

The Pattern and Characteristics of Mandibular Fractures: A 3-Year Prospective Clinical Study

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Abstract

In the absence of early diagnosis and correct treatment, mandibular fractures may lead to major functional and aesthetic complications affecting the subsequent integration of the traumatized patient in society. Mandibular fractures are most frequently masked by associated injuries of adjacent soft tissues, which can mislead less experienced clinicians.

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Materials and methods: The aim of this study was to identify the incidence and type of injuries associated with mandibular fractures and to correlate them with the clinical characteristics of fracture lines. For this, patients diagnosed with mandibular fractures in the Clinic of Oral and Maxillofacial Surgery I in Cluj-Napoca in the period 1 January 2014 – 31 December 2016 were prospectively analyzed. **Results:** The study included 60 patients with 101 mandibular fracture foci. The most frequent location was subcondylar (24.75%). All fracture lines were complete (100%), the majority of which were displaced (70.30%) and intraorally open (50.70%). Displaced fractures were most frequently intraorally or extraorally open, while non-displaced fractures were closed ($p=0.017$). Bone fragment displacement was most frequently found in the case of lateral mandibular fractures ($p=0.576$). The most frequent associated injuries were laceration and soft tissue contusion, in equal proportions. Displaced fractures were most frequently accompanied by associated soft tissue injuries ($p=0.035$). **Conclusions:** Bone fragment displacement favors the opening of the fracture focus. The development and severity of concomitant soft tissue injuries are directly proportional to the degree of bone fragment displacement in the fracture focus.

Keywords: traumatology; mandible; fracture; bone; etiology.

1. Introduction

Mandibular fractures can occur alone or concomitantly with associated injuries, which are sometimes severe, with a high degree of morbidity and risk of mortality [1]. Psychological disorders such as post-traumatic stress syndrome and depression are frequently present in these cases, adding to the difficulty of treatment [2]. In order to prevent late complications, correct diagnosis and rapid initiation of adequate therapy are mandatory [3]. Displaced mandibular fractures are easy to clinically diagnose due to occlusal disorders and eating difficulties that occur right after the trauma, which most frequently do not require additional investigations [3]. However, this cannot be said about non-displaced or incomplete fractures, the clinical diagnosis of which can be difficult due to attenuated symptoms or associated injuries that mask the fracture line, in which case imaging examination is essential for diagnosis [3,4]. The multitude of clinical signs, the wide variety of associated injuries that complement the clinical picture of mandibular fractures, as well as the literature contradictions regarding these aspects can create confusion among specialists [3,5,6]. In this context, we believe that the study and determination of the clinical characteristics of mandibular fractures in the population of our geographic area is absolutely necessary to adopt an optimal treatment.

The aim of this prospective study was to assess the clinical characteristics of mandibular fractures and the injuries associated with these, as well as to establish a correlation between them in order to identify the type of mandibular fracture with the highest incidence of associated injuries.

2. Material and methods

The study was performed in patients who presented to the ambulatory service of the Clinic of Oral and Maxillofacial Surgery I in Cluj-Napoca in the period 1 January 2014 – 31 December 2016. The patients selected to be included in the study gave their informed consent for the use of their medical data in this study.

Data obtained from history taking and extensive clinical examination were recorded on observation charts. The following variables were monitored: the degree of bone involvement (incomplete/complete fracture), the topographic location of the mandibular fracture (median, paramedian, lateral region, mandibular angle, alveolar ridge, ascending ramus, coronoid, subcondylar and condylar process), the degree of displacement of bone fragments (displaced/non-displaced fracture), the relationship of the fracture focus with the external environment (closed/intraorally open/extraorally open fracture), the type of associated injuries (contusion, abrasion, laceration, dental trauma), the presence of dental trauma (crown/root fracture, tooth avulsion/dislocation).

The study inclusion criteria were the following:

- The patient's consent;
- The presence of at least one mandibular fracture;
- Etiology of traumatic origin;
- The presence of imaging investigations (posteroanterior panoramic facial radiograph or computed tomography scan) complementing and confirming the clinical diagnosis of mandibular fracture and at the same time allowing to evidence its characteristics and topographic location.

The exclusion criteria were:

- The patient's refusal to participate in the study;
- The absence of a mandibular fracture;
- Other etiology than trauma of the mandibular fracture;
- The absence of complementary imaging investigations.

Data were centralized in electronic format using Microsoft Excel software. Descriptive statistics of the assessed cases was performed with a two decimal accuracy. Statistical analysis was carried out with the 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 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.

3. Results

The 60 patients included in the study had a total number of 101 fracture lines. There were 71 fracture lines

(70.29%) in the mandibular body, and 30 fracture lines (29.20%) in the vertical mandibular ramus.

Double fractures were predominant in this study, 53.33% (n=32), followed by single fractures, 35% (n=21). Triple fractures and comminuted fractures were a minority, being found in a proportion of 8.33% (n=5) and 3.33% (n=2), respectively. The most frequent topographic location of mandibular fracture lines was the subcondylar region, followed by the mandibular angle and the paramedian mandibular region. No intracapsular condylar or alveolar ridge fracture was registered (Fig. 1).

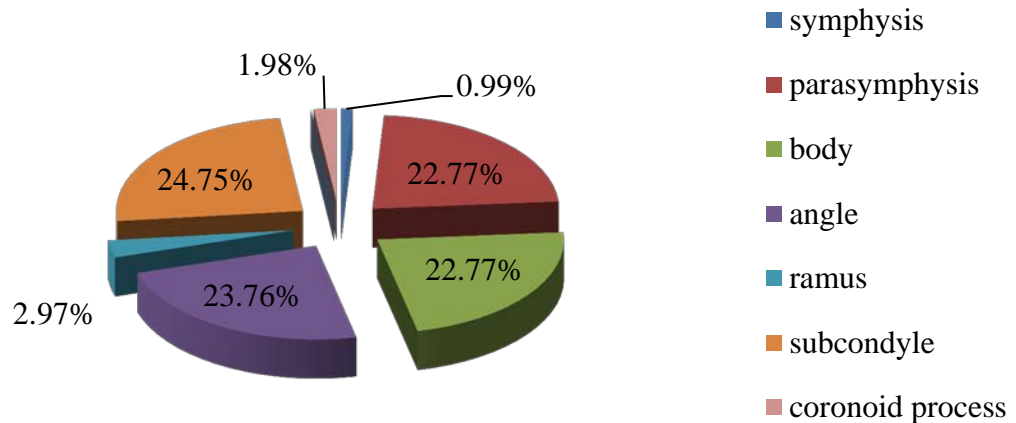


Figure 1: Distribution of fracture lines depending on location

All fracture lines were complete, involving both bone cortices, n=101 (100%); the majority of these were displaced, 70.30% (n=71), non-displaced fractures lines being found in a small proportion 29.70% (n=30).

Most of the fracture foci were intraorally open, being contaminated from the septic environment of the oral cavity, while closed and extraorally open fractures represented a minority (Fig. 2).

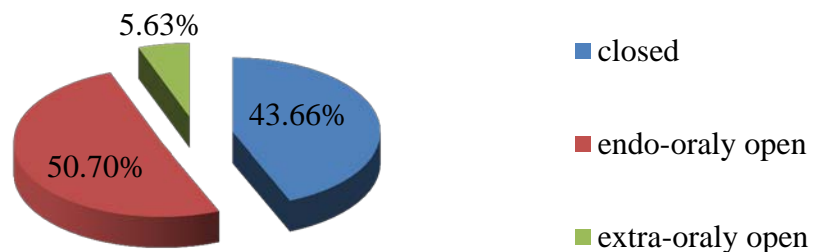


Figure 2: Distribution of fracture lines depending on their relationship with the external environment closed, intraorally open, extraorally open

There were 43 patients (71.67%) with concomitant injuries associated with mandibular fractures, while in the rest of 17 patients (28.33%), these were absent. Laceration and contusion had the highest incidence, followed by abrasion (Fig. 3). Dental traumas had the lowest incidence among associated injuries, being identified only in 5 patients. Of these, tooth avulsions (n=3), and tooth dislocations (n=2) were the most frequent.

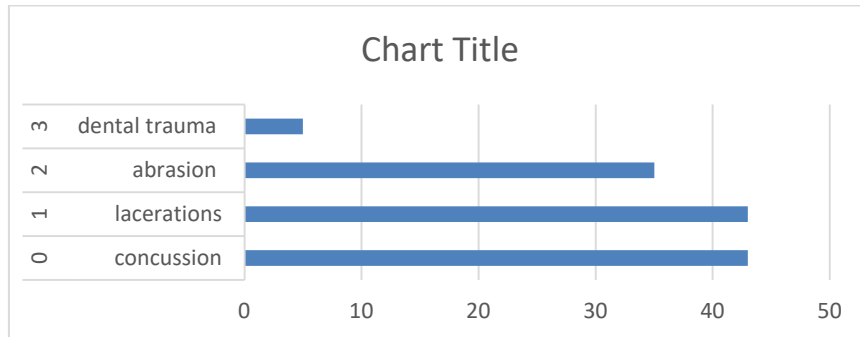


Figure 3: Distribution of patients depending on the incidence of associated injuries dental trauma abrasion laceration contusion

Table 1: Distribution of the frequency of bone fragment displacement depending on the relationship of the fracture focus with the external environment

| | | DISPLACED BONE FRAGMENTS | | Total |
|--|------------------|--------------------------|-------------|-------------|
| | | NO | YES | |
| RELATIONSHIP WITH THE EXTERNAL ENVIRONMENT | CLOSED | 13 72.2% | 12 28.6% | 25 41.7% |
| | INTRAORALLY OPEN | 4 22.2% | 24 57.1% | 28 46.7% |
| | EXTRAORALLY OPEN | 0 0.0% | 2 4.8% | 2 3.3% |
| | | | | P=0.017 |

The correlation between the degree of bone fragment displacement and the relationship of the fracture focus with the external environment was performed. Displaced fractures were most frequently intraorally or extraorally open, while non-displaced fractures were closed. These results were statistically significant (Table 1). The correlation between the frequency of associated soft tissue injuries and the topographic location of fracture lines evidenced no statistically significant differences; the location of the fracture line did not influence the development of associated injuries. Following the correlation of associated injuries with the degree of bone fragment displacement, it was found that associated injuries had the highest frequency among displaced fractures. This result was statistically significant (Tables 2,3).

Table 2: Correlation of the frequency of soft tissue contusion with the topographic location of fracture lines and the degree of bone fragment displacement

| SOFT TISSUE CONTUSION | | | | |
|-----------------------------------|----------------------|---------------|----------------|----------|
| LOCATION | | ABSENT | PRESENT | P |
| PARAMEDIAN | Absent | 13 (33.3%) | 26 (66.7%) | 0.384 |
| | Present | 4 (19%) | 17 (81%) | |
| LATERAL | Absent | 11 (28.9%) | 27 (71.1%) | 1.000 |
| | Present | 6 (27.3%) | 16 (72.7%) | |
| MANDIBULAR ANGLE | Absent | 5 (13.9%) | 31 (86.1%) | 0.600 |
| | Present | 12 (50%) | 12 (50%) | |
| SUBCONDYLAR AND CONDYLAR | Absent | 14 (35%) | 26 (65%) | 0.188 |
| | Present | 3 (15%) | 17 (85%) | |
| BONE FRAGMENT DISPLACEMENT | Without displacement | 8 (44.4%) | 10 (55.6%) | 0.134 |
| | With displacement | 9 (21.4%) | 33 (78.6%) | |

Table 3: Correlation of the frequency of soft tissue laceration and abrasion with the topographic location of fracture lines and the degree of bone fragment displacement

| SOFT TISSUE LACERATION | | | | |
|-----------------------------------|----------------------|---------------|----------------|----------|
| LOCATION | | ABSENT | PRESENT | P |
| PARAMEDIAN | Absent | 14 (35.9%) | 25 (64.1%) | 0.141 |
| | Present | 3 (14.3%) | 18 (85.7%) | |
| LATERAL | Absent | 8 (21%) | 30 (78.9%) | 0.178 |
| | Present | 9 (40.9%) | 13 (59.1%) | |
| MANDIBULAR ANGLE | Absent | 10 (27.8%) | 26 (72.2%) | 1.000 |
| | Present | 7 (29.2%) | 17 (70.8%) | |
| SUBCONDYLAR AND CONDYLAR | Absent | 12 (30.0%) | 28 (70%) | 0.919 |
| | Present | 5 (25%) | 15 (75%) | |
| BONE FRAGMENT DISPLACEMENT | Without displacement | 8 (44.4%) | 10 (55.6%) | 0.134 |
| | With displacement | 9 (21.4%) | 33 (78.6%) | |
| SOFT TISSUE ABRASION | | | | |
| LOCATION | | ABSENT | PRESENT | P |
| PARAMEDIAN | Absent | 20 (51.3%) | 19 (48.7%) | 0.156 |
| | Present | 6 (28.6%) | 15 (71.4%) | |
| LATERAL | Absent | 18 (47.4%) | 20 (52.6%) | 0.576 |
| | Present | 8 (36.4%) | 14 (63.6%) | |
| MANDIBULAR ANGLE | Absent | 12 (33.3%) | 24 (66.7%) | 0.099 |
| | Present | 14 (58.3%) | 10 (41.7%) | |
| SUBCONDYLAR AND CONDYLAR | Absent | 18 (45%) | 22 (55%) | 0.927 |
| | Present | 8 (40%) | 12 (60%) | |
| BONE FRAGMENT DISPLACEMENT | Without displacement | 12 (66.7%) | 6 (33.3%) | 0.035 |
| | With displacement | 14 (33.3%) | 28 (68.7%) | |

4. Discussions

The Double mandibular fractures were predominant in our study, being present in more than half of the cases, a result similar to those reported by other authors [7]. It is known that double or multiple fractures are secondary to trauma caused by an agent with high kinetic energy [8,9]. Kinetic energy should be sufficiently high to induce, in addition to the fracture line directly generated at the site of impact, a secondary contralateral fracture line due to flexion imposed on the mandibular arch [10,11,12,13]. Traumatic agents that do not develop sufficient kinetic energy to induce high secondary tension in the contralateral inner bone cortex of the mandibular arch so as to fracture it will cause a single fracture line in the impact area through a direct mechanism, the contralateral part remaining unaffected [10,11,12,13]. The fact that the majority of the fracture cases in the current study are caused by interpersonal violence explains the predominance of double fractures, as it is known that blows applied directly to the face, particularly with blunt objects, develop considerable kinetic energy. However, accurate data regarding the kinetic energy level of traumatic agents are missing from our study, and this can only be inferred from the history and clinical examination of each patient. Thus, further research of this aspect in our geographic area is recommended. Contrary to our results, many literature studies report the predominance of single mandibular fractures [14,15,16,17,18,19,20].

The most frequent location of mandibular fracture lines in our study was in the subcondylar region. This result is in accordance with those obtained by other authors [21,22,23,24]. The subcondylar region is a minimum resistance area of the mandible through its anatomical structure, with reduced cortical bone [54,2,46,51]. These fractures most frequently occur secondarily to traumas to the median, paramedian or lateral region of the mandible, through a flexion or shear mechanism [10,11,12,13]. The fact that subcondylar fractures can occur secondarily to trauma to any site of the mandibular body explains their high frequency. Contrary to our results, other authors report paramedian [16,18], lateral mandibular [14,25,26] or mandibular angle fractures [15,27,28] to be the most frequent. As shown above, the literature results regarding the topographic location of mandibular fracture lines are extremely varied and contradictory. Knowing the incidence of the locations of fracture lines in our population helps in the rapid choice of optimal treatment. A low incidence was found for vertical ramus and mid-symphyseal fractures, in accordance with the results of other literature studies [15,16, 22,23,24,25,26]. Intracapsular condylar head fractures were absent in our study, probably because of the anatomical position of the condylar head, which is less exposed to direct trauma due to the prominence of the temporo-zygomatic arch that protects it [10,11,12,13]. Also, indirectly, this is fractured secondarily to trauma applied from down upwards to the basilar edge of the mandibular gonion through a compression mechanism. The low incidence of this type of mechanism in oro-maxillo-facial traumatology explains the absence of this type of fracture in this study [10,11,12,13].

The most frequent associations between fracture foci in the case of multiple fractures were lateral fractures associated with mandibular angle fractures, followed by paramedian and ramus fractures. The same results are reported by Ogundare BO [28] in his study. However, other authors show that the most frequent association between the topographic locations of multiple mandibular fractures is the paramedian + subcondylar region [16,18] or the paramedian + mandibular angle region [27]. These differences present in the literature can be attributed to the fact that influences on mandibular fracture biomechanics are multifactorial and have been

extensively discussed in scientific papers related to this subject [10,11,12,13]. The way in which the mandibular bone is fractured, as well as the topographic location of primary or secondary fractures, is the result of several independent factors that act synergistically and can lead to a multitude of variants [10,11,12,13].

All fractures present in our study were complete, and bone stump displacement was found in the majority of the fracture foci. This result is reported by other studies [16,23,24,26,29]. The absence of incomplete fractures emphasizes once more the fact that the mandibular fractures included in this study were caused by traumatic agents with high kinetic energy [10,11,12,13]. Another reason for which incomplete mandibular fractures are absent from our statistics can be the fact that their symptoms are reduced due to the maintenance of mandibular bone continuity [8,11,17,21]. Thus, in the absence of a functional disorder in the oral cavity, patients most frequently do not consider it necessary to present to a specialized service and continue their daily activities [8,11,17,21]. Certainly, these statements are only suppositions, not demonstrated facts. In a previous retrospective study, we obtained similar results, but incomplete fractures were also present in a small number (2.55%) [30]. The increased kinetic energy can also explain the great number of displaced fractures in this study, as it is known that primary bone stump displacement is directly proportional to the force of the causal agent [10,11,12,13]. Displacement of bone stumps can also be secondary to traction on the muscles inserted into these [8,11,17,21]. The highest frequency of bone stump displacement in this study was found among mandibular angle fractures and lateral fractures. These are topographic regions that favor secondary displacement [10,11,12,13,23,31].

Regarding the relationship with the external environment, intraorally open fractures were predominant in this study, a result similar to those of other authors [30,32,33,34,35]. Contrary to our results, Işık [36], Kapoor [37] and Teneç [30] indicate a predominance of closed fractures, uncontaminated from the septic oral environment. The high incidence of intraorally open fracture foci can be attributed to the great number of displaced fracture lines present in this study, considering mucosal and periosteal adherence to the mandibular bone. Thus, the sudden displacement of bone fragments induces laceration of the overlying mucoperiosteum, opening the fracture focus in the oral cavity [3,5,38,39,40,41]. The results of the above mentioned authors, who indicate closed fractures to be the majority, can be explained by either the predominant number of non-displaced fractures or the low severity of traumas inducing those fractures. These statements are speculative in nature, as the mentioned articles do not present concrete data regarding the intensity of traumatic agents. Extraorally open fractures are in a small number in the current study, a result similar to that of Teneç [30] – 0.10%. Studies indicating a high number of extraorally open mandibular fractures are generally conducted in military conflict areas, these fractures being caused by explosions or firearms [6]. Ballistic traumas are particular, inducing comminuted fractures and extensive soft tissue lacerations, with or without lack of substance, their severity being directly proportional to the velocity of the projectile, its diameter and density, as well as the density of the affected tissues [42,43]. Traumas caused by explosions have special characteristics, the causal factors being in fact different types of projectiles [42,43]. The current social and political context of our country can explain the low incidence of extraorally open mandibular fractures.

The majority of the patients in this study had associated dental or soft tissue injuries concomitantly with mandibular fractures, patients without associated locoregional injuries being a minority, a result similar to that

provided by other authors [27,29,33,44,45]. This result is not surprising, given that from an intraoral anatomical point of view, the mandible is covered by mucoperiosteum, and extraorally it is covered by the soft tissues of the genial region (muscles, superficial cervical fascia, platysma, subcutaneous cellular tissue and skin) [46,47]. Thus, the action of the traumatic agent first impacts perimandibular soft tissues and only through them the mandibular bone, soft tissue injuries being self-evident [8,17]. Contrary to this result, there are studies that report a predominance of patients without associated soft tissue injuries [41,48,49,50]. The contradictory results reported in the literature regarding associated injuries are not surprising given the variety of traumatic agents that can induce a mandibular fracture. Further research related to this aspect is required.

Lacerations were the most frequent injuries associated with mandibular fractures in our study. The same result is found in the studies of Anna Kraft [44], Hashim H [32], Hitosugi M [34], Okoje VN [51] and Nonato ER [52]. The great proportion of lacerations, open fractures and displaced bone fragments highlights the high severity of the traumas included in this prospective study. Contrary to our results, other authors report contusion to be the most frequent associated soft tissue injury [27,30,45,48]. This is probably due to a lower intensity of the kinetic energy of the traumatic agents involved. Abraded wounds were present in a small proportion in our study. These are characteristic of trauma from fall, this etiology representing a minority in this study [8,17]. Other publications indicate dental trauma to have the highest incidence among injuries associated with mandibular fractures [53,54,55]. The small number of dental injuries in our statistics can be due to partial or total edentation of the patients on the one hand, and to the small number of patients included in this study compared to other studies, on the other hand.

Tooth avulsion was the most frequent dental injury in our statistics, similarly to the results reported by other authors [48,49,55]. However, this result is in contradiction to those of other publications, which indicate tooth dislocations [39] and crown fractures, respectively [30,44,52,53], to be the most frequent post-traumatic dental injuries. The literature contradictions regarding the incidence of dental injuries can be explained by the fact that the type of dental trauma is influenced by a variety of factors such as: the causal agent and the kinetic energy developed by it, the direction of the agent, the site of impact, the position of the head, the dental and periodontal status of the patient at the time of the trauma, etc. [1,3,17,49].

The correlation between the degree of bone stump displacement in the mandibular fracture focus, the incidence of associated lesions and the relationship with the external environment allowed us to conclude that displaced fractures are most frequently accompanied by associated injuries and are predominantly open to the septic intraoral environment. This result is evidenced by other studies [3,5,39,40,41,44,45,48,49,50]. To the high kinetic energy required for the displacement of the fractured stumps, the possibility of soft tissue laceration through bone fragment displacement is added, which increases the incidence rate of concomitant soft tissue injuries [3,8,17,30,49].

The limitation of our study would be the number of the patients. Our sample was limited to patients diagnosed with mandibular fractures in the Clinic of Oral and Maxillofacial Surgery I in Cluj-Napoca in the period 1 January 2014 – 31 December 2016. We recommend early diagnosis and correct treatment of mandibular fractures in order to prevent major functional and aesthetic complications.

5. Conclusions

Interpersonal Subcondylar fracture was the most frequent mandibular fracture in this study. The most frequent association of fracture lines in the case of multiple fractures was lateral fracture associated with mandibular angle fracture.

All mandibular fractures were complete, with the involvement of both bone cortices; the majority of these were displaced and intraorally open. The presence of displaced bone fragments favored the opening of the fracture focus. Bone fragment displacement in the fracture focus most frequently occurred in the lateral mandibular area.

The most frequent associated soft tissue injury was laceration. The most frequent associated dental injury was tooth avulsion. The development and severity of concomitant soft tissue injuries were directly proportional to the degree of bone fragment displacement in the fracture focus.

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