A Comparative Prospective Study of Two Different Treatment Sequences i.e. Bottom Up–Inside Out and Topdown–Outside in, in the Treatment of Panfacial Fractures

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Abstract

Purpose To compare the sequence bottom-up inside-out with top-down outside-in, in the treatment of pan facial fractures and to evaluate the outcome of these approaches.

Patients and Methods The data from 11 patients with panfacial fracture are prospectively analysed. Five cases are treated with bottom-up approach and six patients with top-down approach.

Results There were 11 male patients (six in top-down approach and five in bottom-up approach), ranging in age from 24 to 50 years. All injuries were result of RTA ($n = 11$, 100 %). Final treatment outcome was excellent in 3 (50 %), 1 (16 %) good and 2 (32 %) cases were fair in topdown approach, 3 (60 %) excellent and 2 (40 %) fair in bottom up approach with contingency coefficient value ($P < .632$) which was insignificant. There was no significant deviation from the two groups in the final treatment outcome.

Conclusion Within the limitation of low sample size we found that both bottom-up inside-out and top-down outside-in approaches have similar clinical outcomes. Hence it could be suggestive to start fixation of least disrupted (more stable) facial half as a guide for reconstruction of the remaining. Choice of the bottom-up inside-out or top-down outside-in sequence should be according to the pattern of

fractures and preference of the surgeon. However, further controlled clinical trials, comparative studies with a larger sample size would be better to evaluate the final clinical outcome of individual techniques.

Keywords Panfacial fractures · Bottom up-inside out approach · Topdown-outside in approach

Introduction

Pan facial fractures (PFF) are those fractures involving the upper, middle and lower thirds of the face, involving mandible, maxilla, zygomaticomaxillary complex (ZMC), frontal bones and naso-orbitoethmoid (NOE) region often associated with emergencies such as cranio-cerebral injury and cervical spine injury [1, 2]. Panfacial fractures are caused by high velocity trauma, motor vehicle collisions, assaults, sports related accidents, industrial accidents, and gunshot wounds [3]. Understanding panfacial fracture pattern is complicated as it varies between patients. Management of patients with panfacial fractures hence can be extremely challenging even for experienced surgeons.

Historically, these fractures were treated conservatively, which led to significant postoperative problems, including crippling malocclusion, significant increase in facial width, and decreased facial projection [4]. Treatment of PFFs can be difficult because of the apparent loss of all references guiding the start of facial skeleton reconstruction, particularly in fractures interrupting the maxillary and mandibular arches that eliminate recognizable stable occlusion and re-establish bone continuity [5]. Efforts at secondary reconstruction of poor clinical results have been dismal overall, enforcing the need to get things right the first time.

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For sequencing purposes, the facial skeleton is figuratively divided about the Lefort I plane [2]. In the 1980s and early 1990s, craniofacial surgeons popularized the principles of wide exposure and the direct visualization of fracture alignment. These principles, developed for cranial surgery, were applied to panfacial fractures and influenced their order of repair. Surgeons began reconstruction with the frontal bone and proceeded into the midface, using the upper face as a template for the lower face [6]. This technique was developed to ensure correct repositioning of the maxillary alveolar ridge in all dimensions, through the anatomic reconstruction of the buttress of the upper face. The maxillary alveolar ridge can then be used as a foundation for three-dimensional (3D) repositioning of the mandible [7].

Maxillofacial surgeons operating in the 1980s struggled with a technical problem: wire fixation of the condyles. Treatment of a condylar fracture accompanying a Le Fort I fracture without rigid fixation can lead to clockwise rotation of the maxillomandibular complex with retropositioning of the chin, an increased occlusal plane, and loss of posterior facial height [8]. The advent of internal fixation with miniplates virtually eliminated this obstacle, allowing the inversion of treatment order. Bottom-to-top sequences focus on the mandible, which is the strongest bone of the facial skeleton and provides a buttress that can be related accurately to the cranial vault through rigid internal fixation [9].

With the availability of detailed imaging, rigid fixation, bone grafting techniques, soft tissue re-suspension and proper sequencing, outcomes can be optimized. Facial reconstruction treatment programs and principle of management are thus unique, but are not without considerable controversy. The determination of ideal sequencing of a complex panfacial fracture can be the greatest challenge to a maxillofacial surgeon [10].

In recent years literature shows that surgeons have popularized bottom-up approach with better outcome. Top-down approach needs reevaluation. In a quest to understand both approaches we proposed to evaluate them prospectively.

Methodology

Eleven patients are randomly divided into two groups (six in Topdown-outside in & Five in Bottom up-inside out approach) one with bottom-up inside-out sequence and other with top-down outside-in sequence.

Two different sequences of treatment are carried out for each group [10] as shown below:

Group A Bottom-up inside-out	Group B Top-down outside-in
Repair of palatal fractures	Repair of frontal sinus fractures
Maxillomandibular fixation (MMF)	Repair of bilateral zygomaticomaxillary complex (including arch) fractures
Repair of condylar fractures	Repair of naso-orbitoethmoid fractures
Repair of mandible fractures (symphysis/body/ramus)	Repair of Le Fort fractures (including midpalatine split)
Repair of zygomaticomaxillary complex (including arch) fractures	Maxillomandibular fixation (MMF)
Repair of frontal sinus fractures	Repair of bilateral sub condylar fractures
Repair of naso-orbitoethmoid complex fractures	Repair of mandibular fractures (symphysis/body/ramus)
Repair of maxilla	

Below two cases have been illustrated case 1 (Figs. 1–3) Bottom up approach and case 2 (Figs. 4–7) top down approach. Proper soft tissue management, wound closure and proper drainage are ensured. Treatment success is established according to face outline, occlusion, mouth opening and local deformity.

Criteria	(1) Face outline basically normal, without the need for additional surgery for correction. (2) Occlusion had returned to pretrauma levels, without the need for additional surgery. (3) The mouth opening more than 35 mm and temporo mandibular joint function was normal and stable. (4) No additional surgery was necessary for secondary local deformity, such as deformities in the orbital and naso-orbitoethmoidal regions, facial nerve injuries, and localized bone.
Excellent	When all four criteria are met.
Good	Three criteria are met.
Fair	Two criteria are met.
Poor	One or none are met.

Case-1: Bottom-Up Approach

Case-2: Top-Down Approach

Fig. 1 Pre op and post-op photo

Results

There were 11 male patients (six in top-down approach and five in bottom-up approach), ranging in age from 24 to 50 years (Figs. 8). All injuries were result of RTA ($n = 11$, 100 %). Five cases were reported with other concomitant injuries ($n = 3$, 50 % of top-down approach, and $n = 2$, 40 % of bottom-up approach).

Fig. 4 Pre op and post op photographs

Occlusal Derangement

Moderate derangement pre-op is seen in six patients (100 %) in top-down approach, and 4 (80 %) patients in bottom-up approach (Table 1). One (20 %) patient in bottom-up approach had gross derangement. All attained normal occlusion at the end of 6 weeks (100 %).

Fig. 2 Pre-op 3D CT images

Fig. 3 Intra-op photographs and post op 3D CT images

Mouth Opening

Pre-op mean mouth opening of 15 mm in bottom-up approach and 16 mm in top down approach was seen (Table 2). Post op mouth opening in top-down approach 6 weeks post

approach (Fig. 11) with contingency coefficient value ($P < .632$) which is statistically insignificant. There was no significant deviation from the two groups in the final treatment outcome.

Bottom-up: five patients

S. no.	Complications	Preoperative	Post 1 day	Post 2 day	Post 3 day	1 week post	2 week post	3 weeks	4 weeks	5 weeks	6 weeks
1	Infection	0	0	0	0	0	0	0	0	1	1
2	Occlusion derangement	6	1	1	1	1	1	1	1	1	0
3	Parasthesia	5	5	5	5	5	5	3	1	0	0
4	Facial asymmetry	5	5	5	5	5	2	2	2	2	2
5	Oronasal fistula	0	0	0	0	0	1	1	1	1	1
6	Post op local deformity	0	0	0	0	0	0	0	0	0	0

Top down approach: six patients

S. no.	Complications	Preoperative	Post 1 day	Post 2 day	Post 3 day	1 week post	2 week post	3 weeks	4 weeks	5 weeks	6 weeks
1	Infection	0	0	0	0	0	0	0	1	1	1
2	Occlusion derangement	6	0	0	0	0	0	0	0	0	0
3	Parasthesia	6	6	6	6	6	6	2	1	1	1
4	Facial asymmetry	6	6	6	6	6	2	2	2	2	2
5	Oronasal fistula	0	0	0	1	1	1	1	1	1	1
6	Post op local deformity	0	0	0	0	0	0	0	0	0	0

operative is mean 43 mm and in bottom-up approach is 42 mm (Fig. 9), statistically insignificant deviation.

Facial Asymmetry

Facial asymmetry is present in two patients each in top-down and bottom-up approach groups (Fig. 10).

Need for Second Surgery

Two patients in bottom-up group and three patients in top-down group required secondary surgery (Table 3), but without statistical significant difference ($P < .740$).

Final Treatment Outcome

Final treatment outcome is, 3 (60 %) excellent and 2 (40 %) fair in bottom-up approach and excellent in 3 (50 %), 1 (16 %) good and 2 (32 %) fair in topdown

Discussion

Some authors define *panfacial fracture* as fracture patterns involving both midface and mandible. Others think it must involve the upper, middle, and lower face that means the NOE complex and possibly frontal sinus, zygomatic complex, Le Fort midfacial area, and the mandible are fractured at the same time [2]. Markowitz and Manson [11] described frontal bone and palatoalveolar fractures as extended injuries with panfacial fractures. In this study, we used the least restrictive definition: a combination of mandibular, maxillary, and zygomatic complex fractures.

For the planning of treatment, one must acquire as much data as possible to help analyze the deformities and plan treatment. We believe that CT scanning from the cranium to the submental region is essential for diagnosis and treatment of panfacial fractures. Three dimensional CT reconstruction provides a better understanding of the

Fig. 5 Pre op 3D images

Fig. 6 Intra op

overall relationships but are not as exacting for assessment of some areas, such as the internal orbit.

There are many advantages to early treatment of pan-facial fractures. It not only reduces the risks of postoperative infection but also maintains soft tissue expansion

[12]. A delay of 2 weeks for definitive repair increases the difficulty in obtaining adequate reduction of fracture dislocations [12]. Carr and Mathog [13] believe bone healing beyond 3 weeks is in a “grey stage”—the edges of the fragment begin to absorb and remodel, which makes it very difficult to obtain anatomic reduction. This can lead to bone mal union, delayed union, nonunion, and bone defect. In our study, in patients who were medically unstable because of associated neurologic or systemic injuries, facial fracture repair was delayed. In our study all cases in top-down approach were treated between 7 and 16 days (mean 9.8 days) and bottom-up approach were treated between 4 and 13 days (mean 7.8) ($P < .37$). There was not much difference in timing of surgery in both groups which could influence the anatomic reduction and overall outcome.

Fig. 7 Post op 3D images

Fig. 8 Age of the patients, location of mandibular fractures, location of maxillary fractures

Table 1 Occlusal derangement

Crosstab			
GRP	Occlusal derangement		Total
	Gross	Moderate	
B_U approach			
Time			
Pre			
Count	1	4	5
% of time	20.0	80.0	100.0
Post			
Count	1	4	5
% of time	20.0	80.0	100.0
6 weeks			
Count	1	4	5
% of time	20.0	80.0	100.0
Total			
Count	3	12	15
% of time	20.0	80.0	100.0
T_D approach			
Time			
Pre			
Count		6	6
% of time		100.0	100.0
Post			
Count		6	6
% of time		100.0	100.0
6 weeks			
Count		6	6
% of time		100.0	100.0
Total			
Count		18	18
% of time		100.0	100.0
Symmetric measures			
GRP	Value	Approximate significance	
B_U approach			
Nominal by nominal			
Contingency coefficient	.000	1.000	
Number of valid cases	15		
T_D approach			
Nominal by nominal			
Contingency coefficient			
Number of valid cases	18		

Jundt and colleagues, in 2012, published a literature review of 842 patients who underwent submental intubation. The technique was successful in 100 % of cases. The average procedural time was 9.9 min, with ranges varying from <4 to

Table 2 Mouth opening

Descriptive statistics					
	GRP		Mean	SD	N
Mo_pre	B_U approach		15.0000	1.73205	5
	T_D approach		16.5000	1.87083	6
	Total		15.8182	1.88776	11
Mo_pos	B_U approach		18.8000	.83666	5
	T_D approach		19.3333	1.50555	6
	Total		19.0909	1.22103	11
Mo_6 weeks	B_U approach		42.0000	4.18330	5
	T_D approach		43.1667	2.63944	6
	Total		42.6364	3.29462	11
Tests of within-subjects effects					
Measure: measure_1					
Source	Type III sum of squares	df	Mean square	F	Significance
Change	4669.315	2	2334.658	765.927	.000
Change × GRP	1.315	2	.658	.216	.808
Error (change)	54.867	18	3.048

Fig. 9 Mouth opening

30 min. No major complications were reported, and minor complications occurred in 7 % of patients. Accidental extubation only occurred in the pediatric population on two occasions. The most frequent complications reported were superficial skin infections, damage to the tube apparatus and fistula formation. Other reported complications included right main stem bronchus intubation or obstruction, hypertrophic scarring, excessive bronchial flexion, venous bleeding, transient lingual nerve paresthesia, patients who were medically unstable because of associated mucocoele, and dislodgement of the throat pack sticker in the submental wound [4].

Fig. 10 Facial symmetry

Table 3 Need for second surgery

Crosstab			
	GRP		Total
	B_U approach	T_D approach	
Need for second_sug			
Yes			
Count	2	3	5
% of sec_sug	40.0	60.0	100.0
No			
Count	3	3	6
% of sec_sug	50.0	50.0	100.0
Total			
Count	6	11	
% of sec_sug	45.5	54.5	100.0
Symmetric measures			
	Value	Approximate significance	
Nominal by nominal			
Contingency coefficient	.100	.740	
Number of valid cases	11		

We believe that submental intubation is a reasonable alternative to tracheostomy for establishing and maintaining an airway when treating PFF. It is relatively easy to carry out, is safe, and does not interfere with the surgical area. It was used successfully in six (three in each group) of the patients in this study, where nasal intubation was contraindicated due to Lefort II, Lefort III and NOE fractures and caused no harm to any of them. Nasal intubation was used in cases where only ZMC fractures were there.

The mandible is the strongest facial bone and can be anatomically reduced more easily than the maxilla. By placing the lower midface into correct occlusion with the reconstructed mandible, serious deformities (such as maxillary rotation and anterior open bite) can be prevented [8]. When there are concomitant maxillary and mandibular dental arch fractures, it is difficult to re-establish the occlusion and 3D relationships of the jaws. Markowitz and

Fig. 11 Outcome

Manson [11] advised reducing and fixing the palatal fracture first, and then using the maxillary dental arch as a template for the restoration of the mandibular dental arch. By doing so, the proper width of the mandible (and face) can be reconstructed. In this way, lower facial width is restored. Facial projection and height are restored by repair of the ascending rami and condylar areas. When there are concomitant fractures of the mandibular dental arch and the condyle(s) or the angle(s), the patients usually present with an increase in the lower facial width that also worsens their mandibular retrusion [14].

Multiple mandibular fractures that are associated with symphyseal or paramedian fractures with bilateral condylar fractures are problematic because they create an increase in the bigonial mandibular dimension by altering inferior facial width. Loss of continuity in the symphyseal region, which is determined by an anteroposterior injury or force vector, causes mandibular repositioning and splaying of the angles because of the action of the suprahyoid, masseter, and temporal muscles. The action of the antagonist pterygoid internal muscles is overwhelmed, and the mandibular gonial angles are flared. When condylar fractures are associated with symphyseal fractures, the splaying mechanism is worsened. A loss of posterior facial height occurs and worsens the lack of the sagittal dimension. Computed tomographic and 3D reconstruction can be used to assess the severity of this problem. The surgeon should restore the correct transversal dimension while considering the bigonial diameter and mandibular base. Indeed, the reduction of dentoalveolar segments appears to be insufficient because of the lateral splaying of the gonial angles. This is determined by the jaw-elevator musculature, which is not opposed at the occlusal level due to possible errors in cuspid fossa contacts with lingual tipping. Therefore, the critical point in treatment planning is anatomic 3D reduction of the mandibular base arch. We treated 2 cases of bottom-up approach and one case of top-down approach who had single symphysis fractures which were reduced with applying high hand force at the gonial angles together

with forward traction of the symphyseal region to get proper lower facial width and projection, ensuring proper lingual cortical plate reduction.

Reconstructing the condyle(s) or angle(s) reestablishes the proper height of the ramus and facial projection, and places the occlusal table in the proper location once the anterior vertical dimension has been established at the time of plating across the Le Fort I level. Tullio and Sesenna [8] also believe reestablishment of the condyles together with the mandibular dental arch is the appropriate first step. Reducing the fractured mandibular condyle(s) is of vital importance in the repair of panfacial fractures by facilitating the positioning of the midface. We encountered only a single case of undisplaced high condylar fracture associated with body and parasymphysis with gross derangement of occlusion; condyle was treated conservatively while parasymphysis and body were treated with open reduction and fixation. Mild occlusal discrepancies occurred post op which were corrected with IMF with elastic traction.

In our study with a mean IMF for 3 weeks for top-down approach. 1 (20 %) patient with gross derangement and 4 (80 %) with moderate derangement in bottom-up approach, after treatment attained normal occlusion (100 %) with a mean IMF of 3.8 weeks, which was statistically insignificant.

Manson and Clark [2] proposed using the maxillary ridge as a template for mandibular ridge, the maxillary ridge should first be fixed posteriorly, at the level of the palatal vault and then at the level of pyriform aperture. Open repositioning and fixation of the palatal vault is problematic in several ways. First, bending a miniplate so that it adheres passively to the concavity of the posterior palate can be difficult. Second applying internal fixation to the palate can be challenging due to the oblique approach and hindrance of the tongue. Third, mucosal incisions overlying the fracture are required to gain access to the palatal vault, but they increase the risk of late palate exposure. We treated four palatal fractures (two in each group). In bottom up approach these were reduced first, plating was done anteriorly. One in each group developed oronasal fistulas, which were surgically corrected later. In top-down approach palatal fractures were reduced after reducing ZMC fractures.

The coronal approach is helpful for the upper and outer facial frame reconstruction. Merville proposed reconstructing the NOE fracture first, but most surgeons prefer to restore the zygomatic body and arch for outer facial projection and then move to the NOE area [11]. We believe the NOE region has less reliable landmarks for orientation because it is comminuted or missing pieces of bone. We treated NOE, one case in bottom-up and two in top-down after restoring ZMC; in 1 patient it resulted in local nasal

deformity and midline shift requiring second surgery for correction.

Three cases, one in bottom-up approach, two in top-down approach had enophthalmos before surgery, all of them underwent internal orbital reconstruction with medpore and titanium mesh and enophthalmos was corrected postoperatively in all cases. Thus, it is essential to assess thoroughly the internal orbital bony disruption and volume of the orbits and, if needed, accurately reconstruct them primarily.

Surgical site infection is multifactorial in nature. It has patient- and iatrogenic-factors. Surgical site, access, type of hardware, technical errors, fracture mobility, and medical comorbidities are all elements that contribute to postoperative infection. O'Connell and Murphy [15] encountered a total of 32 (3 %) plate infections which were removed. Superficial infection accounted for 41 % of all plates removed. One (20 %) patient in top-down group, and one patient in bottom-up (16.7 %) encountered post op infection due to severely comminuted fractures and delay of 15 days in top-down and 5 days in bottom-up approaches.

Final treatment outcome is excellent in 3 (50 %), good in 1 (16 %) and fair in 2 (32 %) in topdown approach due to several factors including infection, facial asymmetry, oronasal fistula, nasal deformity and 3 (60 %) excellent and 2 (40 %) fair in bottom-up approach due to infection, facial asymmetry and oronasal fistula with contingency coefficient value ($P < .632$) which was insignificant. There was no statistically significant deviation from the two groups in the final treatment outcome.

Conclusion

Within the limitation of low sample size we found that both bottom-up inside-out and top-down outside-in approaches have similar clinical outcomes. Hence it could be suggestive to start fixation of least disrupted (more stable) facial half as a guide for reconstruction of the remaining. Choice of the bottom-up inside-out or top-down outside in sequence should be according to the pattern of fractures and preference of the surgeon. However, further controlled clinical trials, comparative studies with a larger sample size would be better to evaluate the final clinical outcome of individual techniques.

References

1. Wenig BL (1991) Management of panfacial fractures. *Otolaryngol Clin N Am* 24:93
2. Manson PN, Clark N (1999) Subunit principles in midface fractures: the importance of sagittal buttresses, soft-tissue reductions,

- and sequencing treatment of segmental fractures. *Plast Reconstr Surg* 103(4):1287–1307
3. Sawhney CP, Ahuja RB (1988) Faciomaxillary fractures in North India: a statistical analysis and review of management. *Br J Oral Maxillofac Surg* 26(5):430
 4. William Curtis W, Horswell BB (2013) Panfacial fractures: an approach to management. *Oral Maxillofac Surg Clin N Am* 25(2013):649–660
 5. McGraw-Wall B (2005) Sequencing of facial fracture repair. In: Stewart MG (ed) *Head, face, and neck trauma: comprehensive management*, chap 15. Thieme publishers, New York pp 142–149
 6. Pau M, Reinbacher KE (2014) The mandibular symphysis as a starting point for the occlusal-level reconstruction of panfacial fractures with bicondylar fractures and interruption of the maxillary and mandibular arches: report of two cases. *J Cranio Maxillo Fac Surg* 42:e51–e56
 7. Gruss JS (1992) Craniofacial fractures: an algorithm to optimize results. *Clin Plast Surg* 19:195–206
 8. Tullio A, Sesenna E (2000) Role of surgical reduction of condylar fractures in the management of pan facial fractures. *Br J Oral Maxillofac Surg* 38:472–476
 9. Yang R, Zhang C, Liu Y (2012) Why should we start from mandibular fractures in the treatment of pan facial fractures? *J Oral Maxillofac Surg*. doi:[10.1016/j.joms.2011.11.006](https://doi.org/10.1016/j.joms.2011.11.006)
 10. Louis PJ (2004) Management of pan facial fractures. In: Miloro M (ed) *Peterson's principles of oral and maxillofacial surgery*, chap 28, vol 1, 2nd edn. BC Decker Inc, Hamilton pp 547–559
 11. Markowitz BL, Manson PN (1989) Panfacial fractures: organization of treatment. *Clin Plast Surg* 16(1):105–114
 12. He D, Zhang Y, Ellis E (2007) Pan facial fracture: analysis of 33 cases treated late. *J Oral Maxillofac Surg*. doi:[10.1016/j.joms.2007.06.625](https://doi.org/10.1016/j.joms.2007.06.625)
 13. Carr RM, Mathog RH (1997) Early and delayed repair of orbitozygomatic complex fractures. *J Oral Maxillofac Surg* 55:253
 14. Ellis III E, Throckmorton G (2000) Facial symmetry after closed and open treatment of fractures of the mandibular condylar process. *J Oral Maxillofac Surg* 58:719–728
 15. O'Connell J, Murphy C (2009) The fate of titanium miniplates and screws used in maxillofacial surgery: a 10 year retrospective study. *Int J Oral Maxillofac Surg* 38:731–735