56). The unsightly scar was seen only in cases of two-point fixation group (41.2%), (*P*< 0.001). The plate was palpable only in patients of the two-point fixation group (35.3%) at the frontozygomatic region, (*P*<0.001). Patient' satisfaction with surgical outcomes was significantly higher in the one-point fixation group (94.1%) vs. (58.8%) in the two-point fixation group, (*P*<0.001).
Conclusion
The one-point fixation technique for tripodal ZMC fractures is considered effective as the two-point fixation technique; and it offers advantages of scarless operation, reduced operation time, fewer complications, and lower cost.

Keywords
Two-point, fracture, internal fixation, zygomaticomaxillary complex, one-point

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Introduction

Zygomaticomaxillary complex (ZMC) fractures are common injuries in maxillofacial trauma, and more common in adult males. The main causes of ZMC fractures include road traffic accidents, violent assaults, falls, and sports injuries. however, the epidemiology of facial bone fractures is variable based on socio-economic and environmental factors [1].

Diagnosis of ZMC fractures is usually clinical and confirmed by computed tomography (CT) scan of the facial bones in three-dimensional (3D) reconstruction film, axial and coronal planes [2].

ZMC fractures without or with minimal displacement are treated conservatively without surgery; while fractures with functional or aesthetic problems in the form of abnormal position of the eye globe, diplopia, limitation of mouth opening, and depression of the malar eminence require surgical intervention [3].

Variable surgical techniques have been performed to achieve satisfactory outcomes e.g. the Gillies' temporal approach, upper eyelid, lateral eyebrow, sub ciliary, transconjunctival, and intraoral approaches [4].

The intraoral approach has been described in 1909 by Keen, for fixation of ZMC fractures at the zygomaticomaxillary buttress. Also, we can expose the

frontozygomatic region or the inferior orbital ridge for fixation in cases of unstable ZMC fractures [5].

The current study compares the efficacy of one-point versus two-point fixation of tripodal zygomatic fractures by using miniplates, through assessment of clinical and radiological outcomes.

The clinical outcomes include evaluation of facial contour, malar symmetry and eye globe position; while radiological outcome includes evaluation of reduction and fixation of fractures through postoperative CT scan of facial bones.

Patients and Methods

This study is a prospective randomized controlled clinical trial, carried out at the trauma unit in Assiut university hospital, in the period from September 2019 to March 2021. Data of 68 patients with tripodal zygomatic fractures admitted to the trauma unit were collected and included in the study.

Inclusion criteria

Adult patients with tripodal zygomatic fractures that are indicated for open reduction and internal fixation by miniplates and screws.

Exclusion criteria

1) Patients with Le Fort I/II/III maxillary fractures.
2) Patients with orbital blow-out and blow-in fractures.

Randomization

Patients were allocated randomly into two groups (34 patients in each group); group [1] for one-point fixation of tripodal zygomatic fractures at the zygomaticomaxillary buttress, and group [2] for two-point fixation at the zygomaticomaxillary buttress and the frontozygomatic region. SPSS program version 20 was used for randomizing 68 patients and allocating each patient into either of the two groups based on the patient's enrollment number in the study.

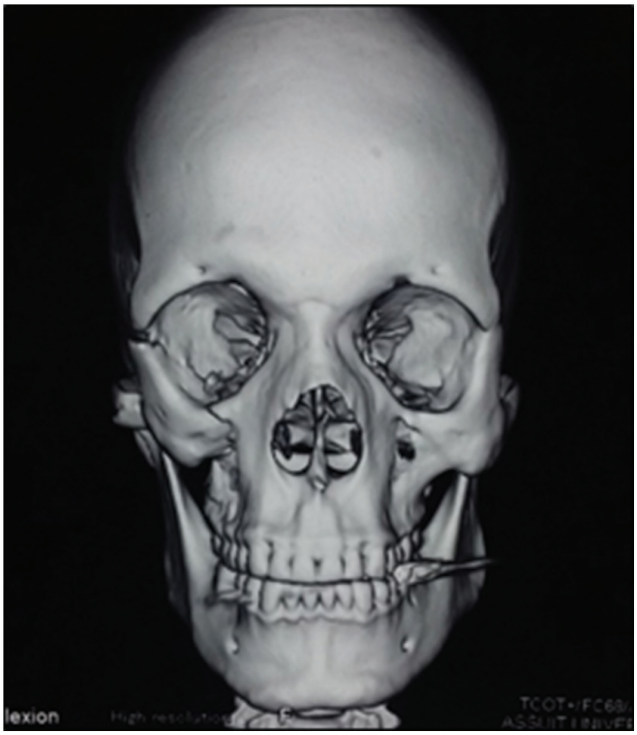
Preoperative evaluation of patients

This includes clinical examination, radiological and laboratory investigations.

All cases were evaluated clinically by taking a full history, general examination and maxillofacial examination for signs of zygomatic complex fractures. Also, assessment of the infraorbital nerve injury and ophthalmological evaluation were documented.

Radiological evaluation through CT scan of facial bones in three-dimensional (3D) reconstruction film, axial and coronal planes. (Figure 1).

Figure 1



CT scan facial bone, 3D reconstruction film, tripodal zygomatic fracture.

Laboratory investigations include complete blood count (CBC), coagulation profile and renal function test.

Operative procedure

All selected patients were prepared and operated under general anesthesia. An incision in the upper buccal sulcus is made above the mucogingival junction. Then the mucoperiosteum is elevated for exposure of the zygomaticomaxillary and nasomaxillary buttresses (Figure 2).

The ZMC is reduced into its optimal anatomical alignment, whilst palpation of the infraorbital ridge and the frontozygomatic junction to confirm proper reduction (Figure 4).

When the fracture reduction is stable and shows adequate anatomic alignment, the zygomatic complex fracture is stabilized with miniplate and screws at the zygomaticomaxillary buttress (in group 1 and 2) (Figures 2 and 3).

The frontozygomatic junction is exposed for a second fixation point through the lateral eyebrow incision, 2.0 cm incision is made within the confines of the lateral eyebrow parallel to the superior lateral orbital rim, (Figure 4), dissection is continued through the orbicularis oculi muscle and the periosteum to the

Figure 2

Exposure of fracture at zygomaticomaxillary buttress through upper buccal sulcus incision.

Figure 3

Reduction and fixation of fracture at zygomaticomaxillary buttress by miniplates and screws.

fracture site, which is stabilized by miniplate (in group 2). The sulcus and the lateral eyebrow incisions are closed using sutures (Vicryl 3-0) and (Prolene 5-0) respectively. **Postoperative CT scan of the facial bones** was done to evaluate adequacy of fracture reduction and fixation, by measuring the distance between the fracture ends (bone diastasis) at the inferior orbital margin; measurements were obtained using RadiAnt DICOM viewer software. (Figure 5 and 6).

Figure 4

Exposure and fixation of fracture at the frontozygomatic region through lateral eyebrow incision.

{According to Starch-Jensen T. *et al*, the reduction was classified as adequate reduction (when bone diastasis ≤3 mm) and inadequate reduction (when bone diastasis >3 mm)} [6].

Post-operative follow-up

Follow-up of patients was done at one week, 3 weeks, and 6 weeks after the operation for assessment of the facial contour, malar symmetry, eye globe position, neurosensory disturbance of the infraorbital nerve, union of the fracture and surgical site infection. Also, patients were evaluated for complications of the lateral eyebrow incision e.g. unsightly scar or keloid formation, and complications of the miniplates e.g. infection and palpability of the plate. Finally, patients' satisfaction with surgical outcomes was assessed.

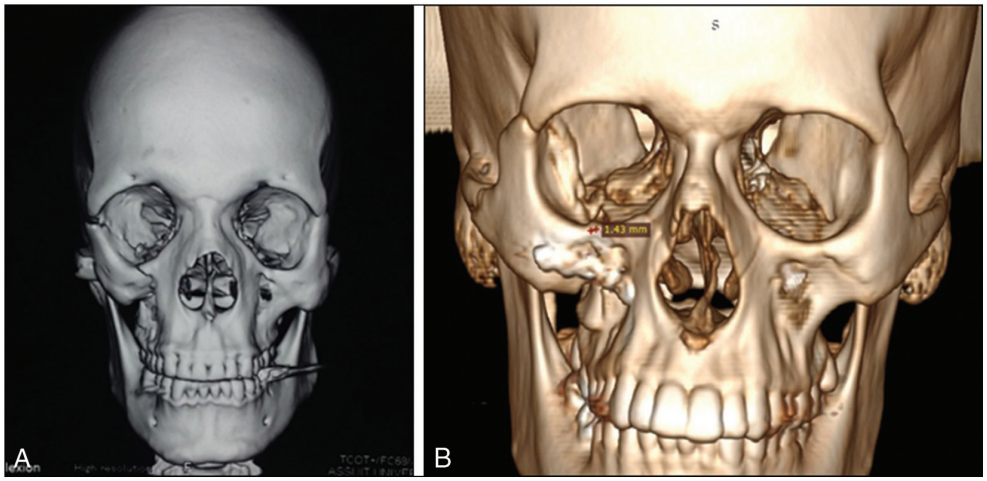
Study design

This Study is an experimental randomized controlled clinical trial. Patients who were diagnosed to have tripodal zygomatic fractures that met the inclusion criteria and gave informed consent to participate in the study were included in the study. Patients were assigned randomly into two groups (34 patients in each group).

Ethical consideration

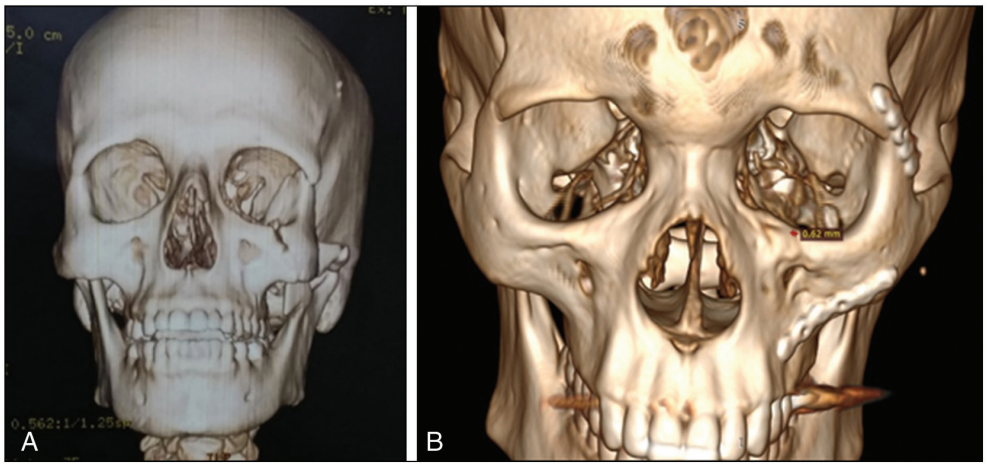
Approval was obtained from the Clinical Research Ethics Committee, Faculty of Medicine, Assiut University, before recruiting patients. Data collection and analysis included patients' medical records and reports after taking permission from the relevant authorities in the trauma unit in Assiut university

Figure 5



a-b: Postoperative CT scan of the facial bones for measuring the distance between the fracture ends at the inferior orbital margin using RadiAnt DICOM viewer software in one- point fixation technique, preoperative (Fig.5a) and postoperative (Fig.5b).

Figure 6



a-b: Postoperative CT scan of the facial bones for measuring the distance between the fracture ends at the inferior orbital margin using RadiAnt DICOM viewer software in two- point fixation technique, preoperative (Fig.6a) and postoperative (Fig.6b).

hospital. Patient medical records were kept privy throughout the study. Informed written consent was obtained before the procedure.

Data collection

Data collection was gathered from the trauma unit, Assiut university hospital after study approval. Pre- and post-operative data were collected for each patient included in the study.

Statistical analysis

Data was collected and analyzed by using SPSS (Statistical Package for the Social Science, version 20, IBM, and Armonk, New York). Numerical data were expressed in form of mean ± SD while categorical data were expressed in form of frequency (percentage).

Chi^2-test was used to compare the nominal data of different groups in the study, while Student t- test was used for comparison of continuous data of the studied groups. The level of confidence was kept at 95% and hence *P* value was considered significant if < 0.05.

Results

Patient demographics are shown in Table 1.

Mode of trauma among enrolled patients

The most frequent mode of trauma in both groups was a road traffic accident (RTA) (73.5%), followed by assault (14.7%) and fall from height (11.7%) (Table 2).

Clinical and radiological evaluation of enrolled patients

As regard restoration of malar symmetry; all patients in both groups had malar symmetry with exception of two patients in the one-point fixation group and another patient in the two-point fixation group who had malar asymmetry (*P*= 0.56).

Table 1: Age and sex of the studied patients

	One-point fixation (*n* = 34)	Two-point fixation (*n* = 34)	*P* value
Age (years)	32.46 ± 8.73	29.82 ± 6.90	0.14
Range	20-45	20-45	
Age group			0.06
18-20 years	2 (5.9%)	6 (17.6%)	
20-40 years	24 (70.6%)	26 (76.5%)	
More than 40 years	8 (23.5%)	2 (5.9%)	
Sex			0.38
Male	26 (76.5%)	28 (82.4%)	
Female	8 (23.5%)	6 (17.6%)	

Data expressed as frequency (percentage), mean (SD). *P*-value was significant if < 0.05

Table 2: Mode of trauma among enrolled patients

Mode of trauma	One-point fixation (*n* = 34)	Two-point fixation (*n* = 34)	Total
RTA	22	28	50 (73.5%)
Assault	6	4	10 (14.7%)
Fall from height	6	2	8 (11.7%)

Data expressed as frequency (percentage).

As regard anatomical alignment in post-operative CT scan facial bones; all patients had adequate alignment with exception of two patients in the one-point fixation group and another patient in the two-point fixation group had an inadequate alignment (*P*= 0.56).

Post-operative diastasis between the fracture ends (gap size) was measured on a postoperative CT scan to evaluate the fracture reduction and fixation (anatomical alignment). It was (1.20 ± 0.80 mm) in group 1 and (0.99 ± 0.64 mm) in group 2. There was no statistically significant difference between both groups. (*P*=0.40). All patients had normal eye globe positions. Manifestations of infraorbital nerve injury were found preoperative in 40 (58.8%) patients, which were caused by the trauma, but none of the patients had iatrogenic infraorbital nerve injury post-operative (Table 3).

Outcome and satisfaction among enrolled patients

None of those patients who underwent one-point fixation had an unsightly scar, while 14 (41.2%) patients of the two-point fixation group had unsightly scar (*P*< 0.001). Also, none of the patients who underwent one-point fixation complained of palpability of the plate, while it was present in 12 (35.3%) patients of the two-point fixation group at the frontozygomatic region (*P*<0.001) Patients who underwent two-point fixation had a higher frequency of surgical site infection 6 (17.6%) vs. 2 (5.9%) in the one-point fixation group, (*P*= 0.12) Patient' satisfaction with surgical outcomes was significantly higher among one-point fixation group 32 (94.1%) vs. 20 (58.8%) in the two-point fixation group, (*P*<0.001) (Table 4).

Table 3: Clinical and radiological evaluation of enrolled patients

	One-point fixation (*n*= 34)	Two-point fixation (*n*= 34)	*P* value
Malar symmetry	32 (94.1%)	33 (97%)	0.56
Normal eye globe position	34 (100%)	34 (100%)	-
Infraorbital nerve injury			-
Pre-operative	17 (50%)	23 (67.6%)	
Post-operative	17 (50%)	23 (67.6%)	
Alignment on CT scan			0.56
Adequate	32 (94.1%)	33 (97%)	
Inadequate	2 (5.9%)	1 (3%)	0.40
Gap size on CT scan (diastasis) in mm.	1.20 ± 0.80	0.99 ± 0.64	

Data expressed as frequency (percentage). *P*-value was significant if < 0.05. CT: computed tomography.
mm: millimeter.

Table 4: Outcome and satisfaction among enrolled patients

	One-point fixation (*n*= 34)	Two-point fixation (*n*= 34)	*P* value
Unsightly scar	0	14 (41.2%)	< 0.001
Palpability of plate	0	12 (35.3%)	< 0.001
Surgical site infection	2 (5.9%)	6 (17.6%)	0.12
Satisfaction with outcomes	32 (94.1%)	20 (58.8%)	< 0.001

Data expressed as frequency (percentage). *P*-value was significant if < 0.05.

Discussion

In the current study; the mean age of patients who underwent one-point fixation was 32.46 years with a range between 20 and 45 years, the mean age of patients who underwent two-point fixation was 29.82 years with a range between 20 and 45 years, and the majority of patients were males (26 in one-point group and 28 in two-point group). As stated by Bradley D. *et al* [7] the mean age was 33.1, the range was 19–55 years and the majority of cases (47) were males; and by Kim SY. *et al* [8] the mean age was 39.5 years (range 17–54 years) and the majority of patients were males; and by Kumar PS. *et al* [9] of

60 patients, all patients with a mean age of 35 years (20–50 years) and 58 of them were males.

In this study; the most frequent mode of trauma in both groups is road traffic accidents (RTA) (76.4%), then assault (14.7%), and fall from height (8.8%). As stated by Arora I. *et al* [10] Road traffic accident was the most common cause of zygomatic fractures in 80% of cases, then the accidental falls in 10% and assault 10%; while by Bradley D. *et al* [7] the most common cause was interpersonal violence (53%), followed by falls (23%) and RTA (13%). These variations of the etiology of zygomatic bone fractures are influenced by multiple factors that include geographical location, the incidence of RTA, and socioeconomic trends. A road traffic accident is a major etiology of zygomatic bone fractures in developing countries.

In the current study, 97% (*n*=33) of 34 patients treated with two-point fixation had malar symmetry while one patient had malar asymmetry because of comminuted fracture at the inferior orbital ridge. As stated by Starch-Jensen T. *et al* [6] of 46 patients, satisfying facial contour and malar alignment was observed in 45 patients (98%) and one patient had asymmetry because of comminuted fracture at the inferior orbital rim, and by Shanmugam D. *et al* [11] 96.4% (*n*=53) of 55 patients who underwent two-point fixation had malar symmetry and 2 patients had malar asymmetry which was attributed to severely displaced fractures, while by Mittal G. *et al* [12] found that 100% (*n*=20) patients were treated with two-point fixation of simple non-comminuted tripodal fractures and had satisfactory malar height and symmetry.

As regards anatomical alignment in post-operative CT scan; 94.1% (*n*=32) of 34 patients who underwent one-point fixation had an adequate alignment, while two patients had inadequate alignment which were the cases of comminuted fractures. In Vatsa R. *et al* [13] good reduction and alignment was present in 90% (*n*=9) of cases, and one patient had inadequate alignment as there was comminution of the zygomatic buttress which made the fixation difficult, while Fujioka M. *et al* [14] found that 100% (*n*=15) patients had good anatomical alignment after one-point fixation of simple tripod fractures that were not comminuted. Of 34 patients who underwent two- point fixation in this study, 97% (*n*=33) had a good alignment in post-operative CT scan while one patient had inadequate alignment because of comminuted fracture at the inferior orbital rim. As stated by Starch-Jensen T. *et al*, 2018 [6] CT-scans showed adequate anatomical alignment in 98% of patients after two-point fixation, while inadequate alignment was present in one patient due to comminuted fracture at the inferior orbital rim, while by Mittal G. *et al* [12] 100% (*n*=20) patients had a good alignment of non-comminuted fractures.

The post-operative diastasis between the fracture ends was measured on postoperative CT scan to assess the fracture reduction and fixation, it was (1.20 ± 0.80 mm) in group 1 and (0.99 ± 0.64 mm) in group 2, and we found no statistically significant difference between both groups (*P*=0.40), proving non-inferiority of the one-point fixation technique as regard postoperative radiological outcomes. As stated by Starch-Jensen T. *et al*, 2018 [6], the quality of fracture reduction was estimated on postoperative CT scans, the diastasis between fracture ends was measured. Fractures exhibiting a bone diastasis ≤3 mm have adequate anatomical alignment, whereas fractures exhibiting a bone diastasis >3 mm have inadequate anatomical alignment.

In this study; none of the patients who underwent one-point fixation had an external scar, while 14 (41.2%) patients of group 2 who were treated with two-point fixation had an unsightly scar related to the lateral eyebrow incision. As stated by Kim ST. *et al* [15] 63% (*n*=10) of 16 patients in the two-point fixation group complained of unsightly scar in the lateral eyebrow incision site, also patients may undergo surgery for plate removal, and repeated lateral eyebrow incisions may leave further unsightly scars, and stated by Kumar PS. *et al* [9] 33.3% (*n*=10) of patients complained of unsightly scar in the lateral eyebrow region, and by Vatsa R. *et al* [13] unsightly scar was found in 40% of cases.

In this study, palpability of plate was present at the frontozygomatic area in 12 patients (35.3%) of two-point fixation group because the soft tissue overlying the frontozygomatic area is very thin and the plate is easily palpable, while none of the patients of one-point fixation group complained of palpability of the plate. As stated by Kim ST. *et al* [15] (25%) of patients in the two-point fixation group complained of palpability of plate in the frontozygomatic area, whereas none in the one-point fixation group complained of palpability, and by Kumar PS. *et al* [9] 15 patients (50%) complained of palpability of plates in the frontozygomatic region but there was no incidence of palpability of plate in cases of one-point fixation, and by Vatsa R. *et al* [13] palpability of plate was found in (40%) of cases at the frontozygomatic region, while not found in cases of one-point fixation.

In this study, patients who underwent two-point fixation had a higher frequency of surgical site infection 6 (17.6%) versus 2 (5.9%) in the one-point fixation group, which could be attributed to an increased number of incisions in the two-point fixation

technique. As in Starch-Jensen T. *et al* [6] post-operative wound infection occurred in five patients (11%) who underwent two-point fixation, and by Kim JH. *et al* [16] wound infection was found in one patient (3.4%) post-one- point fixation.

In this study, the satisfaction of patients with surgical outcomes was significantly higher in the one-point fixation group (94.1%), while it was (58.8%) in the two-point fixation group, which is mostly attributed to the unsightly scar formation and palpability of plate in the lateral eyebrow region among patients of two-point fixation group. As stated by Kim ST. *et al* [15] satisfaction with surgery was (94%) among the one-point fixation group, while it was (70%) among the two- point fixation group and this lower rate in the two-point group was due to external scars and palpability of plates in the lateral eyebrow area.

In this study, one-point fixation of tripodal zygomatic fractures could provide good stability and cosmetic results in 94.1% of cases and has advantages of avoiding external scars and palpability of plate, decreased incidence of wound infection, and higher rates of patient satisfaction with surgery (94.1%), while disadvantages include the inability to achieve good results in cases with comminuted zygomatic buttress which occurred in 5.9% of cases. However, two-point fixation of tripodal zygomatic fractures could provide good stability and cosmetic results in 97% of cases, but has disadvantages of unaesthetic scars that occurred in 41.2% of cases, palpability of plate in 35.3% of cases, increased incidence of wound infection in 17.6% of cases and lower rates of satisfaction (58.8%). The current study some limitations, e.g. given the small sample size. Also, there was difficulty in the intraoperative assessment of the reduction and alignment of the fracture lines especially in case of incompletely resolved facial edema.

Conclusion

This study suggested that one-point fixation of tripodal zygomatic fractures at the zygomaticomaxillary buttress through an intraoral approach can provide sufficient stability of the zygomatic complex and good aesthetic results in selected cases of tripodal zygomatic fractures without comminution of the zygomatic buttress or the inferior orbital rim. However, this fixation is not advised in cases of incomplete or unsatisfactory reduction and fixation through the intraoral approach, in these cases more than one point of fixation should be performed. It is better to use intraoperative imaging scanner as C-arm X-ray machine or CT scan to evaluate reduction of fractures to avoid redo surgery in cases of unsatisfactory results.

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Conflicts of interest
There are no conflicts of interest.

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