



Double unilateral, bilateral, and multiple mandibular fractures: an observational study

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Abstract

Purpose Double and multiple mandibular fractures are associated to high morbidity and functional damage. This study aimed to evaluate the characteristics and outcomes of double unilateral, bilateral, and multiple mandibular fractures.

Methods A 7-year observational retrospective analysis was performed, and the injury-related data were collected from the medical records. Statistical analysis was performed using Fisher's exact test ($p < 0.05$).

Results In this period, 283 patients showed mandibular fractures. Of them, 83 (29.7%) had double or multiple mandibular fractures and were included in the study. Double bilateral fractures were more prevalent than multiple or double unilateral. Multiple fractures presented significant association with the combination of load-bearing and load-sharing fixation protocols. Most cases (94.0%) applied at least one type of internal fixation system. However, there was a positive association between condylar fractures and non-surgical treatment ($p < 0.01$). Moreover, mandibular body fractures were associated with load-bearing fixation ($p < 0.01$). In 56 cases, no complications were observed (67.5%). Complications were divided into treatment failure (10.8%) and transitory or minor complications (21.7%). There was no statistical association between complications and fracture pattern, fracture-tooth relation, and treatment modality.

Conclusion Double and multiple mandibular fractures represented almost one third of all mandibular fractures, and regardless to treatment protocol, there was no difference about complications. Moreover, although a considerable complication rate was found, most of them were minor or transitory.

Keywords Mandibular fractures · Mandibular injuries · Surgical treatment · Complications

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Introduction

Mandibular fractures are common in maxillofacial trauma and occur up to twice more than midface fractures [1]. The fracture pattern depends of a variety of factors such as geographical area, socioeconomic status, and cultural aspects [1, 2]. Commonly, mandibular fractures occur in young and middle-aged men, and the main causes are traffic accidents, violence, and sports-related accidents [2]. Those injuries result in high morbidity, functional damage, and aesthetic loss with social repercussion. Moreover, the treatment requires hospital admission and high cost materials [3].

Faced to a double or multiple mandibular fracture, the treatment requires a more stable fixation, and the application of nonrigid fixation will be limited to just one of the sites [4]. Those fractures are classified according to the region and number of sites, as double bilateral (contralateral), double unilateral, or multiple mandibular fracture [4–6]. Double bilateral

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mandibular fractures are more common due to the trauma mechanism and mandibular anatomy [7, 8]. Double unilateral fractures are rare and generally are represented by a free mandibular segment without anterior or posterior support [5]. Multiple mandibular fractures involve more than two sites and are associated with high energy trauma [4].

The number of involved sites has an important role in the treatment and outcomes in mandibular fractures. A complex treatment is expected when a higher number of fractures is present. Although most of the mandibular fractures are isolated, 22 to 52% of them involve two or more sites [5]. Ellis and collaborators [1] described that 80% of patients with double mandibular fractures require surgical intervention, whereas all patients with multiple mandibular fractures need surgical intervention, especially open reduction and internal fixation. Therefore, due to the clinical implications of double unilateral, bilateral, and multiple mandibular fractures, the aim of this study was to evaluate the characteristics and outcomes of those fractures in a reference center in Oral and Maxillofacial Surgery.

Material and methods

Study design

The present observational study was reviewed and approved by an Institutional Research Ethics Committee for Human Beings (protocol no. 60021316.3.0000.5416). The medical records of patients treated for mandibular fracture, between 2009 and 2015, in a single reference center in Oral and Maxillofacial Surgery were reviewed. The inclusion criteria were patients with double unilateral, double bilateral, or multiple mandibular fractures. The exclusion criteria were isolated mandibular fractures, previous mandibular fracture, patients with bone-related diseases, incomplete records, or without follow-up. The records selection and data extraction were performed by three trained researchers (JCSO, GST, and MG).

The following data were extracted:

- Age;
- Gender;
- Injury mechanism;
- Anatomic site;
- Fracture classification: double bilateral, double unilateral, multiple;
- Fracture-tooth relation: tooth-bearing area, non-tooth-bearing area;
- Treatment: load sharing and/or load bearing and/or non-surgical;
- Occlusion: all teeth present, partially edentulous, totally edentulous;
- Presence of complications/failure:

Complications: wound dehiscence, inferior alveolar nerve (IAN) impairment, transitory mouth opening limitation, and local infection (treated just with antibiotics)

Failure: mobility, malocclusion, fixation failure, pseudoarthrosis, and major infection (disseminated to fascial spaces that required surgical intervention);

- Time between trauma and treatment.

Data analysis

The data were evaluated by means of descriptive statistics, and statistical analysis was performed using PASW SPSS Statistics 18.0 (SPSS Inc., Chicago, USA). Qualitative variables were compared by Fisher's exact test considering 95% significance level; when the null hypothesis was rejected, complex test analysis was performed in order to verify the association between the variables.

Results

In this 7-year retrospective analysis, 283 patients were treated for mandibular fractures. Of them, 199 (70.3%) presented isolated mandibular fracture and were excluded of the study. One patient (0.4%) with multiple mandibular fracture had incomplete record (patient did not return to follow-up) and also was excluded. Therefore, the final sample included 83 (29.3%) patients with double unilateral, bilateral, or multiple mandibular fractures.

About demographic data, there were majority of male patients (86.7%, $n = 72$) in relation to female ones (13.3%, $n = 11$). The male:female ratio was 6.5:1. The mean age was 29.3 (SD 13.2) years, ranging from 5 to 69 years. The main causes of injury were traffic accidents (38.6%), personal violence (36.1%), falls (10.8%), and sport-related accidents (6.0%).

Regarding to fracture pattern, most of cases were double bilateral fractures (67.5%), especially symphysis/parasymphysis fracture combined with mandibular angle fracture. Multiple fractures represented 21.7% of the sample, with a predominance of symphysis/parasymphysis fracture associated with bilateral condylar fractures. Furthermore, double unilateral fractures occurred just in 10.8% of the cases. Table 1 describes the distribution of involved sites according to fracture classification.

Most of fractures (49.4%) involved tooth-bearing areas and non-tooth-bearing areas. Also, 31.3% of the cases were limited to tooth-bearing areas, and the remaining 19.3% were limited to non-tooth-bearing areas. Concerning about type of occlusion, 36.2% of the patients had all teeth, 51.8% were partially edentulous, and 12.0% were totally edentulous. The 83 included patients presented 183 lines of fracture. The most

Table 1 Fracture classification and involved sites

Fracture classification	Sites	Number	Percent
Double bilateral (<i>n</i> = 56, 67.5%)	Para/symphysis–angle	16	19.3
	Body–angle	12	14.5
	Body–condyle	10	12.0
	Para/symphysis–condyle	7	8.4
	Body bilateral	3	3.6
	Angle bilateral	3	3.6
	Para/symphysis–body	2	2.4
	Para/symphysis–ramus	1	1.2
	Body–ramus	1	1.2
	Condyle bilateral	1	1.2
Multiple (<i>n</i> = 18, 21.7%)	Para/symphysis–condyle bilateral	10	12.0
	Para/symphysis–angle–condyle	2	2.4
	Body–condyle bilateral	2	2.4
	Symphysis–ramus–condyle	1	1.2
	Symphysis–body–condyle	1	1.2
	Body–angle–coronoid	1	1.2
	Body–angle–ramus–condyle	1	1.2
	Parasymphysis–condyle	3	3.6
Double unilateral (<i>n</i> = 9, 10.8%)	Body–angle	2	2.4
	Body–condyle	1	1.2
	Parasymphysis–body	1	1.2
	Parasymphysis–angle	1	1.2
	Parasymphysis–ramus	1	1.2

involved sites were condyle (*n* = 50, 27.2%), angle (*n* = 41, 19.8%), body (*n* = 41, 19.8%), parasymphysis (*n* = 31, 15.0%), and symphysis (*n* = 15, 7.2%).

The time between trauma and treatment ranged from 0 to 20 days, with a mean of 5.4 (SD 4.3) days, and the mean of follow-up was 9.7 months. Usually, the chosen treatment was performed using internal fixation. Both load-bearing fixation and load-sharing fixation were used, isolated or in combination, to treat 94.0% of the cases. Statistical analysis demonstrates association between treatment modality and type of fracture ($p < 0.01$) and between treatment modality and site of fracture ($p < 0.01$). Tables 2 and 3 show treatment modalities according to fracture classification and site. It is important to highlight that multiple fractures presented a negative association with isolated load-bearing fixation and showed a positive association with the application of the three modalities of treatment and with the combination of load-sharing fixation and non-surgical treatment. Regarding the anatomical sites, condylar fractures showed a positive association with non-surgical treatment, whereas body and angle fractures presented a negative association with the non-surgical treatment. Moreover, body fractures showed positive association with load-bearing fixation.

Concerning about complication rate, 56 cases (67.5%) did not show any type of complications. The remaining 27 cases

were divided into complications (*n* = 18) and treatment failure (*n* = 9). Table 4 describes the distribution of complications and failures in the sample. The cases classified as complication showed transitory or minor complications, such as wound dehiscence, abnormal limitation of mouth opening, temporary facial nerve impairment to motion, and local infection. Those cases were solved without additional surgical treatment. The mean of mouth opening limitation was 28.6 days. Moreover, 14 cases showed inferior alveolar nerve (IAN) impairment; however, we did not include it as complication because it was related to the trauma. The mean time with IAN impairment was 3.2 months. The failures cases showed mobility, postoperative malocclusion, fixation failure, or pseudoarthrosis, and an additional surgical treatment was necessary. Table 5 shows the distribution of complications according to fracture classification, fracture-tooth relation, and treatment modality. There was no statistical association between complications and fracture classification ($p = 0.733$), fracture-tooth relation ($p = 0.119$), and treatment modality ($p = 0.284$).

Discussion

Due to anatomical characteristics, the mandible is one of the most involved bone in facial fractures [7–11]. The treatment is

Table 2 Treatment modalities according to fracture classification

Treatment	Fracture classification			Total
	Double bilateral	Double unilateral	Multiple	
Load bearing + load sharing	17	3	5	25
Load sharing	19	2	2	23
Load bearing	15	4	—*	19
Non-surgical	3	—	2	5
LB + LS + Ns	—*	—*	4*	4
Load bearing + non-surgical	2	—	2	4
Load sharing +non-surgical	—*	—*	3*	3
Total	56	9	18	83

LB, load bearing; LS, load sharing; Ns, non-surgical

Fisher's exact test ($p < 0.01$)

*Statistical association according to complex test analysis

complex, especially in cases with double or multiple mandibular fractures [4]. In analyzed sample, almost one third of the patients presented multiple mandibular fractures. This data agrees with the proportion rate reported in the literature which ranges from 22 to 52% [5, 7, 12].

The gender distribution presented a male:female ratio of 6.5:1. The male prevalence in facial trauma is reported in several studies [1, 2, 5–8, 11, 13–17] and is explained by the increase violence rates, negligence in traffic, and exposition of men to risk activities [7–14]. The sample had a mean age of 29.3 years; this result is similar to the literature and occurs because the population has a higher number of people in this age group [7].

In general, the mandibular fractures present a well-defined pattern of causes such as personal violence, traffic accidents, gunshot injuries, sport-related injuries, and falls [1, 14, 15]. De Matos and collaborators [17] performed an epidemiological analysis in a similar demographic region of our study and found the same prevalence of traffic accidents, personal violence, and falls. The pathophysiology of mandibular fractures

demonstrates the important role of the cause to the pattern and site of the fractures [16]. Usually, traffic accidents result in condylar fractures whereas aggression produce angle or body fractures [13, 18]. The condyle and symphysis/parasymphysis were the most involved regions in our study, present in almost one third of the fractures, in the same way of the study from Cillo and Ellis [5].

Due to its anatomy, the arch-shaped mandibular bone reacts to an impact with the distribution of loading along all structure [5, 19]. Some anatomical features (foramens, curves, constrictions, and regions with absence of teeth) decrease the mandible resistance and increase the susceptibility to fractures [1, 20]. Moreover, bilateral fractures are more likely to occur due to the mandibular biomechanics [1, 7, 21]. In general, the fracture occurs directly in the site of trauma and indirectly in the contralateral region [22]. In our study, bilateral fractures represented more than two thirds of the sample, similarly to the current literature [4–8]. Additionally, it is important to notice that the described mandibular characteristics contribute to the rarity of double unilateral fractures [5]. In this sample,

Table 3 Treatment modality according to site of fracture

Fracture site	Treatment			Total
	Load bearing	Load sharing	Non-surgical	
Condyle	2*	27	21*	50
Symphysis/parasymphysis	25	18	3	46
Body	26*	14	1*	41
Angle	23	18	—*	41
Ramus	2	2	1	5
Coronoid	—	1	—	1
Total	78	80	26	184

Fisher's exact test ($p < 0.01$)

*Statistical association according to complex test analysis

Table 4 Complication rates and types, according to degree of complication

Complication	Number	Percent
Complications (18 patients, 21.7%)		
Local infection	9	24.3
Wound dehiscence	7	18.9
Mouth opening limitation	4	10.8
Seroma	1	2.7
Facial nerve impairment to motion	1	2.7
Transitory salivary gland fistula	1	2.7
Failure (9 patients, 10.8%)		
Incorrect occlusion	4	10.8
Major infection	4	10.8
Mobility	2	5.4
Wound dehiscence	2	5.4
Pseudoarthrosis	1	2.7
Fixation failure	1	2.7
Total complications	37	100.0

the double unilateral fracture represented 10.8% of the double/multiple mandibular fractures and 3.1% of all mandibular fractures.

The treatment of double/multiple mandibular fractures is more complex than that of isolated fractures. In order to achieve optimal stability during the healing period, the requirements for internal fixation are different, mainly due to the mandibular biomechanical function [4, 22]. Following the principles of treatment of mandibular fractures, there are three different protocols that can be applied: load-bearing fixation, load-sharing fixation, and non-surgical (conservative) treatment [22]. As long this study included cases with at least two fractures, the patients were treated with a combination of the protocols cited above.

The condylar fractures represented 27.2% of all fractures and showed statistical association with non-surgical treatment. However, 54.0% of those cases were treated by load-sharing fixation. These findings agree with the literature, regarding prevalence [23] and the controversies of the treatment [24, 25]. Leiser and collaborators [25] treated 72.0% of condylar fracture using non-surgical protocol while Landes and collaborators [24] treated 67.0% of them by open reduction and internal fixation. Therefore, it is highlighted that the surgical treatment of condylar fractures is dependent on several factors, from fracture pattern to surgeon's experience [18, 24].

Multiple mandibular fractures presented negative association with the exclusive treatment with load-bearing fixation

Table 5 Complication distribution according to fracture classification

Variable	Classification	Complication			Fisher's exact test
		Without complication	Complications	Failure	
Fracture classification	Double bilateral	38	13	6	$p = 0.733$
	Multiple	10	4	3	
	Double Unilateral	8	1	—	
Relation to tooth	Combination	26	13	2	$p = 0.119$
	Tooth-bearing area	18	4	4	
	Non-tooth-bearing area	12	1	3	
Treatment modality	Load sharing	19	2	2	$p = 0.284$
	Load bearing + load sharing	15	8	3	
	Load bearing	11	7	1	
	Non-surgical	4	—	1	
	LB + LS + Ns	3	—	1	
	Load bearing + non-surgical	2	—	1	
	Load sharing + non-surgical	2	1	—	
	Total	56	18	9	

LB, load bearing; LS, load sharing; Ns, non-surgical

and a positive association with the combination of all protocols. It is explained because there is a decreasing in complications rate when nonrigid fixation is applied in only one of the sites of fracture [22]. It follows the strict principle that in multiple mandibular fractures, only one fracture should be treated with nonrigid fixation or non-surgical treatment and all the other fractures should be treated with stable internal fixation [4, 22]. Therefore, the principles of internal fixation must guide the surgeon in the decision-making process [26].

Of 83 patients included in this study, 32.5% presented complication or treatment failure. 21.7% presented minor and transitory complications, and all of them were treated with medication and/or physiotherapy without need of new surgical procedure. However, nine cases (10.8%) showed treatment failure and requested additional surgery. In general, mandibular fractures (isolated, and double or multiple) present a 17.7% of complication rate, being infection the most common [27]. The literature reports a 24.4–25.8% rate of malocclusion and facial asymmetry [5, 18], 26.8% of major infections, and 9.7% of pseudoarthrosis [18]. Additionally, Christensen and collaborators [28] emphasize that patient noncompliance is the strongest predictor variable for development of complications in mandibular fractures. They showed 27% of major complications as outcome from patient noncompliance. Therefore, the complications rate founded in our study remained within the expected range.

In conclusion, considering the limitations of a retrospective study, the data founded corroborates with the literature and showed an incidence of almost 30% of double and multiple mandibular fractures and a prevalence of double bilateral fractures over multiple and double unilateral fractures. The treatment of double and multiple mandibular fractures is challenging, and there are several aspects that will dictate the treatment plan, fixation protocol, and prognosis. Furthermore, a considerable complication rate is expected; however, most of them are minor and transitory. The proper treatment following the principles of internal fixation and patient's needs regardless to fractures classification provides feasible outcomes.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The present cross-sectional study was review and approved by the Ethics Committee for Human Beings of the São Paulo State University – School of Dentistry (protocol no. 60021316.3.0000.5416).

References

1. Ellis E, Moos KF, El-Attar A (1985) Ten years of mandibular fractures: an analysis of 2,137 cases. *Oral Surg Oral Med Oral Pathol* 59:120–129
2. Marinho K, García Guevara HA, Henrique Paiva F, Rocha B, Gonzales D, Lobo Leandro LF (2015) Epidemiological analysis of mandibular fractures treated in Sao Paulo, Brazil. *Rev Esp Cir Oral Maxillofac* 37:175–181. <https://doi.org/10.1016/j.maxilo.2014.03.002>
3. Erdmann D, Price K, Reed S, Follmar KE, Levin LS, Marcus JR (2008) A financial analysis of operative facial fracture management. *Plast Reconstr Surg* 121:1323–1327. <https://doi.org/10.1097/01.prs.0000304603.19047.0b>
4. Ellis E 3rd (2014) An algorithm for the treatment of noncondylar mandibular fractures. *J Oral Maxillofac Surg* 72:939–949. <https://doi.org/10.1016/j.joms.2013.11.026>
5. Cillo JE, Ellis E 3rd (2007) Treatment of patients with double unilateral fractures of the mandible. *J Oral Maxillofac Surg* 65:1461–1469
6. Cillo JE, Ellis E 3rd (2014) Management of bilateral mandibular angle fractures with combined rigid and nonrigid fixation. *J Oral Maxillofac Surg* 72:106–111. <https://doi.org/10.1016/j.joms.2013.07.008>
7. Ogundare BO, Bonnick A, Bayley N (2003) Pattern of mandibular fractures in an urban major trauma center. *J Oral Maxillofac Surg* 61:713–718
8. Morris C, Bebeau NP, Brockhoff H, Tandon R, Tiwana P (2015) Mandibular fractures: an analysis of the epidemiology and patterns of injury in 4,143 fractures. *J Oral Maxillofac Surg* 73:951.e1–951.e12. <https://doi.org/10.1016/j.joms.2015.01.001>
9. Afrooz PN, Bykowski MR, James IB, Daniali LN, Clavijo-Alvarez JA (2015) The epidemiology of mandibular fractures in the United States, part 1: a review of 13,142 cases from the US National Trauma Data Bank. *J Oral Maxillofac Surg* 73:2361–2366. <https://doi.org/10.1016/j.joms.2015.04.032>
10. Giri KY, Singh AP, Dandriyal R, Indra N, Rastogi S, Mall SK, Chowdhury S, Singh HP (2015) Incidence and pattern of mandibular fractures in Rohilkhand region, Uttar Pradesh state, India: a retrospective study. *J Oral Biol Craniofac Res* 5:140–145. <https://doi.org/10.1016/j.jobcr.2015.07.007>
11. D'Avila S, Barbosa KGN, Bernardino Íde M, da Nóbrega LM, Bento PM, E Ferreira EF (2016) Facial trauma among victims of terrestrial transport accidents. *Braz J Otorhinolaryngol* 82:314–320. <https://doi.org/10.1016/j.bjorl.2015.10.004>
12. Buch K, Mottalib A, Nadgir RN et al (2016) Unifocal versus multifocal mandibular fractures and injury location. *Emerg Radiol* 23:161–167. <https://doi.org/10.1007/s710140-015-1375-9>
13. Vetter JD, Topazian RG, Goldberg MH, Smith DG (1991) Facial fractures occurring in a medium-sized metropolitan area: recent trends. *Int J Oral Maxillofac Surg* 20:214–216
14. Gassner R, Tuli T, Hächl O, Rudisch A, Ulmer H (2003) Cranio-maxillofacial trauma: a 10 year review of 9,543 cases with 21,067 injuries. *J Craniomaxillofac Surg* 31:51–61
15. Brasileiro BF, Passeri LA (2006) Epidemiological analysis of maxillofacial fractures in Brazil: a 5-years prospective study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 102:28–34
16. Sakr K, Farag IA, Zeitoun IM (2006) Review of 509 mandibular fractures treated at the University Hospital Alexandria, Egypt. *Br J Oral Maxillofac Surg* 44:107–111
17. De Matos FP, Amez MFM, Sverzut CE, Trivellato AE (2010) A retrospective study of mandibular fracture in a 40-month period. *Int J Oral Maxillofac Surg* 29:10–15. <https://doi.org/10.1016/j.ijom.2009.10.005>

18. Dell'Aversana Orabona GD, Iaconetta G, Abbate V, Califano L (2012) Bifocal mandibular fractures: which should be treated first? *J Craniofac Surg* 23:1723–1727. <https://doi.org/10.1097/SCS.0b013e31826bf24d>
19. van den Bergh B, van Es C, Forouzanfar T (2011) Analysis of mandibular fractures. *J Craniofac Surg* 22:1631–1634. <https://doi.org/10.1097/SCS.0b013e31822e5f20>
20. Heulke DF, Harger JH (1969) Maxillofacial injuries: their nature and mechanisms of production. *J Oral Surg* 27:451–460
21. Huelke DF, Burdi AR, Eyman CE (1962) Association between mandibular fractures and site of trauma, dentition and age. *J Oral Surg Anesth Hosp Dent Serv* 20:478–481
22. Ellis E 3rd (2013) Open reduction and internal fixation of combined angle and body/symphysis fractures of the mandible: how much fixation is enough? *J Oral Maxillofac Surg* 71:726–733. <https://doi.org/10.1016/j.joms.2012.09.017>
23. De Riu G, Gamba U, Anghinoni M, Sesenna E (2001) A comparison of open and closed treatment of condylar fracture: a change in philosophy. *Int J Oral Maxillofac Surg* 30:384–389
24. Landes CA, Day K, Lipphardt R, Sader R (2008) Prospective closed treatment of nondisplaced and nondislocated condylar neck and head fractures versus open reposition internal fixation of displaced and dislocated fractures. *Oral Maxillofac Surg* 12:79–88. <https://doi.org/10.1007/s10006-008-0108-6>
25. Leiser Y, Peled M, Braun R, Abu-El Naaj I (2013) Treatment of low subcondylar fractures – a 5-year retrospective study. *Int J Oral Maxillofac Surg* 42:716–720. <https://doi.org/10.1016/j.ijom.2013.03.006>
26. Schilli W, Stoll P, Bähr W, Prein J (1998) Mandibular fractures. In: Prein J (ed) *Manual of internal fixation in the craniofacial skeleton*, 1st edn. Springer-Verlag, Berlin, pp 57–93
27. Lamphier J, Ziccardi V, Ruvo A, Janel M (2003) Complications of mandibular fractures in an urban teaching center. *J Oral Maxillofac Surg* 61:745–749
28. Christensen BJ, Mercante DE, Neary JP, King BJ (2017) Risk factors for severe complications of operative mandibular fractures. *J Oral Maxillofac Surg* 75:787.e1–787.e8. <https://doi.org/10.1016/j.joms.2016.12.003>