



Sequencing of Fixation in Panfacial Fracture: A Systematic Review

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Abstract

Objective In panfacial fracture management, the controversy still exists in the sequencing of fixation. The purpose of this systematic review is to establish the best sequence pattern which assists in achieving definite facial width, vertical height and anteroposterior projection.

Methods The review was conducted according to the “Preferred Reporting Items for Systematic Reviews and Meta-Analyses” (PRISMA) guidelines. Two independent authors performed a comprehensive search of the PUBMED, EBSCO, J-Gate, SCOPUS and NDH for articles published up until December 2018. Sequence of fixation, timing of intervention, outcome, follow-up period and complications were evaluated for patients with panfacial fracture.

Results In total, 202 articles were identified from the databases. After screening and full text analysis, 25 studies were included in this systematic review. Nineteen studies reported bottom-to-top sequence and two studies reported top-to-bottom approach. However, four studies reported both the approaches. The follow-up period ranges from 3 weeks to 4 years.

Conclusion Based on the literature support and evidence, good and satisfactory outcome achieved in “Bottom-top and outside-in” sequence when compared with other sequence pattern. Early repair of panfacial fracture is advised for proper reduction and fixation, but can be delayed in accompanying life-threatening injuries.

Complications are perceptible in all the sequences; it can be avoided by definitive treatment planning and stepwise management.

Keywords Panfacial fracture · Sequencing · Timing of repair · Polytrauma

Introduction

The sequencing in the management of panfacial fracture still remains a conundrum. The two schools of thought in the management of panfacial fracture are “bottom-top, outside-in” and “top-bottom, inside-out” [1]. Variations exist among these sequences but major consensus exists between the above two sequence, as it is the first point of fixation in panfacial fracture [2]. It is challenging for the surgeon to establish facial frame in all dimensions because panfacial fracture results in lack of reliable bony and soft tissue landmarks [3]. Failure to achieve proper reduction results in post-traumatic facial deformity [4]. Sequencing serves as a guide for stepwise management and assists in achieving facial symmetry [5]. There is no standard protocol available in the literature for the pattern of sequencing in the panfacial fracture management.

The two published timing for the organization of repair of panfacial fracture are early and late intervention [6]. Late intervention can cause secondary injury to the weakened soft tissue and it is more complex as fracture callus formation and fibrosed tissue may compromise functional and esthetic outcome [7]. Though other life-threatening injuries should be given pre-eminence, early stabilization of fractured segments aids in the restoration of symmetric facial contour. Still some surgeons prefer late intervention than early intervention due to various reasons like

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concomitant injuries, patient status at the time of surgery especially after the invention of modern osteosynthesis and less invasive plating system [8, 9]. Controversy exists in the timing of repair in the panfacial fracture management.

This systematic review is to eliminate the perplexity in sequencing of fixation and to determine the ideal operative time in the panfacial fracture management. The purpose of this review is to establish the best sequence pattern which assists in achieving good functional and esthetic outcome.

Methods

Protocol and Registration

This systematic review was based on the “Preferred Reporting Items for Systematic Reviews and Meta-analyses” (PRISMA) checklist and guidelines [10, 11].

Eligibility Criteria

The focused question addressed was “What is the sequence of fixation in the panfacial fracture to achieve good functional and esthetic outcome with minimal complications?” Primary outcome assessed was the sequence pattern, and secondary outcomes evaluated were the radiological and functional outcome of the patient and the complication rate. Table 1 shows the components of the PICO question.

Study types permitted for inclusion were Randomized Controlled Trials (RCTs), Review articles, Prospective studies, Case series/report and Retrospective studies. (Because of the limited literature support for panfacial sequencing no restrictions were applied to the study types.) All studies reported the sequence pattern in the fixation of panfacial fractures and those were published in English until December 2018 were included. In vitro studies, cadaver studies, pediatric panfacial fractures, panfacial burns, vascular complications associated with panfacial fracture and use of distraction device in the treatment of panfacial fractures were excluded (Table 2).

Information Source and Search

Two independent authors (I.P and J.N) conducted an electronic search and in case of conflicts, the resolution was mediated by a third author (K. R). Databases including PUBMED, SCOPUS, EBSCO, J-Gate and NDH were searched for articles published until December 2018. The keywords used were tabulated (Table 3). In addition, grey databases were used to retrieve literature via Open Grey (<http://www.opengrey.cut>).

Data Collection Process

One author (J.N) independently retrieved information from included studies which was checked by second author (I.P). A deliberate analysis was carried out for difference or disagreements between the authors. Any such disagreements were resolved through discussion with a third author (K.R) until a consensus was reached.

Risk of Bias Assessment

Two investigators assessed the methodological quality of the studies using the Newcastle–Ottawa scale (NOS), which is based on three major components: selection, comparability, and outcome. According to the NOS, a maximum of nine stars can be given to a study, which represents the highest quality. A score of five or fewer stars indicates a high risk of bias, while a score of six or more stars indicates a low risk of bias [12].

Results

Study Selection

The primary and secondary search identified 202 articles. These 202 articles were retrieved from database search (PUBMED, SCOPUS, EBSCO, J-Gate and NDH). After the duplicates were removed, 119 articles remained. Titles

Table 1 Components of the PICO question

Components of the PICO question:	
P—Participants	Patients with panfacial fracture were treated by open surgical method
I—Intervention	What is the sequence followed for the open surgical method
C—Comparisons	“Bottom-top, outside-in”, “Bottom-top, inside-out”, “Top-bottom, outside-in” and “Top-bottom, inside-out”.
O—Outcome	Effects of sequencing in panfacial fracture management on functional/radiological outcome and complications

Table 2 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Prospective/clinical study	Cadaveric or in vitro studies
Review of literature	Panfacial fracture in pediatric patients
Retrospective study	Panfacial burns
Case report/case series	Vascular complications associated with panfacial fracture
Published in English language	Use of distraction device in the treatment of panfacial fracture
Published until Dec 2018	Other than English language

Table 3 Primary and secondary keywords

Primary keywords	Secondary keywords
Panfacial fracture	Facial frame
Timing of repair	Complications of panfacial trauma
Sequencing	Complex trauma
Top-bottom/Bottom-top	Polytrauma
Outside-in/Inside-out	

and abstracts were read against eligibility criteria and 76 articles were excluded. Remaining 43 articles were screened. The full text eligibility assessed for 32 articles. After full text reading 7 articles were removed, as the

studies did not describe the pattern of sequencing. Finally, 25 articles were included in this systematic review (Fig. 1).

Study Characteristics and Data Extraction

The included articles were 1 review article, 4 clinical studies, 1 retrospective and literature review, 1 literature review and case series, 6 retrospective studies, 2 case series and 10 case reports. A standard template for data extraction was designed on sequencing, time of intervention, follow-up period, complications and outcome of the included studies. Apart from these details, bibliographic information (author and year) was also extracted (Table 4).

Fig. 1 Flowchart of the search strategy

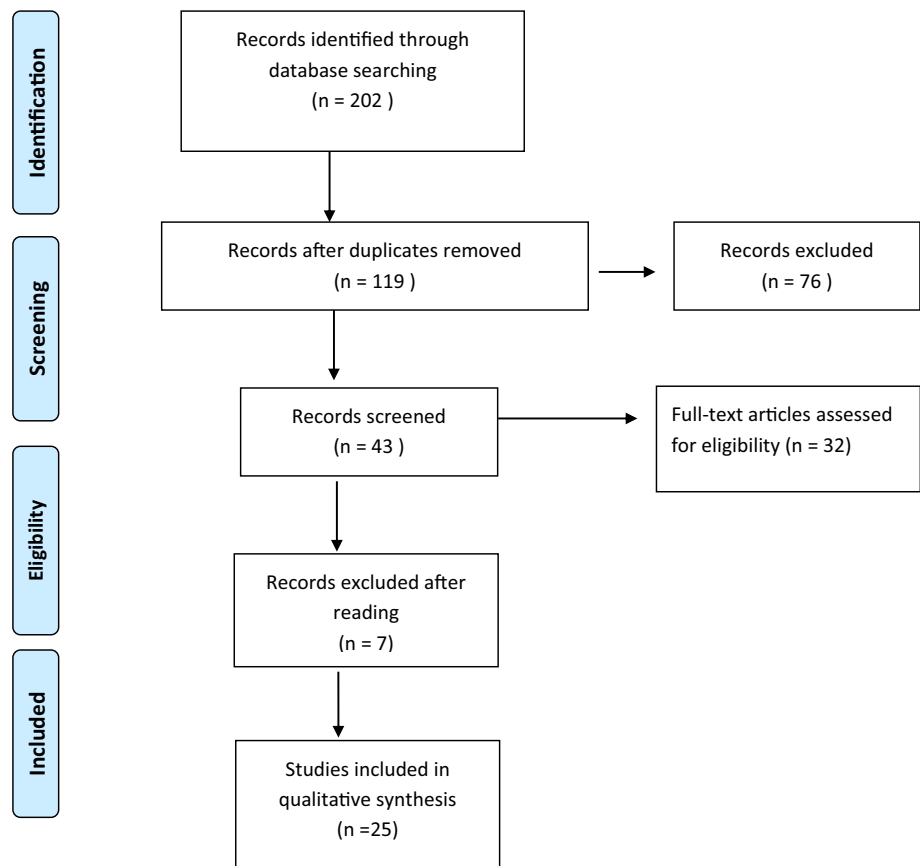


Table 4 Characteristics of the studies included in the systematic review

S. no	First author and year	Study design	Sample (NO)	Sequence	Time of intervention	Outcome	Follow-up period	Complications
1	Dongmei [13]	Retrospective review	33	Bottom to top and outside in	4 weeks	Good (63.64%)	3 to 12 months	Present
2	Mauro pau [14]	Case report	2	Bottom to top and inside out	NM	Satisfactory	NM	Present
3	Ramanujam [15]	Retrospective analysis	15	Bottom to top and outside in	Within 3 days	Satisfactory	NM	Nil
4	Usha Asnani [16]	Case report	1	Bottom to top and outside-in	NM	NM	NM	NM
5	Morais de Melo [17]	Clinical study	1	Bottom to top, outside in	5 days	Good	6 months	No serious complications
6	Vasudev [18]	Review of literature and case series	2	Bottom to top and outside in	NM	Satisfactory	4 months	Present
7	Ruba [19]	Case report	3	Bottom to top and outside in	3 months	Good	2 to 8 months	Present
8	Kelly [20]	Clinical study	40	Bottom to top and outside in	Early (exact time not mentioned)	NM	NM	Present
9	Hameed [21]	Case report	1	Bottom to top and outside in	NM	Good	NM	NM
10	Mall [22]	Case report	1	Bottom to top and outside in	Few days after injury	NM	NM	NM
11	Yang [23]	Retrospective study	107	Bottom to top and outside in	NM	Good	3 to 24 months	Present
12	Powers [24]	Retrospective study	109	Bottom to top and outside in	NM	Good	4 to 6 weeks	Present
13	Bainton [25]	Case report	2	Top to bottom	NM	NM	NM	Present
14	Sharma [26]	Case report	1	Bottom to top and outside in	Early	Satisfactory	1 month	Nil
15	Morrison [27]	Case report	1	Bottom to top and outside in	NM	Satisfactory	NM	Nil
16	Tang [28]	Retrospective study	68	Bottom to top and outside in	NM	Satisfactory	12 months	Present
17	Clauser [29]	Case report	1	Top to bottom	Immediate intervention after injury	Satisfactory	NM	Present
18	Merville [30]	Case series	42	Bottom to top and outside in	Immediate to 2 days	Satisfactory	1 year	Present
19	Guerrissi [31]	Clinical study	58	Both bottom to top, outside in and top to bottom and inside out	7–15 days	Acceptables 85% and not acceptables 15%	12 months	Present
20	Gruss [32]	Case series	401	Both bottom to top, outside-in and top to bottom, inside out	Immediately after resuscitation and CT scanning	Acceptable	4 years	Present
21	Ranganath [33]	Case report	1	Bottom to top and outside in	7 months	Satisfactory	NM	NM

Table 4 continued

S. no	First author and year	Study design	Sample (NO)	Sequence	Time of intervention	Outcome	Follow-up period	Complications
22	Kim [34]	Review article	53	Both bottom to top outside in and top to bottom inside out	NM	Good (similar outcome on both approaches)	3 weeks	Present
23	Degala [35]	Comparative prospective study	11	Both bottom to top—inside out and top to bottom—outside in	4 to 13 days—bottom top 7 to 16 days—top to bottom sequence	Bottom-up approach 60%—excellent 40%—fair Top-down approach 50%—excellent 16%—good 32%—fair	6 weeks	Present
24	Sawhney [36]	Retrospective study	44	Bottom to top and outside in	NM	NM	NM	NM
25	Abouchadi [37]	Retrospective study and review of Literature	48	Bottom to top and outside in	9 days	Fair	6 months	Present

Quality Analysis/Risk of Bias of the Studies Included

The risk of bias and the quality of analysis showed that all the studies included for this review were awarded more than five stars indicating a low risk of bias. Fifteen studies were given nine stars by both the reviewer. There was no statistically significant difference found in the distribution of stars based on NOS, Chi square = 1.500, *p* = 0.682 (Table 5).

Additional Analysis

The kappa statistic (*k*) was used to determine inter-reader agreement during the article selection process in the database search. An agreement of 100% was observed for Sequencing, Outcome, complications, timing of intervention and follow-up as 96%.

Sequencing in Fixation

Eighteen studies reported bottom-top and outside-in sequence for the fixation of panfacial fracture. Mandible as a long, isolated and strong bone in the face serves as a foundation and stable base to reconstruct the craniofacial skeleton [13, 16, 27]. By fixing the mandible as a first point

of fixation in panfacial fracture, it determines the width, height, and projection through body, condyle/ramus, and symphysis region [22, 26, 28, 36]. It also assures the continuity with lower facial third and entire facial skeleton by interacting with maxilla through occlusion and skull base through TMJ [37]. After the anatomic reduction by bottom-top principle, the midface was fixed based on “outside-in” principle [17, 18, 24]. Midface fixation begins with ZMC region ends in the NOE region. ZMC has definitive landmarks than NOE complex for the fractured segment reconstruction [15, 21, 33]. The ZMC fixation also provides the control for transverse and anteroposterior dimension, stability of lateral pillars, and prevents asymmetry of face [19, 20, 30]. This bottom-top and outside-in approach is based on the basic principle of fracture management—“simple to complex” [23].

Mauro Pau et al. [14] followed bottom-top and inside-out sequence as it requires intracranial reduction with neurosurgery team due to nasal bone dislocation into anterior cranium.

On contrary, two studies delineated “top-bottom” sequence. Clauser et al. [17] reported “top-bottom” approach as it requires immediate intervention of traumatic dislocation of right globe with optic nerve elongation and presence of existing deeply lacerated wounds in the

Table 5 Quality assessment of the included studies based on the Newcastle–Ottawa scale

Groups	Six star	Seven star	Eight star	Nine star	<i>X</i> ²	<i>p</i> value
Reviewer 1	1	5	5	14	1.500	0.682
Reviewer 2	3	3	5	14		

midface region. Bainton [13] 1990 also reported “top-bottom” approach to terminate oculocardiac reflex by the elimination of pressure in the globe and peri-orbital tissue occurred after 2 h of anesthetics.

Three studies described both “top-bottom, inside-out” and “bottom-top, outside-in” sequences [31, 32, 34]: top-bottom, inside-out sequence in undisplaced fronto-orbital fractures, as it serves as a stable base for lateral projection and width of the face by permitting the media line re-saturation; bottom-top, outside-in sequence in mandibular fracture, where establishment of reduction is more accurate to re-establish the lower facial width, height and projection. Saikrishna Degala [35] delineated both “Bottom-top, Inside-Out” and “Top-bottom, Outside-in” sequences. The reason for the above sequence was not mentioned.

Outcome

The outcome variables were re-establishment of facial profile and shape, facial symmetry, occlusion, mouth opening, mandibular movements, good reduction and fixation of fractured segments and soft tissue healing. Outcomes that report from individual studies were assessed. The quality of evidence and treatment effect magnitude for the superior outcome were evaluated.

Functional and esthetic outcome were reported good in seven articles [13, 17, 21, 23, 24, 31, 34]. In addition, the radiological outcome with proper reduction and fixation was reported in four articles [15, 27, 32, 37]. Improved soft tissue scar healing with satisfactory extraoral and intraoral wound healing were reported in three articles [18, 19, 29].

When compared with pre-morbid condition, the post-operative rehabilitative outcomes were reported satisfactory in five articles [14, 26, 28, 30, 33]. In five articles, the outcome is not mentioned [16, 20, 22, 25, 36].

A study which compared the outcomes of both “bottom-top” and “top-bottom” sequences and reported 60% of excellence and 40% of fair outcome in “Bottom-top” sequence and 50% of excellence and 16% good, 32% fair outcome in “top-bottom” sequence [35].

Time of Intervention

The timing for the repair of panfacial fracture remains controversial. The emphasis in the intervention of panfacial fracture should be early, i.e., within first few days of injury because callus formation and contraction of the soft tissue make reduction and reconstruction of craniofacial skeleton more challenging. It also avoids residual deformity. However, in patients with associated life-threatening injuries, hemodynamically and neurologically unstable patients, late management is indicated. In our systematic review, 12 articles reported early management of panfacial fracture

[13, 15, 17, 20, 22, 26, 29–32, 35, 37]. The timing of intervention in the panfacial fracture management was not mentioned in 11 articles [14, 16, 18, 21, 23–25, 27, 28, 34, 36]. Two articles reported late management because the panfacial fracture was addressed as a secondary procedure [19, 33].

Discussion

Facial trauma is one of the leading causes for significant rate of morbidity and mortality especially people under 40 years of age [38]. Pan facial trauma is the involvement of at least two of the three vertical third—upper, middle and lower one-third of face simultaneously [39]. The mechanism of injury includes road traffic/motor vehicle accidents, fall from height, slip down, assault, sports related, industrial accidents, gunshot wounds and animal-inflicted injuries [40–43].

Successful management of panfacial fractures begins with proper pre-operative planning. Pre-operative planning includes complete physical examination, radiographic imaging as Computed Tomography to define the fracture patterns, bone loss assessment for possible bone grafting and soft tissue defect for potential flap coverage [44–46].

Management of panfacial fracture is complex because of devoid of reliable hard tissue and soft tissue landmarks affecting the function, esthetics and contours of the associated structures [47].

The goal is to restore the anatomy in all three dimensions which can be achieved by plating vertical, horizontal and sagittal buttresses whenever necessary. The buttresses provide resistance to external forces and give structural support by absorbing the forces acting on the face [48, 49].

In “bottom-top and outside-in” approach, the first bone to be fixed depends on whether the mandible is fractured or not. If there is a mandibular fracture, then the focus shifts to whether the condyle is fractured or not along with other parts of the mandible. In case of condylar fractures, the first bone to be fixed is condyle to establish the height of the face in reference to the cranial base. After the condylar fixation, dentate segments such as angle, body, parasymphysis or symphysis were fixed to create the occlusal base for further fixation. The mandibular occlusal base recreates the width and projection of lower two-thirds of the face. Controversy arises whether condyle or dentate segments have to be fixed first. Mauro paul et al. [14] state that “the lingual realignment of a symphyseal fracture allows realignment of mandibular ramus in the correct transverse position, facilitating reduction and fixation of condyle”. However, both anatomical sites were fixed only with an anatomical reduction and not in reference to any stable landmarks.

The next keystone is to create a stable occlusal base of maxilla. In case of Lefort type fractures and sagittal palatal fractures, the next bone to be addressed after mandible is palate. Depending on the pattern, the palatal fractures have to be managed either by closed or open reduction. Kelly [20] insisted the reduction and fixation of the maxillary palate which is the template for the width of the reconstruction of the lower face. Unfortunately, the importance of palate fixation in the sequencing of panfacial fracture was not mentioned in most of the articles [13, 17, 23].

Once the mandible is reconstructed and occlusal relationship is established with IMF, the outside-in sequencing of fixation is followed. Most of the articles suggest the fixation of fronto-zygomatic fracture using speno-zygomatic suture as a guide. Proper alignment of the zygomatic arch and the infraorbital rim must be taken into consideration. In the reviewed articles, the sequence of comminuted zygomatic arch fixation is not well documented. The need of fixation of root of zygoma fracture to the temporal bone is not discussed. Though the approach is said to be “outside-in” the sequence starts either with speno-zygomatic suture or fronto-zygomatic suture. It is then followed by zygomatico-maxillary suture and orbital rim. After the reconstruction of zygoma and maxilla, NOE has to be addressed. The final step is the orbital wall reconstruction.

The top-bottom, inside-out approach is followed mainly when there is neurocranium fractures or fractures which necessitates emergency intervention [25, 29]. The first priority is to address any significant calvarial, frontal sinus and orbital roof fractures. Using calvarium as the foundation for the midface reconstruction, the sequence of fixation progresses to the Lefort I level. Occlusion has to be achieved with midface as a stable base. Reconstruction of mandible is the final step in this approach.

Inside-out sequence of fixation is carried only after stabilizing and fixing the outer frame. Again, though the approach has been called “inside-out”, the sequence starts only from the malar or orbit zygomatic complex fracture which is followed by NOE fixation [30]. So in both approaches generalizing the term “bottom-top, outside-in or top-bottom, inside-out” is actually a misnomer. Moreover, it confuses the readers from the actual sequence of fixation.

The complications documented in the literature have got no relevance to the sequence of fixation. It has to be related to the complexity, number of bones fractures and soft tissue damaged in the panfacial fracture. The most common complication includes CSF leakage, dish face deformity, enophthalmos, traumatic telecanthus, malocclusion, limited mouth opening, paresthesia, facial nerve injury, infection and soft tissue scarring [4, 50].

Primary or secondary management depends on the stability of the patient, severity of injury and other

concomitant injuries. Primary management of panfacial fracture is definitive to acquire best functional outcome, esthetic outcome and to evade residual deformity. Definitive intervention can be performed up to 15 days beyond that callus formation takes place and soft tissue becomes pliable which make the reduction more challenging. If the definitive intervention is not possible due to neurologic, cardiac or hemodynamic status and concomitant cervical, rib or other injuries, then secondary management is mandatory. The intent of both primary and secondary management is to restore function and aesthetics.

This systematic review is to emphasize the sequence of fixation in panfacial fracture which abets to achieve best esthetic and functional restoration. Repositioning of the bone fragments is difficult in top-bottom sequence and excessive pressure can lead to the failure of internal fixation, which is the common disadvantage in top-bottom sequence. Top-bottom sequence can be applied in patients with accompanying neurosurgical procedures. In bottom to top sequence, mandible as a strongest bone in face can be reduced easily and provides a strong foundation for craniofacial reconstruction. The need for secondary procedures was less in bottom-top approach when compared with top-bottom sequence. Based on the evidence, the definitive approach for panfacial fracture fixation is “bottom top–outside in” sequence. “Outside-in” sequence provides absolute facial contour by acquiring width and projection of face. On contrary some authors prefer “inside-out” sequence with intact or stable frontal bone which would be a reliable landmark for NOE complex fixation but NOE fragments are fragile and it is difficult to fix even with the stable base. From the results of this review and literature sustenance, the good and satisfactory outcome is achieved in “Bottom-top and outside-in” sequence when compared with other sequence patterns. Complications are perceptible in all the sequences, and it can be avoided by definitive treatment planning and step-wise management.

In conclusion, this systematic review indicates that “Bottom-top and outside-in” is the preferred sequence pattern in the fixation of panfacial fracture in patients with non-life-threatening injuries. In case of life-threatening injuries, the sequence pattern should be tailored individually for each patient. Early repair of panfacial fracture is advised for proper reduction and fixation but can be delayed in accompanying life-threatening injuries.

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Compliance with Ethics Standards

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