

Long-term complications of mandibular fractures – a 10-year retrospective clinical study

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Abstract. Introduction: There are many treatment methods that have been continuously developed and improved over time, osteosynthesis surgery gaining ground in the past years. However despite the rigorousness and the advantages of modern medicine, the treatment of mandibular fractures is not free of postoperative complications. Objective: The aim of this study is to determine the type and frequency of postoperative mandibular fracture complications in the population of our geographical area, as well as their correlation with the therapeutic methods that preceded them in order to establish their efficacy. Material and methods: A retrospective study was conducted at the Clinic of Oral and Maxillofacial Surgery I in Cluj-Napoca. All medical records of patients with the diagnosis of mandibular fracture admitted and treated in this institution in a 10 year period were evaluated. Results: From a total of 709 (100%) patients only 27 (3.81%) developed post-surgical complications. The most frequent complication was osteitis (66,67%) followed by deep space infection (22,22%) and mal-union (11,11%). Paramedian mandibular fractures were followed by the most post-surgical complications ($p=0.050$). The most postsurgical complications occurred in cases resolved by orthopedic treatment ($p=0.018$). Conclusions: Paramedian, displaced, and intraorally open fractures had the highest rate of postoperative complications. Patients treated with surgical treatment implying open reduction and internal fixation with titanium miniplates and screw had the lowest rate of post-surgical complications.

Key Words: mandibular fractures, complications, long-term.

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Introduction

Mandibular fractures are one of the most frequent pathologies in oral and maxillofacial surgery, their treatment becoming routine practice (van Hout et al 2013). There are many treatment methods that have been continuously developed and improved over time, osteosynthesis surgery gaining ground in the past years (Morales et al 2010). The choice of the therapeutic method depends on the severity of the trauma, on the patient's age and general state, on the location and characteristics of the fracture focus, and not least, on the surgeon's equipment and experience (Kraft et al 2012). Regardless of the treatment method chosen to allow bone healing under favorable conditions, reduction and fixation of the fracture focus should be impeccable (Ellis et al 2012).

Despite the rigorousness and the advantages of modern medicine, the treatment of mandibular fractures is not free of postoperative complications (Ellis et al 2012). The complications of mandibular fractures according to the literature are of infectious nature (osteitis in the fracture focus and periosteal or soft tissue suppuration) and non-infectious (delayed union, malunion, pseudarthrosis, temporomandibular ankylosis and mandibular

constriction) (Freiberg et al 1997). Their causes are multiple, depending on a number of factors related to the degree of fracture displacement, the relationship with the external environment, the location and the presence or absence of teeth in the fracture focus (Ellis 2012). Also, the patient's associated pathology, smoking, alcohol or drug consumption can interfere with bone healing (Taher 1993). Non-compliance with postoperative indications and inadequate oral hygiene favor the development of infectious complications (Mathog et al 2000).

Therapeutic reintervention in the case of mandibular fracture complications is mandatory given the functional, anatomical and cosmetic disorders that may occur, with severe consequences on quality of life (Kyrgidis et al 2013). The need for surgical reintervention involves readmission of the patient to the hospital, a prolongation of the convalescence period, which leads to prolonged leave of absence and implicitly, increased social costs (Assael et al 1994). In order to avoid this series of social and medical consequences that derive from the postoperative complications of mandibular fractures, the oral and maxillofacial surgeon should minimize their number (Mathog et al 2000).

Table 1 Distribution of postoperative complications depending on the topographic location of the fracture lines and the degree of displacement of the fractured fragments

SITE OF FRACTURE		POSTSURGICAL COMPLICATIONS		
		NO	YES	P
MEDIAN	Absent	648 (95.2%)	23(95.8%)	1
	Present	33 (4.8%)	1(4.2%)	
PARAMEDIAN	Absent	505(74.2%)	13(54.2%)	0.05
	Present	176(25.8%)	11(45.8%)	
LATERAL	Absent	443(85.1%)	16(66.7%)	1
	Present	238(34.9%)	8(33.3%)	
MANDIBULAR ANGLE	Absent	385(56.5%)	13(52.2%)	0.984
	Present	296(43.5%)	11(45.8%)	
RAMUS	Absent	661(97.1%)	24(100%)	0.821
	Present	20(2.9%)	0(0%)	
CONDYL	Absent	465(68.3%)	18(75%)	0.636
	Present	216(31.7%)	6(25%)	
DEGREE OF DISPLACEMENT	with	57(8.4%)	4(16.7%)	0.129
	without	602(88.4%)	18(75.0%)	
	Both	22(3.2%)	2(8.3%)	

However, this cannot be achieved without a thorough search for their causes (Yamamoto et al 2013).

The aim of this study is to determine the type and frequency of postoperative mandibular fracture complications in the population of our geographical area, as well as their correlation with the therapeutic methods that preceded them in order to establish their efficacy.

Materials and methods

This retrospective study was conducted at the Clinic of Oral and Maxillofacial Surgery I in Cluj-Napoca. All medical records of patients with the diagnosis of mandibular fracture admitted and treated in this institution in the period 1 January 2002 – 31 December 2011 were evaluated.

The study inclusion criteria were:

- Presence of at least one fracture focus in the mandible evidenced clinically and by imaging;
- Fracture of traumatic etiology;
- Treatment performed in the clinic hosting the study;
- Complete documentation of the case;
- Follow-up for at least 6 postoperative weeks;
- Unfavorable evolution with the development of postoperative complications.

The study exclusion criteria were:

- No evidencing of the fracture focus by imaging;
- Fracture of a different nature than traumatic;
- Incomplete documentation;
- No follow-up for at least 6 postoperative weeks;
- Favorable evolution without the development of postoperative complications.

The patient records were retrospectively evaluated, while monitoring the following variables: the type of treatment applied (orthopedic, surgical, orthopedic-surgical and circummandibular wiring), the location of the fracture line, the evolution of the case (favorable/unfavorable), the displacement of the fractured

bone fragments (with displacement/without displacement), the relationship with the external environment of the fracture focus (closed/intraorally open/extraorally open), the type of postoperative complications, the method for the treatment of complications, as well as the correlation between these.

We mention that this study was approved by the University of Oradea Ethics Commission and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Centralization of data in electronic format and statistical interpretation were carried out using Microsoft Excel software. Descriptive statistics of the evaluated cases was performed with a percent accuracy of two decimals. Statistical analysis used MedCalc Statistical Software version 17.2 (MedCalc Software bvba, Ostend, Belgium; <https://www.medcalc.org>; 2017). Continuous data were expressed as mean and standard deviation, and nominal data were expressed as frequency and percentage. The comparisons of the frequencies of a nominal variable between the categories of another nominal variable were performed with the Chi-square test. The comparison of a continuous nominal variable between two groups was performed with the T test for independent variables. A p value < 0.05 was considered statistically significant.

Results

Of 709 patients diagnosed and treated with mandibular fractures in the period 1 January 2002 – 31 December 2011, only 27 (3.81%) developed postoperative complications and met the study inclusion criteria. The rest of 682 patients (96.19%) had a favorable postoperative evolution regardless of the treatment method applied. The 27 patients included in the study had 45 fracture lines in the mandible.

The most frequent postoperative complication in our study was osteitis in the fracture focus, followed by malunion (Fig. 1).

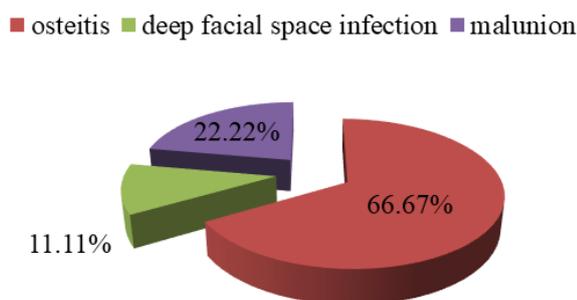


Fig. 1. Distribution of fracture lines depending on the type of postoperative complications

Mandibular fractures located in the paramedian region developed postoperative complications the most frequently. Also, the development of postoperative complications was favored by the displacement of bone fragments in the fracture focus. These differences have statistical relevance (Table 1). Of all fracture foci that developed postoperative complications, 35 (70%) were intraorally open, the rest of 15 (30%) being closed.

The majority of the patients who developed postoperative complications suffered from no associated general diseases interfering with the bone healing process, $n=22$ (81.48%). Three patients (11.11%) had chronic cardiovascular diseases and 2 patients (7.41%) suffered from mental disorders. Neither category of patients was on treatment at the time of admission. All patients were smokers and consumed alcoholic beverages daily. Most postoperative complications occurred in patients who had teeth in the fracture focus, 88.9% ($n=24$), the complications developed in edentulous areas representing a low percentage, 11.1% ($n=3$).

The most frequent postoperative complications appeared in the case of patients treated by the orthopedic method, followed by those treated by the orthopedic-surgical method. The smallest number of complications was registered in the case of patients treated by osteosynthesis surgery with titanium miniplates and screws. These results were statistically significant (Table 2).

In the case of all patients with osteitis in the fracture focus, surgery with bone stump debridement, open reduction of the fracture under direct visual control, and osteosynthesis with titanium plates and screws, 2 for each focus, were carried out. Rigid fixation by intermaxillary block was performed for 2 weeks. In the case of patients with primary and secondary fascial space infections, incision, drainage and washing of the infection were initially performed, and after the amelioration of the infectious processes, surgery was conducted for the treatment of osteitis in the fracture focus using the protocol described above.

In the case of malunion, the 2 fragments were refractured, replaced in a correct anatomical position and fixed by osteosynthesis with monocortical titanium plates and screws, 2 for each focus. The evolution of all cases was favorable ($n=27$, 100%).

Discussions

The aim of this study was reached. The incidence, the type and the characteristics of postoperative mandibular fractures in our

Table 2. Distribution of postoperative complications depending on the treatment method

TYPE OF TREATMENT	Complications		Total	P
	without	with		
ORTOPEDIC	521	20	541	0.01
	77.00%	76.90%	77.00%	
SURGICAL	22	0	22	
	3.20%	0.00%	3.10%	
CERCLAGE	51	1	52	0.01
	7.50%	3.80%	7.40%	
COMPOUND	74	3	77	
	10.90%	11.50%	11.00%	
	677 (100%)	26(100%)	709 (100%)	

geographical area, as well as the most effective method for their treatment could be determined.

The fracture lines situated in the paramedian mandibular region developed postoperative complications the most frequently in our study. Similar results are indicated by other authors (Wang et al 2011, Laverik et al 2012, Christensen et al 2017). This aspect can be explained by the anatomical and biomechanical particularities of this region. At this level, the difference in the distribution of insertions between the elevator and depressor muscles of the mandible favors the displacement of bone fragments, making difficult the anatomical reduction of the stumps and favoring the development of complications (Rudderman et al 1992, Kalfarentzos et al 2009). Also, the displacement of bone fragments itself causes the comminution of surrounding tissues, given the increased adhesion of the periosteum in the paramedian mandibular region, which leads to the development of gingival wounds that expose the fracture focus in the septic oral environment (Lynham et al 2012, Businger et al 2012). Due to the retrospective nature of this study, it cannot be precisely established which of the factors mentioned above predominantly caused each postoperative complication. Further research of these aspects is required.

In contrast, other authors indicate the appearance of complications mainly in the case of lateral mandibular fractures (Kyrgidis et al 2013, van den Bergh 2012), but they do not provide data related to the severity of the lesions or the general state of the patients. The multitude of factors that may contribute to the development of postoperative complications can explain the discrepancy of the results reported in the literature.

Intraorally open fractures developed most of the postoperative complications. This is in accordance with the results of other literature studies (van den Bergh 2012, Vajgel et al 2012, Teñ et al 2016). It is obvious that through the existing gap, the saliva carries microbial elements to the fracture focus, transforming the sterile bone environment into a septic environment (Ellis et al 2012). This affects bone healing, increasing the risk of complications (Moraes et al 2010).

In this study, the highest incidence of complications was identified among displaced fractures, which is supported by other authors (de Matos et al 2010, van den Bergh et al 2012, Vajgel et al 2013, Teñ et al 2016, Christensen et al 2017). This could be due on the one hand to the fact that most displaced fractures

are intraorally open (Brown et al 1991). A traumatic agent should develop sufficiently high kinetic energy to displace the bone fragments in the fracture focus, which also affects the perimandibular soft tissues and may induce their discontinuity, opening the fracture focus into the septic intraoral environment (Farwell et al 2008). On the other hand, depending on the degree of displacement and the direction of the fracture line, the reduction of the fragments can be difficult or even impossible by orthopedic methods (Brown et al 1991, Farwell et al 2008). Imperfect reductions with minimum steps of several millimeters may go unnoticed on postoperative clinical examination, causing subsequent disorders that will probably require surgical correction (Lynham et al 2012). In this context, the result obtained is not at all surprising.

Most of the complications occurred in fracture foci situated in dentate areas. This is highlighted by other authors (Anyanechi et al 2011, Mangone et al 2011, Brajdic et al 2011, Oruc et al 2016). It is known that the presence of teeth in the fracture focus involves an increased risk of infection, because of the possible propagation of microorganisms along periodontal ligaments or along the root canal (Kamboozia et al 1993, Aulakh et al 2017). The tooth may also undergo pulp necrosis following the transection of the periapical vascular-nervous bundle by the fracture line (Kamboozia et al 1993, Aulakh et al 2017). In addition, mobility may persist in the fracture focus due to inadequate reduction and fixation, as it is known that mechanical instability potentiates the propagation of periodontal or endodontic microorganisms in the bone (Shetty et al 1989, Aulakh et al 2017). The fact that the most frequent therapeutic approach to teeth in the fracture focus in our study was dental extraction allows us to suppose that a great number of teeth were lost. In this context, incomplete curettage of periapical processes and inappropriate suturing of the post-extraction alveolar mucosa allow the entry of microorganisms, favoring the infection of the fracture focus and the development of complications (Aulakh et al 2017). This statement is purely speculative because in our statistics there are no accurate data regarding the correctness of treatment for teeth in the fracture focus. Further studies focusing on this aspect are needed in our geographical area. In contrast, some authors report that in the context of open reduction and rigid osteosynthesis fixation, as well as correctly conducted antibiotic therapy, complications due to teeth in the fracture focus are minimal and statistically irrelevant (Mangone et al 2011, Brajdic et al 2011, Oruc et al 2016).

Most of the patients who developed postoperative complications had no general chronic diseases that might have interfered with bone healing. This result is confirmed by other authors (Mathog et al 2000, Yamamoto et al 2013, Teñ et al 2016, Christensen et al 2017). Three patients suffered from uncontrolled arterial hypertension and were treated orthopedically, general anesthesia being contraindicated in their case. Due to the retrospective nature of this study, there are no precise data available indicating the need for surgical treatment in these 3 cases; the complications might have derived from inadequate treatment. In this context, no conclusions can be drawn regarding this fact. One patient with severe neuropsychic disorders developed osteitis in the fracture focus. This was treated strictly by surgery with open reduction and fixation with titanium plates and screws; intermaxillary block was not applied because of the contraindication

given by the general disease. Considering the patient's background disease, it can be assumed that the development of osteitis was due to the patient's non-compliance. However, no exact data regarding this aspect are available in the medical record, which is why no conclusion can be drawn about it.

All patients were smokers and daily alcohol consumers. This finding is also present in other literature studies (Adams et al 2001, Sandler 2001, Serena-Gomez et al 2008, Yamamoto et al 2013). Alcohol inhibits the formation of T lymphocytes, their migration and adhesion to microorganisms, and decreases the immune response of the body, making it susceptible to bacterial colonization, infection and delayed healing (Sandler 2001). Alcohol also inhibits the metabolism of proteins, especially collagen, thus interfering with tissue healing processes (Sandler 2001). Smoking induces peripheral vasoconstriction, decreasing tissue perfusion in the fracture focus, while tars resulting from cigarette smoke interfere by a direct molecular mechanism with osteoinduction and osteoconduction processes, delaying bone healing (Adams et al 2001, Serena-Gomez et al 2008). In his study, Adams et al 2001 indicates the fact that in the case of tibial fractures in smokers, bone healing was delayed by 4 weeks compared to non-smokers. Adding to these effects, the continuous contamination of the mandibular fracture focus from the septic oral environment makes obvious the increase in the rate of postoperative complications among smokers and alcohol users. The most frequent postoperative complication in our study was osteitis, a result similar to those published by other authors (Mathog et al 2000, Gandhi et al 2011, Teñ et al 2016, Christensen et al 2017). In contrast, Yamamoto et al 2013 reports in his study the highest incidence among complications for delayed union, while B. van den Bergh et al 2012 attributes the highest incidence to malunion. Our result is not surprising given the septicity of the oral cavity. However, it is known that all fracture foci with osteitis also have delayed union (Serena-Gomez et al 2008), but according to our methodology, we included in the category of delayed union only those foci that did not present septic processes.

The highest incidence of postoperative complications in our study was among patients treated orthopedically, similarly to the results reported by other authors (Newlands et al 2003, Laverick et al 2012, Kyrgidis et al 2013, Rana et al 2014). In contrast, Neupert and Boyd 1991 indicate the highest rate of postoperative complications among patients treated surgically by osteosynthesis, and B. van den Bergh et al 2012 among those treated by circummandibular wiring. However, these authors do not refer to potential tobacco or alcohol use among the treated patients, so that the exact cause of complications is not known. Our result can be attributed to the mechanical instability and sometimes imperfect reduction of the fracture focus, a situation more frequently found in the case of orthopedically treated patients and confirmed by the publications of other authors (Rana et al 2014). Patients treated surgically by osteosynthesis with titanium plates and screws developed the fewest postoperative complications. This result is in agreement with most of the literature studies (Alkan et al 2007, de Matos et al 2010, Gandhi et al 2011, Ellis et al 2012, Vajgel et al 2013). This is probably due to the anatomically perfect reduction of the fractured fragments under direct visual control and to the maintenance of close contact between them, characteristic of rigid

osteosynthesis fixation (de Matos et al 2010, Gandhi et al 2011, Ellis et al 2012, Vajgel et al 2013). Also, primary bone union by Haversian remodeling obtained by surgery is much more rapid than secondary union with the formation of bone callus that characterizes orthopedic fixation (Assael 1994, Freinberg et al 1997, Farwell et al 2008, Lynham et al 2012). The longer duration of healing due to the many stages required for callus formation prolongs the duration of exposure of the healing focus to external agents, thus increasing the risk of postoperative complications (Assael 1994, Freinberg et al 1997, Farwell et al 2008, Lynham et al 2012).

However, like any retrospective study, our study has its limitations. As information was collected from the medical records, some data could be incomplete. In order to overcome this drawback, only complete medical records were selected, but in this way, a number of cases were lost from the statistical database.

Conclusions

The most frequent long-term postoperative complications in the case of mandibular fractures were septic complications, represented by osteitis in the fracture focus. Paramedian, displaced, and intraorally open fractures had the highest rate of postoperative complications. The lowest incidence of postoperative complications was obtained following osteosynthesis surgery, by which open reduction of the mandibular fractures followed by their fixation with titanium plates and screws was performed.

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