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Review

Comparative evaluation of 2-point vs 3-point fixation in the treatment of zygomaticomaxillary complex fractures – A systematic review

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ABSTRACT

Background: The zygomaticomaxillary complex (ZMC) functions as the main buttress for the lateral portion of the middle third of the facial skeleton and because of its prominent position & convex shape, it is frequently fractured, alone or along with other bones of the midface. The management of the ZMC fractures is debatable as the literature is saturated with various theories. A number of techniques, from closed reduction to open reduction and internal fixation can be effectively used to manage these fractures. Controversies lie right from the amount of fixation (1-, 2-, 3- or 4- point fixation) required to the ideal approach, and there is no conclusive view on its ideal line of management.
Objective: To compare Malar asymmetry after 2-point vs 3-point fixation in the treatment of zygomaticomaxillary complex fractures.
Data source: Electronic search of Pub Med, Google Scholar, Institutional Library, Email to authors and manual search of various journals.
Study eligibility criteria: The following criteria were used to select the studies on 2- point and 3-point fixation methods in Zygomaticomaxillary complex fractures. Inclusion criteria had articles that included clinical studies published in the English language or those having sufficient data in English on 2-point or 3-point fixation in the treatment of zygomaticomaxillary complex fractures between the period of 1st January 2008 to 30th September 2018. While exclusion criteria were articles not published in the English language before 1st January 2008 and after 30th September 2018, any reviews, abstracts, letters to editors, editorials and in vitro studies were excluded. Studies that included patients with craniofacial and secondary deformities were also excluded.
Intervention: Open reduction and internal fixation using 2-point and 3-point fixation methods in the treatment of Zygomaticomaxillary complex fractures.
Results: Preliminary screening consisted of 757 studies and additional records identified through other sources of 272 studies. Amongst these 1029 studies, 837 studies were excluded after reviewing the titles. A review of abstract further excluded 71 studies, so 34 studies that remained were evaluated to fit the eligibility criteria. On the basis of information on fixation methods and parameters of evaluation of fixation method, 26 studies were further excluded. Thus 8 studies with a total of 823 estimates were included in qualitative synthesis.
Limitations: Parameters assessed by all the authors varied and hence a standardisation for comparison could not be done.
Conclusion: Five out of eight studies showed that the use of 3-point fixation in the treatment of zygomaticomaxillary complex fractures was superior than 2-point fixation for the same. Hence it can be concluded that 3-point fixation is superior than 2-point fixation in reducing malar asymmetry in zygomaticomaxillary complex fractures.
Future implications: Future studies with uniform parameters being assessed can be done. 3-point fixation can be used as a standard treatment modality in the effective management of Zygomaticomaxillary complex fractures.

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1. Introduction

The zygomaticomaxillary complex (ZMC) is the main buttress of the lateral portion of the middle third of the facial skeleton and is frequently fractured, along with other bones of the midface (Ellis et al., 1985; Zingg et al., 1992).

The ZMC's unique tetrapod arrangement, articulating with several bones, demarcates the anterolateral aspect of the face and delineates the midfacial width, the inferior and lateral orbital borders as well as the cheek prominence (Brennan et al., 2017).

If these fractures are not attended to, they may lead to functional and aesthetic deficits such as loss of facial symmetry, paraesthesia of the infraorbital nerve, depressed malar prominence, limited mouth opening, obstruction of the lacrimal duct, epiphora, diplopia, orbital dystopia, enophthalmos, and loss of vision when related to orbital floor fractures (Kovacs and Ghahremani, 2001; Vriens et al., 1998; Enislidis et al., 1997).

Management of these fractures is debatable, and various theories supporting different treatment modalities exist. A number of techniques, from closed to open reduction and internal fixation, can be effectively used to manage ZMC fractures, but no uniform consensus exists.

The main goal of the treatment is to attain anatomic reduction and stable fixation to prevent post-operative aesthetic or functional deficits (Zingg et al., 1992; Lee et al., 2010).

This can be accomplished by one-, two-, three- or four-point fixation of the fractured ZMC, depending on the displacement of the fractured segment, type of fracture, and stability of zygoma after reduction, as suggested in the literature (Marinho and Freire-Maia, 2013; Brennan et al., 2017; Meslemani and Kellman, 2012).

Therefore, the aim of this study was to systematically review the scientific literature to determine whether two-point or three-point fixation is a better treatment modality that provides stability and reduces malar asymmetry in the management of ZMC fractures.

2. Materials and methods

This research was approved by the institutional ethics committee and conducted in accordance with Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) (Moher et al., 2009) to answer the following question: Which fixation method corrects Malar asymmetry better in the treatment of Zygomaticomaxillary complex fractures?.

The following keywords were used to conduct the study: Zygomaticomaxillary complex, fractures, fixation, and stability (Annexure 1).

2.1. Inclusion and exclusion criteria

The chosen articles had to meet the following inclusion criteria: 1) articles published in the English language or those having sufficient data in English on two-point or three-point fixation in the treatment of zygomaticomaxillary complex fractures; 2) studies published between 1 January 2008 and 30 September 2018 having relevant data on two-point or three-point fixation in the treatment of zygomaticomaxillary complex fractures; and 3) clinical studies that include essential data on zygomaticomaxillary complex fracture fixation relating to malar asymmetry.

Exclusion criteria were as follows: 1) any studies conducted before 1 January 2008; 2) articles not published in the English language; 3) review, abstracts, letters to editors, editorials and in vitro studies are excluded which have information on zygomaticomaxillary complex fracture fixation; 4) studies that include patients with craniofacial and secondary deformities to be excluded.

The PICO criteria for this review were as follows:

P (Participants) - Patients with zygomaticomaxillary complex fractures.

I (Intervention) - Use of two-point fixation.

C (Comparison) - To compare two-point vs three-point fixation methods for treating zygomaticomaxillary complex fractures.

O (Outcome) - To evaluate the correction of malar asymmetry in the treated fracture.

S (Study design) - Clinical studies.

2.2. Search strategy

A comprehensive search of the literature was undertaken, date restriction from 2008 to 2018 and a language restriction of English were placed while undertaking the electronic search. Search terms (Medical Subject Headings [MeSH]) such as zygomaticomaxillary complex, fractures, fixation, stability, and their synonyms were used in various combinations to form search strategies (Annexure 1).

The electronic search included PubMed, Google, and data from the learning resource centre of our institute. In addition, the bibliographies of included studies were hand searched to identify potentially eligible studies that were not captured by the electronic search.

Electronic mail (e-mail) communication to authors of potentially eligible studies was also done. In addition, a manual search of oral and maxillofacial surgery journals such as The Journal of Craniofacial Surgery, Archives of Craniofacial Surgery, Open Journal of Stomatology, Pakistan Oral & Dental Journal, Dentistry and Medical Research, and Craniomaxillofacial Trauma Reconstruction was performed. Reference lists of identified studies on the subject were scanned for possible additional studies.

2.3. Study selection

All studies were independently screened by two reviewers (NG and SB). At first, the studies were screened by title and abstract. The second step included obtaining the full texts of studies that fulfilled the eligibility criteria.

Any disagreements between the two reviewers were resolved by discussion with the third reviewer (DK). All of the selected data were individually checked by the fourth reviewer (KB). After this, a data extraction sheet was prepared.

2.4. Data extraction

The two investigators independently abstracted the following data from the articles included and recorded it using a standard pilot form in a Microsoft Excel sheet for data extraction, with the following headings included in the final analysis:

Study ID, Author: name of author, Year: year in which study was published, Location: country in which study took place, Setting: place in which the study took place, Mean age of the participants, Sample size: number of participants, Study design: whether the study was a controlled or clinical trial, Method of fixation used: whether two-point or three-point fixation was used, Parameters assessed: Malar asymmetry and stability, Duration of follow-up, Author's conclusion and Remarks.

2.5. Statistical analysis

The data accumulated from the Excel sheet (Table 1) were analysed using qualitative data analysis. Demographic and clinical data such as country, mean age, study design, setting, type of fixation, number of participants, parameters assessed such as malar asymmetry, stability, and duration of follow up were included.

Table 1
Data extraction sheet.

Study Id	Author/year	Country	Mean Age	3-point fixation	2-point fixation	Follow up duration	Parameter 1	Radiographic assessment/ Imaging technique	Outcome for parameter 1	Parameter 2	Clinical assessment	Outcome for parameter 2	Conclusion	Remarks
							Malar Asymmetry			Stability				
1	Dutt, 2018	India	Not specified in the study	20 patients	20 patients	6 weeks	Malar Asymmetry, Vertical Dystopia and Enopthalmos assessed	Extra- oral radiographs used for assessment of malar asymmetry pre and post operatively. Type of extra -oral radiograph used not specified.	The mean of vertical dystopia in group I and group II was 2.10 mm and 0.94 mm respectively. The mean of enopthalmos was 2.6 mm and 1.27 mm in group I and group II respectively. The difference was significant ($P < 0.05$). Group I showed malar asymmetry as grade I (5), grade II (8) and grade III (7). Group II showed malar asymmetry as grade I (6), grade II (9) and grade III (5).	Stability assessed using clinical signs and symptoms	In this study, stability was evaluated by assessing common signs and symptoms such as periorbital swelling, subconjuctival haemorrhage, malar asymmetry, infraorbital sensation, external laceration, vision loss and diplopia.	3- point fixation stability was superior than 2-point fixation, the authors found that -A miniplate applied across the fronto-zygomatic suture will resist translatory movement and also rotation along an axis perpendicular to the plane of miniplate because of the width of the plate. Hence; for improving the stabilization, application of the plates should be done in such a way that weak axis of the bone doesn't coincide with the plate axis.	Zygomatic bone fracture is not frequently observed among facial bone fractures, Management with three point fixation appears better than two point fixation	The mean of vertical dystopia in group A and group B was 2.10 mm and 0.94. Hence 3 point fixation is superior than 2 point fixation respectively.$P < 0.05$
2	Kim et al., 2012	Korea	44.8 ± 16.7 years	13 patients	14 patients	12 weeks	Not specified in the study	Pre and Post operative CT images taken	Not specified in the study	Stability assessed using clinical signs and symptoms	Assessed using clinical signs and symtoms such as -parasthesia, step deformity, diplopia etc	Not statistically significant, $P > 0.05$	There was little difference in post operative stability between the groups, hence the amount of displacement is not a very important consideration when deciding the fixation method, including the number and location of miniplates for fixation.	The authors conducted this study on a limited sample size and did not find any statistically significant differences in post operative stability in the two groups. $P > 0.05$
3	Latif et al., 2017	Saudi Arabia	15–60 years with the mean 32.62 ± 12.826.	50 patients	50 patients	6 weeks	Post-operative complications like vertical dystopia and malar height prominence were recorded at 1st week, 3rd week and 6th week of the operation	3-D CT scans were taken pre and post operatively	At the 6th week of follow-up, there was significant difference in the malar height and vertical dystopia between the two groups i.e. $p = 0.004$ and $p = 0.000$ respectively. Group B (3-point fixation) showed more malar height prominence, less vertical dystopia and more stability at the 6th week follow-up. Final assessment revealed that there was significant difference	Stability assessed using clinical signs and symptoms	Assessed using clinical signs and symptoms.	The statistical analysis showed that patients who underwent ORIF with three point fixation (Group B) suffered with fewer complications like vertical dystopia and altered malar height as compared to Group A (two-point fixation). There was a significant difference ($p < 0.05$), as far as the post-operative stability of the fractured zygomatic bone was	It was concluded from the study that ORIF using, three point fixation technique in the treatment of zygomatic bone fractures is a better option in order to minimize the post-operative complications like altered malar height and vertical dystopia	The authors concluded that 3 point fixation was superior to 2 point fixation in terms of post operative complications such as malar assymetry, vertical dystopia and stability. $P < 0.05$. SD of malar height in group A- Malar height - 1.347 - 1st week, 1.480- 3rd week, 1.096 - 6th week. Group B -Malar Height: 1.428- 1st week, 1.425 - 3rd week, 0.858- 6th week

								(p = 0.001) in stability of the fractured bone between the groups at 6th week. So over all 3-point fixation showed more promising results than 2-point fixation			concerned 3-point fixation offers superior stability than 2-point fixation		
4	Nasr et al., 2017	Egypt	29 (18–40) years	20 patients	20 patients	12 weeks	Malar eminence asymmetry; projection (forward displacement)and width (medial displacement) in axial CT; inferior displacement; superior displacement and width (medial displacement) in coronal CT; angle of displacement (outward displacement) in 3D CT	CT scans in all three planes (axial, saggital and coronal) with 3-D reconstruction	Malar eminence asymmetry revealed significant improvement in malar prominence with both two-point ($p < 0.001$) and three- point (p ¼ 0.007) groups without statistically significant difference between both modalities (p ¼ 0.519;. Regarding radiological assessment more perfect reduction without postreduction displacement is obtained by three-point fixation treatment modality (group B) than two-point fixation modality (group A) with statistically significant results	Stability assessed using clinical signs and symptoms	Stability assessed using clinical signs and symptoms such as - facial pain and swelling, Parasthesia, Diplopia, problems in opening and closing the mouth, vertical dystopia, enopthalmus etc	Moreover, postoperative CT lateral zygoma displacement was statistically significantly better in three-point fixation. Two-point fixation modality for displaced ZMC fractures is as effective as three-point method in fixation and prevents postreduction rotation or clinical displacement with significantly lower cost.	Apart from asymptomatic and clinically unnoticeable radiological difference, two-point fixation modality for displaced ZMC fractures is almost as effective as three-point ation and prevents postreduction rotation or clinical displacement with significantly lower cost.	Three-point fixation technique is the standard fixation technique as seen on CT lateral zygoma displacement evaluation, and is more superior to 2 point fixation. $P < 0.001$ and $P < 0.007$
5	Ji et al., 2016	Korea	40.2 (5–87) years	52 patients	348 patients	10 years	Not specified in the study	CT images obtained before surgery, Waters view/CT scans obtained after surgery	Not specified in the study	Not specified in the study	Not specified in the study	Not specified in the study	In conclusion, minimal incision, familiar approach and fixation methods of the surgeon are recommended	The authors did not specify which form of fixation was superior in the study, however they concluded that many fixation procedures are available, however, a safe and facilitated procedure is the best way. P value not specified
6	Candamourty et al., 2013	India	20–60 years mean age of 39.5 years.	2 patients	4 patients	4 weeks	This study compared the following variables after reduction and fixation of fracture zygomatic complex; 1. Esthetics 2. Restoration of anatomical form 3. Occlusion 4. Function 5. Neurological deficits	All the patients were subjected to routine investigation, which includes routine blood investigation, radiographs (PNS and OPG)	No statistical difference was found between the two groups, ie- 2-point and 3-point fixation in the assessment of malar asymmetry	Stability assessed using clinical signs and symptoms	Clinical assessment was done by evaluating parameters such as - mouth opening, diplopia, dysesthesion and facial asymmetry	It was found by the authors that 3-point fixation provided better stability compared to 2-point fixation	The protocol of three point, miniplate fixation was effective in terms of stability and relapse	Three-point fixations are preferred in zygomatic complex fractures to avoid rotation of fragment postoperatively in vertical or horizontal axis. P value not specified
7	Rana et al., 2012	Pakistan	14–60 years	50 patients	50 patients	6 weeks	Malar height assessed on the 1st,3rd and 6th week post-operatively	Submentovertex view used pre and postoperatively to assess the Malar height; Pre-operatively malar height was	The final outcome of malar height was measured at 6th weeks so; the average malar height in group A was	Stability assessed using clinical signs and symptoms	Assessed using clinical signs and symtoms such as - parasthesia, step deformity, diplopia etc	According to the final assessment, fractures stability was seen in 56 patients in which 16 patients were from group A and 40	Based on this study open reduction and internal fixation using three point fixation by miniplates is the best available method for the treatment of	Precise reconstruction with rigid internal fixation at 3 points is superior than 2 point fixation. Vertical dystopia P (0.000 < 0.05). Stability: p-value (0.000 < 0.05) Group A SD- Malar Height 1 st week

(*continued on next page*)

Table 1 (*continued*)

Study Id	Author/year	Country	Mean Age	3-point fixation	2-point fixation	Follow up duration	Parameter 1	Radiographic assessment/ Imaging technique	Outcome for parameter 1	Parameter 2	Clinical assessment	Outcome for parameter 2	Conclusion	Remarks
							Malar Asymmetry			Stability				
								measured from vertex view of the patient comparing fractured site with normal site and measuring with a vernier calliper. For measurement of malar height a single reference point (intersection point of midsagittal line with the intercanthal line) was taken and second point was taken at the maximum height of malar region as viewed from vertex view of patient and distance was measured between these two points preoperatively and post operatively. Waters view used to assess the Vertical Dystopia, using a scale and a tracing paper (to measure the difference in the level of the bony orbits).	66.72 ± 3.62 mm with minimum and maximum value 59 mm and 75 mm respectively. In group B the average malar height at 6th week was 68.26 ± 3.76 mm with minimum and maximum value 60 mm and 74 mm respectively. According the measurement at the 6th week, the malar height was statistically significant (i. e. the average malar is greater in group B) i.e. p-value (0.04 < 0.05).			patients were from group B. Thirty-four fractures were unstable in group A and 10 were unstable in group B. The fracture stability was statistically higher in Group B as compared to group A, i.e. p-value (0.000 < 0.05).	zygomatic bone fractures.	(mm) ± SD 69.18 ± 3.2, 67.02 ± 3.52−3 week, 66.72 ± 3.62−6 week, Group B -Malar Height 1 st week (mm) ± SD = 69.02 ± 3.25, 3 weeks = 68.38 ± 3.62, 6 weeks = 68.26 ± 3.76
8	Hasse et al., 2011	Brazil	21–64 years (mean = 33 years)	3 patients	11 patients	16 months	Two radiographic points were established in order to evaluate the symmetry of the zygomatic bone from both ides. The first point was defined by the intersection of the nose bones (nasal pyramid) and the nasal septum, being called the nasal point (NP). The second point, called the zygomatic point (ZP), was established from the most sideward point and outside the zygomatic arch	PA Waters view was used pre and post operatively. For all of the radiographs a size of standard image was established, so that there would not be differences among them. After obtaining the images, the analysis was carried out by way of the program Im- age Lab 2000/ 2.4—a program of analysis and digital pro- cessing/ computerized image.	For the area, the average of the operated side was 263.86 mm and 269.19 mm for the opposite side, not having any statistical difference between them.From the measuring of the distance from the NP to the ZP, the average values of 44.50 mm for the right side and 45.16 mm for the left side presented a statistically significant difference (p = 0.003).	Stability assessed using clinical signs and symptoms	Assessment done by evaluating signs and symptoms such as ectropion, entropion, enophthalmos, exophthalmos, diplopia, sclera apparent, malocclusion or limited mouth opening.	The type of fixation which provided better fixation was not specified however, The good stability obtained from the fixation in two points gains force when compared with the sides obtain-ed from the Control Group, in other words, the patients who did not have fractures of the ZMC. In those we verified that the differences in the values obtained be-tween the right side and the left side, in referring to the perimeter and, as well as the area, were also not statistic-cally significant	The treatment of unilateral fractures of the zygomaticomaxillary complex with the use of plates and screws of the 1.5 mm system proved to be effective, showing good esthetic results and low complication rates.	The authors did not specify which form of fixation was superior in the study, however malar asymmetry was lesser in the treated group. p < 0.05. Mean of treated group −62.53 (perimeter), area - 266.53. SD Treated group −4.71 (perimeter), area −38.41

2.6. Assessment of study quality

The quality of the studies was assessed by two investigators (NG and SB) based on ASNBR modifications. Seven qualitative parameters were used for analysis (mean age, study design, type of fixation, number of participants, malar asymmetry, and stability).

3. Results

This systematic review followed the guidelines in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (Fig. 1).

Preliminary screening consisted of 757 studies and additional records identified through other sources of 272 studies.

Among these 1029 studies, 837 studies were excluded after reviewing the titles. Thus, 192 studies were left, which were screened for duplicates. A total of 52 duplicates were removed, leaving 105 studies. A review of abstract further excluded 71 studies, so 34 studies that remained were evaluated to fit the eligibility criteria. On the basis of information on fixation methods and parameters of evaluation of fixation method, 26 studies were further excluded.

A final number of eight studies were included in the qualitative synthesis. Of these eight articles, two were randomized controlled trials, one was a prospective short clinical study, one was a retrospective study and four were clinical studies. Data of 823 participants with zygomaticomaxillary complex fractures were extracted from the eight articles included in our final review.

3.1. Mean age

In our study, the mean age of the patients with ZMC fractures was 38.87 years.

3.2. Study design

Among the eight included studies, four were clinical studies, two were randomized clinical trials (RCTs), one was a retrospective clinical study and one was a prospective clinical study.

Out of the eight studies, three articles were of good quality (37.5%), four articles moderate quality (50%) and one article poor quality (12.5%).

3.3. Number of participants and type of fixation

The eight studies were divided into two groups assessing two-point vs three-point fixation methods. A total of 823 patients were evaluated as follows:

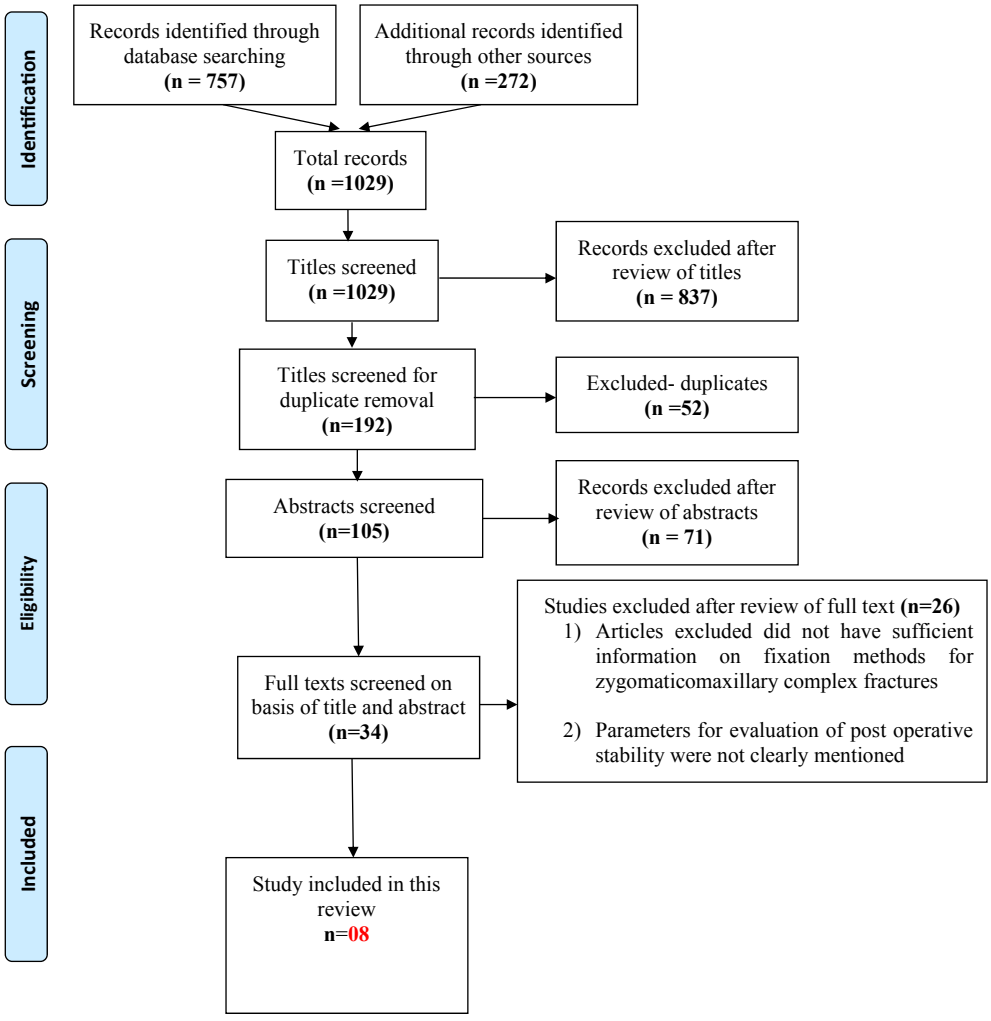

Fig. 1. Prisma flow chart.

Group A, which assessed two-point fixation consisted of 492 patients (60%).

Group B, which assessed three-point fixation consisted of 331 patients (40%).

3.4. Malar asymmetry

There was a considerable methodological heterogeneity between the studies for the assessment of malar asymmetry, as each author had implemented their own method of evaluating it. Out of eight articles, two articles did not mention any information on malar asymmetry. Hence, a qualitative assessment could not be performed among these studies; however, each article could be inferred on the technique implemented by the author. Out of the six studies with their 250 participants, the incidence of malar asymmetry was less in the three-point fixation group (N = 120) as compared to the two-point fixation group (N = 130).

3.5. Stability

There was ambiguity in the assessment of postoperative stability, among the eight articles. Three studies had not mentioned postoperative stability. Among the 6 studies with 209 participants, it was found that post-operative stability was superior in cases treated with three-point fixation (N = 110) as compared to two-point fixation (N = 113).

4. Discussion

The zygomaticomaxillary complex is an important part of the facial skeleton, and because of its lateral prominence is commonly injured, particularly in road traffic accidents and interpersonal violence (Peretti and Macleod, 2017). Hence it is the second most common mid-facial bone fractured after the nasal bones and overall represents 13% of all craniofacial fractures. However, the incidence and etiology vary from area to area; another study shows that zygomatic bone fractures were commonly found among young males and the most common cause was found to be road traffic accidents (Rana et al., 2012).

These injuries can result in both functional (diplopia, trismus, and paraesthesia) and aesthetic deformities (midfacial widening, malar flattening and globe malposition (Bradley Strong and Gary, 2017).

Because of its importance in the facial skeleton, which dictates soft tissue overlay and harmony, zygomaticomaxillary complex fractures require suitable diagnosis and effective management to restore premorbid form and function (Peretti and Macleod, 2017).

Despite the high frequency of the zygomaticomaxillary complex (ZMC) fractures, there is no consensus among surgeons regarding the best surgical management. Thus, the surgical treatment of these fractures remains challenging. Basically, four principles must be considered when undertaking the repair of a facial fracture: namely, adequate exposure, proper reduction, stable fixation, and minimal complications (Nasr et al., 2017).

The use of open reduction and internal fixation of simple displaced fractures of the zygoma is an attempt to define the simplest method of achieving premorbid aesthetic and post-reduction stability.

Various surgical techniques have been described for the reduction of the zygomatic complex fracture. Open reduction with surgical incisions has been accomplished through Keen's approach, Gillie's approach, bicoronal scalp flap approach, or the more popular Dingman's approach (Rana et al., 2012).

Historically, surgeons have focused on the number and location of buttresses that should be repaired for optimal ZMC fracture stability (Bradley Strong and Gary, 2017).

The need for one-point, two-point, three-point, or four-point fixation should be based on fracture stability, and applying the minimum amount of hardware to maintain fracture reduction throughout the process of healing. This approach has been termed functionally stable fixation (Bradley Strong and Gary, 2017).

Irrespective of the fixation used, reduced fractures are vulnerable to postoperative displacement due to masticatory forces, and hence result in a delayed malar asymmetry and vertical dystopia (Nasr et al., 2017). According to Rudderman and Mullen (1992), the displacement may occur in six possible directions of motions: translation about the x, y, z-axis and rotation about the x, y, z-axis.

In spite of several academic debates that exist in the literature regarding the fixation of ZMC fractures, there is not one conclusive treatment that is used as a gold standard to treat zygomaticomaxillary complex fractures. Thus, we undertook this study to systematically review the existing literature on treatment and management of ZMC fractures and to evaluate malar asymmetry postoperatively using two-point vs three-point fixation techniques.

In our review, eight clinical studies were included that satisfied the inclusion criteria (Dutt, 2018; Kim et al., 2012; Latif et al., 2017; Nasr et al., 2017; Ji et al., 2016; Candamourty et al., 2013; Rana et al., 2012; Hasse et al., 2011). These had been conducted in India, Korea, Saudi Arabia, Egypt, and Pakistan. A university or dental hospital was the setting in all the studies.

A total of 823 participants were investigated based on the different modes of fixation used to treat zygomaticomaxillary complex fractures. The study included both sexes. The participants had a clinical diagnosis of zygomaticomaxillary complex fractures. Mean age range of the participants was 15–64 years. Cause of trauma was road traffic accidents, interpersonal violence and assault, with road traffic accidents being the main causative factor in accordance with results derived from Latif et al. (2017).

In our review, most of the studies designed on ZMC fractures lacked a standard method of comparison of different parameters. A few studies assessed malar asymmetry and vertical dystopia (Rana et al., 2012; Nasr et al., 2017); in addition, they also evaluated projection displacement (forward and medial on an axial computed tomography), patient satisfaction and actual duration of surgery. Latif et al., 2017 evaluated 100 patients divided into two groups of 50 each. Parameters such as malar height and vertical dystopia at 1, 3, and 6 weeks post-surgery were assessed; in their study, they concluded that three-point fixation reduced post-operative complications such as altered malar height, vertical dystopia, and stability of bone. Dutt, 2018, evaluated a total of 40 patients over a period of 6 weeks and concluded that three-point fixation was a better treatment modality than two-point fixation for ZMC fractures. Candamourty et al., 2013, had conducted a study in 20 patients with a follow-up of 4 weeks. They concluded that the protocol of three-point, miniplate fixation was effective in terms of stability and relapse. However, three-point fixations are preferred in zygomatic complex fractures to avoid rotation of fragments postoperatively on a vertical or horizontal axis. Rana et al., 2012, also concluded based on their study that open reduction and internal fixation using three-point fixation by miniplates is the best available method for the treatment of zygomatic bone fractures and precise reconstruction with rigid internal fixation at three points is superior to two-point fixation. Kim et al., 2017, evaluated 41 patients and divided them into two groups receiving two-point and three-point fixation respectively; they were evaluated over a period of 12 weeks. It was concluded that there was little difference in post-operative stability between the two groups; hence the amount of displacement is not a very important consideration

when deciding the fixation method, including the number and location of mini plates for fixation. The authors conducted this study with a limited sample size and did not find any statistically significant differences in post-operative stability in the two groups ($P > 0.05$).

Nasr et al., 2017, conducted a study in 40 patients with a duration of follow-up of 12 weeks; they concluded that apart from asymptomatic and clinically unnoticeable radiological difference, the two-point fixation modality for displaced ZMC fractures is almost as effective as three-point fixation and prevents post-reduction rotation or clinical displacement with a significantly lower cost.

A few studies included in this review had their own drawbacks as well. Hasse et al., 2011, evaluated 30 patients over a period of 16 months and concluded that the treatment of unilateral fractures of the zygomaticomaxillary complex with the use of plates and screws of the 1.5-mm system proved to be effective, showing good aesthetic results and low complication rates. Although the authors did not specify which form of fixation was superior in the study, it was statistically proved that malar asymmetry was less in the treated group, ($P < 0.05$). A retrospective study done in 502 patients by Ji et al., 2016, assessed patients over a period of 10 years and concluded that minimal incision, familiar approach and fixation methods of the surgeon are recommended to treat ZMC fractures. However, the authors did not specify which form of fixation was superior in the study, although they concluded that many fixation procedures are available, and hence, a safe and facilitated procedure is the best way to treat such fractures.

In this systematic review, five out of eight authors were in favour of three-point fixation for the treatment of ZMC fractures. In a study conducted by Kim et al., 2017, no statistically significant differences in post-operative stability were found in the two groups (two-point fixation and three-point fixation). In two studies conducted by Hasse et al., 2011 and Ji et al., 2016, the authors did not specify which form of fixation was superior in their study, however they concluded that many fixation procedures are available, and hence a safe and facilitated procedure is the best way to manage ZMC fractures.

According to this systematic review, it was concluded by five out of eight authors that three-point fixation is superior to two-point fixation, which is in accordance with the findings of Rana et al., 2017, which revealed that postoperative complications, such as decreased malar height prominence and persistent or increased vertical dystopia, were more frequent in two-point fixation as compared to three-point fixation technique.

Hence it could be concluded that three-point fixation can be used as a standard treatment modality in the effective management of zygomaticomaxillary complex fractures.

5. Conclusion

To conclude, zygomaticomaxillary complex fractures are commonly occurring fractures of the midface that occur due to various etiological factors, with road traffic accidents being the primary cause. The literature includes a variety of different treatment modalities and methods of fixation that could be employed to treat these fractures. However, a uniform consensus is not available to date, and this remains one of the most debated topics in maxillofacial surgery.

In our systematic review, we aimed to evaluate which method of fixation corrects malar asymmetry in the treatment of zygomaticomaxillary complex fractures. A comprehensive search of the literature identified eight articles that fit the inclusion criteria.

Five out of eight studies showed that the use of three-point fixation in the treatment of zygomaticomaxillary complex fractures was superior to two-point fixation for these fractures.

Hence, it can be concluded that three-point fixation is superior to two-point fixation in reducing malar asymmetry in zygomaticomaxillary complex fractures.

5.1. Study limitations

Parameters assessed by all the authors varied, and hence a standardization for comparison could not be done. In one study conducted by Kim et al., 2017, no statistically significant differences in post-operative stability in the two groups (ie, two-point fixation and three-point fixation) were found.

In two studies conducted by Hasse et al., 2011 and Ji et al.,2016, the authors did not specify which form of fixation was superior in their study; however they concluded that many fixation procedures are available, and hence a safe and facilitated procedure is the best way to manage ZMC fractures.

5.2. Future implications

According to this systematic review, it was concluded by five out of eight authors that three-point fixation is superior to two-point fixation. However, further studies should be conducted to evaluate uniform parameters with a larger sample size, and studies should also be conducted to guide the law and enforce strict traffic legislation in order to help prevent such accidents.

Conflicts of interest

Gadkari Nishtha, Bawane Shilpa, Chopra Ratima, Bhate Kalyani and Kulkarni Deepak declare that they have no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcms.2019.07.009.

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