

Bifocal Mandibular Fractures: Which Should Be Treated First?

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Abstract: Fractures of the mandible have been reported to account between 40% and 62% of all facial fractures. Most surveys show that just under 50% are isolated, the same amount are doubly fractured. This study aims to clarify, according to our experience, the correct surgical sequence which should be followed in order to treat bifocal mandibular fractures. From January 2004 to January 2009, we have conducted a retrospective study on a sample of patients operated on in our department because of bifocal mandibular fractures. We include only those cases in which the jaw was fractured in 2 places, in particular patients who suffer a fracture in tooth-bearing areas (symphysis, parasymphysis, and anterior body) and also contralaterally in non-tooth-bearing areas (posterior body, angle, ramus, and condyle). The sample was divided into 2 groups based on the fracture sequence of reduction. At 1-year follow-up, the group of patients who received first the tooth-bearing fractured areas treatment, followed by treatment of non-tooth-bearing fractured area on bifocal mandibular fracture, showed less postoperative complications and reduced surgical time and costs. It is recommended from this study that reduction of the tooth-bearing fragment be prior to that of the tooth-free fragment for the bifocal mandible.

Key Words: Multiple mandibular fracture, bifocal mandibular fracture, tooth-bearing area, non-tooth-bearing area

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Fractures of the mandible have been reported to account between 40% and 62% of all facial fractures.^{1–3} About half of all patients



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who suffer mandibular fractures are involved in a motor vehicle accident as reported in literature.^{1,4,5} Males are overwhelmingly reported to be affected more frequently than females in a ratio ranging from 3:1 to 7:1 depending on the surveys and especially the country involved.^{1,6,7} Many studies reveal that the most susceptible age group for both sexes is between 21 and 30 years of age.^{6,8,9} In most cases, mandibular fractures are encountered in isolation from any other facial fractures, but different studies have revealed that almost 20% of these patients have concomitant fractures in other anatomic structures of the facial skeleton, the most common one being the zygomaticomaxillary complex.^{10–13} Because of the shape of the mandible, its fractures are often multiple. Most surveys show that just under 50% are isolated, the same amount are doubly fractured, and a small percentage have more than 2 fractures.^{1,14,15} Multiple mandibular fractures can be grouped into the main categories listed below:

- Unilateral fractures (double or multiple)
- Bilateral fractures
- Fractures with contralateral condyle compromise
- Bilateral condyle fractures with symphysis/anterior body compromise

When multiple fractures of the mandible are considered, the most common combinations are angle and opposite anterior body, subcondylar and opposite anterior body, and bilateral condylar and symphyseal body.³

In response to loading, the mandible is similar to an arch because it distributes the force of impact throughout its length.¹⁶ However, unlike the arch, the mandible is not a smooth curve of uniform bone, but rather it has discontinuities such as sharp ridges, foramina, bends, and regions of reduced cross-sectional dimension like the subcondylar area. As a result, parts of the mandible develop greater force per unit area, and consequently, tensile strain is concentrated in these locations.^{17–20}

When a force is directed along the parasymphysis-body region of the mandible, compressive strain develops along the buccal aspect, whereas tensile strain develops along the lingual aspect. This produces a fracture that begins in the lingual region and spreads toward the buccal aspect.^{17,21,22} The mobile contralateral condylar

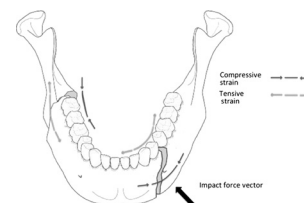


FIGURE 1. Bifocal mandibular fractures pathogenesis: the effect of a load on an arch in which the edges are free to rotate. The kinetic energy vector acting on a tooth-bearing area generates a direct fracture line on the site of impact while an indirect fracture occurs in a contralateral non-tooth-bearing area. The force is discharged along the mandibular arc through the compressive and tensile strain.



FIGURE 2. Bifocal mandibular fractures: A, facial aspect; B, posttraumatic open bite.

process moves in a direction away from the impact point until it is limited by the bony fossa and associated soft tissue. At this point, tension develops along the lateral aspect of the contralateral non-tooth-bearing area, and a fracture occurs (Fig. 1). In the management of any bone fracture, the goals of treatment are to restore proper function by ensuring union of the fractured segments and re-establishing pre-injury strength, to restore any contour defect that might arise as a result of the injury, and to prevent infection at the fracture site.

Another important consideration in the management of multiple mandibular fractures is about what fractures should be treated first. Actually, there is no univocal consensus regarding the clear indication to answer this question. This study aims to clarify, according to our experience, the correct surgical sequence which should be followed in order to treat these fractures.

MATERIALS AND METHODS

We have conducted a retrospective study on a sample of patients operated on between January 2004 and January 2009 in our department because of bifocal mandibular fractures. We decided to include in the study only those cases in which the jaw was fractured in 2 places, in particular cases suffering a fracture in tooth-bearing areas (symphysis, parasymphysis, and anterior body) and also contralaterally in non-tooth-bearing areas (posterior body, angle, ramus, and condyle).

During the 5-year observation period, 52 patients met these criteria; however, 11 of 52 patients (21.6%) were excluded from the study because 3 (5.9%) of them were lost to follow-up and 8 (15.7%) were treated by intermaxillary fixation (IMF) only in 1 of the 2 fractured sites. Twenty-seven (65.9%) of the 41 patients enrolled were male and 14 (34.1%) were female, and the mean age was 33.17 years. Twenty-six (63.4%) patients had suffered the fractures following a road accident, 11 (26.8%) following an accidental fall, and 4 (9.8%) after fights. The non-tooth-bearing/tooth-bearing combinations of the fracture in our series were as follows: 22 (53.7%) patients had presented a condylar/parasymphysarian fracture, and 13 (31.7%) patients showed an angle/parasymphysarian fracture; 5 (12.2%) suffered a condylar/anterior body fracture.

All patients were studied preoperatively by photographic documentation (mouth occlusion, mouth opening, and lateral and protrusive mandibular movements) (Fig. 2A, B), mandibular computed tomography (CT) scans without contrast (Fig. 3), and orthopantomography (Fig. 4).

The surgery was performed in all 41 patients by a standardized surgical technique. All patients were treated by open reduction and



FIGURE 3. Preoperative craniofacial 3D CT reconstruction showing a parasymphysarian/subcondylar mandibular fracture.



FIGURE 4. Preoperative orthopantomography showing a parasymphysarian/subcondylar mandibular fracture.

internal rigid fixation (ORIF) using Synthes MatrixMANDIBLE plates and screws 2.0 and 2.3. In 6 of 27 (22.2%) cases treated for condylar fracture, fixation was obtained using a MODUS Trauma 2.0 Trapezoid Condyle Plate (TCP). The sample was divided into 2 groups based on the fracture sequence of reduction. The first group (group A) consists of 24 patients (58.5%) who first received tooth-bearing area (symphysis, parasymphysis, and anterior body) reduction and fixation, and then were treated on the contralateral non-tooth-bearing area (posterior body, angle, ramus, and condyle) (Table 1). The second group (group B) consists of 17 patients (41.5%) who received the reverse sequence of reduction (Table 2).

For tooth-bearing area, a transoral mucosal incision (inferior gingival fornix) was performed in all cases; for non-tooth-bearing area, we performed a transcuteaneous retromandibular approach in 29 cases (70.3%) and a pre-auricular approach in 12 cases (29.3%).

In group A, the IMF was performed only preoperatively in order to obtain open reduction and internal fixation much easier (Fig. 5A). In group B, the ORIF was performed manually for the non-tooth-bearing fractures; we use the IMF in order to obtain reduction and fixation in tooth-bearing area (Fig. 5B).

All patients were followed up by observation 1, 3, 6, and 12 months after surgery. At each control, by using a millimeter ruler, the jaw functionality (mouth opening extension, mandibular laterality, and protrusion) were evaluated; furthermore, we assessed the facial nerve functionality, the lip and chin sensibility, and the presence of temporomandibular joint pain and disocclusion. At first

TABLE 1. Group A Patient List

No.	Age	Sex	Type of Fractures
			Non-Tooth-Bearing + Tooth-Bearing
1	16	M	Condyle + parasymphysis
2	81	F	Condyle + parasymphysis
3	44	F	Angle + parasymphysis
4	35	M	Condyle + parasymphysis
5	25	M	Angle + parasymphysis
6	61	F	Condyle + ant. body
7	58	M	Condyle + ant. body
8	42	M	Angle + parasymphysis
9	44	M	Angle + parasymphysis
10	27	F	Angle + parasymphysis
11	25	M	Condyle + parasymphysis
12	14	M	Condyle + parasymphysis
13	68	M	Condyle + parasymphysis
14	11	M	Condyle + parasymphysis
15	25	F	Angle + parasymphysis
16	26	M	Condyle + parasymphysis
17	19	F	Angle + parasymphysis
18	24	M	Condyle + parasymphysis
19	28	M	Condyle + parasymphysis
20	16	F	Condyle + parasymphysis
21	42	M	Condyle + parasymphysis
22	33	F	Condyle + parasymphysis
23	46	M	Angle + parasymphysis
24	29	F	Condyle + parasymphysis

TABLE 2. Group B Patient List

N°	Age	Sex	Type of Fractures
			Non-Tooth-Bearing + Tooth-Bearing
1	39	F	Condyle + parasymphysis
2	19	M	Condyle + parasymphysis
3	14	F	Condyle + parasymphysis
4	16	M	Angle + parasymphysis
5	63	M	Condyle + parasymphysis
6	29	M	Condyle + ant. body
7	15	M	Condyle + ant. body
8	16	M	Angle + parasymphysis
9	16	F	Condyle + parasymphysis
10	18	M	Condyle + parasymphysis
11	23	F	Angle + parasymphysis
12	71	M	Angle + parasymphysis
13	26	F	Condyle + ant. body
14	70	M	Condyle + parasymphysis
15	23	M	Condyle + parasymphysis
16	35	M	Condyle + parasymphysis
17	28	M	Angle + parasymphysis

and 12th month, all patients were evaluated postoperatively by mandibular CT scans without contrast and orthopantomography to assess infected osteosynthesis materials and pseudarthrosis (or "nonunions") (Figs. 6 and 7).

The operation time for each patient was calculated by subtracting the ending time to the starting surgical time obtained by our records.

Data were processed using the R Project open source software for Statistical Computing version 2.14.1 released on December 22, 2011. For nonparametric data, χ^2 test was performed.

RESULTS

In group A, the mean operation time was 102.2 (\pm 28.0) min; patients had reduced operative time and an excellent postoperative outcome. In group B, at 1-year follow-up, disocclusion associated with mandibular asymmetry occurred in 8 cases (47%) (Fig. 8A, B) and pseudoarthrosis (or "nonunions") in 4 cases (23.5%) (Fig. 9). In 3 cases (17.6%), a reduced mouth opening and restricted mandibular lateral and protrusive movements were observed (Fig. 10A–D). No facial and mandibular nerve deficits were observed at 1-year follow-up. In 6 patients (35.2%), a re-intervention was necessary to remove infected titanium screws and plaques. Operative time in group B was about 18.1 minutes longer compared to group A. In group A, 1 patient showed slight facial nerve deficit on the lateral side to the fractured site 1 year postoperatively (Table 3). For each outcome variable (disocclusion, infected osteosynthesis materials, pseudoarthrosis, and limited jaw functionality), a nonparametric χ^2 test for comparison of proportions was performed.

For limited jaw functionality variable, the test shows a statistical $\chi^2 = 6.1287$, with 1 degree of freedom, and a *P* value = 0.0133. Since the *P* value is less than 0.05, we reject the null

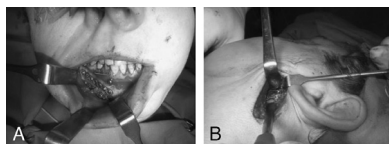


FIGURE 5. A, Intraoperative tooth-bearing open reduction and internal fixation (ORIF) after intermaxillary fixation (IMF); B, intraoperative non-tooth-bearing open reduction and internal fixation (ORIF) a retromandibular approach.

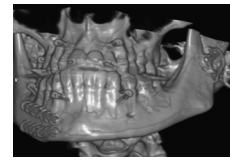


FIGURE 6. Postoperative craniofacial 3D CT reconstruction showing the right positioning of titanium plates and screws. TCP placed on subcondylar area.



FIGURE 7. Postoperative orthopantomography.

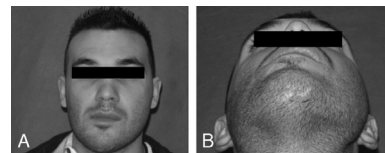


FIGURE 8. A, Frontal and submentovertebral projections; B, mandibular asymmetry.

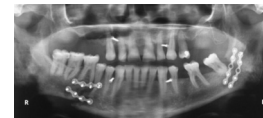


FIGURE 9. Postoperative orthopantomography showing fractured sites pseudoarthrosis.

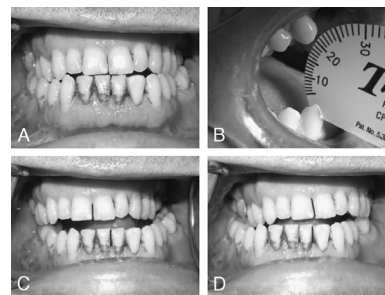


FIGURE 10. A, Mandibular disocclusion. B, Reduced mouth opening, and restricted mandibular left (C) and right (D) movements.

TABLE 3. Main Comparison Variables Between the Two Groups

Operative Time (min)	One Year Postoperative Outcomes					
	Disocclusion	Infected Osteosynthesis Materials	Pseudarthrosis	Limited Jaw Functionality	Facial Nerve Deficit	Mandibular Nerve (V3) Hypersensitivity
A 102.2 (±28.0)	2	5	0	1	1	0
B 120.1 (±20.5)	8	6	4	3	0	0

hypothesis of equality of proportions; therefore, the data confirm the superiority of treatment A.

For the variable pseudarthrosis, the test provides a statistical $\chi^2 = 3.8704$, with 1 degree of freedom, and a P value = 0.04914. Even in this case, the P value is less than 0.05, so we reject the null hypothesis of equality of proportions and confirm the superiority of treatment A.

For the variable disocclusion, the test produces a statistic $\chi^2 = 6.1287$, with 1 degree of freedom, and a P value = 0.0133. In this case, since the P value is less than 0.05, we can reject the null hypothesis of equality of proportions, confirming the superiority of treatment A.

For infected osteosynthesis materials, the variable produces a statistical test $\chi^2 = 0.4514$, with 1 degree of freedom, and a P value = 0.5017. In this case, since the P value is greater than 0.05, there is enough evidence to say that the 2 treatments are different between them; therefore, the test is not statistically significant.

DISCUSSION AND CONCLUSIONS

Fractures of the mandible have been reported to be between 40% and 62% of all facial fractures.^{1–3} More than 50% of mandibular fractures are multiple and among these the most frequent fractures are bifocal. The reasons for this high frequency of bifocal fractures can be attributed to the biomechanics of the mandible.^{23,24}

In response to loading, the mandible is similar to an arch because it distributes the force of impact throughout its length. However, its structure is uneven due to discontinuities such as foramina, sharp bends, ridges, and regions of reduced cross-sectional dimension like the subcondylar area.^{1,14,15,25} When a trauma occurs, the kinetic energy is transmitted along the mandibular arch; this causes a direct fracture on the impact site and an indirect fracture on a contralateral weakness point. The site of the indirect fracture is also determined by the direct fracture site, size, direction, and surface area of the impacting blow. An impact to the chin with a line of force through the symphysis and temporomandibular joints will produce a single subcondylar fracture at 193 kg (425 lb.) and a bilateral subcondylar fracture at about 250 kg (550 lb.), whereas symphyseal fractures require force between 250 and 408 kg (900 lb.).^{26,27} In the management of any bone fracture, the goals of treatment are to restore proper function by ensuring union of the fractured segments and re-establishing pre-injury strength, to restore any contour defect that might arise as a result of the injury, and to prevent infection at the fracture site. Restoration of mandibular function, in particular, as part of the stomatognathic system must include the ability to masticate properly, to speak normally, and to allow for articular movements as ample as before the trauma. In order to achieve these goals, restoration of the normal occlusion of the patient becomes paramount for the treating surgeon. Fixation requirements for double (or multiple) fractures differ from isolated fractures.²⁸

One can use less rigid forms of fixation on isolated fractures because the forces generated during function are less complex than when a second or third fracture is present. When 2 fractures are present, there is a greater tendency for the segments to displace because of the bilateral loss of support that occurs. Widening of the

mandible must be prevented by applying adequate internal fixation to resist that tendency. Regarding bilateral simple linear fractures, one should always consider using a more rigid form of fixation on at least 1 of the fractures. If in literature it is now clear that the ORIF represents the most reliable pattern of treatment for bifocal fractures of the jaw, it is not the same regarding the ideal sequence of treatment for these fractures.

From the analysis of our results, patients in group A had a better postoperative outcome. For the 3 outcome variables examined, the statistical χ^2 test provides a P value less than 0.05. We reject the null hypothesis of equality of proportions and the data confirm the superiority of group A treatment.

We also found a significant reduction of operative time and costs. The restoration of the horizontal dimension (tooth-bearing fractures area) of the jaw and consequently the proper occlusion allows to obtain a guide to re-establish the vertical dimension (non-tooth-bearing fractures area). However, the muscular tractions acting on mandible angle and condyle make the reduction of fractures in these areas more difficult due to the decreased mobility of the mandible already fixed in tooth-bearing area. In patients of group B, the non-execution of rigid IMF for the non-tooth-bearing fractures made bone segments more free to move. Thus, reduction and fixation of non-tooth-bearing fractures is facilitated, but poses a greater risk of complications.²⁹ The surgeon in this case does not have the occlusal help guide; thus, the tooth-bearing fracture reduction and the subsequent fixation may be imperfect. This may explain the higher incidence of disocclusion and pseudarthrosis in group B patients. In conclusion, based on our experience, the tooth-bearing fractured areas treatment, followed by non-tooth-bearing fractured area on bifocal mandibular fracture, displays less postoperative complications and reduced surgical time and costs. It is recommended from this study that reduction of the tooth-bearing fragment be prior to that of the tooth-free fragment for the bifocal mandible fractures. In our opinion, further studies are needed to confirm the data obtained and to better define the correct surgical sequence of treatment for these fractures.

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