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ANALYSIS OF THE FORMATION OF NON-GUNSHOT FRACTURES OF THE MANDIBLE (LITERATURE REVIEW)

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Abstract. The article presents the results of clinical, retrospective and experimental studies of the formation of mandibular fractures of non-dunshot origin depending on the direction and angle of impact, the peculiarities of destruction of its surface during closing and opening of the jaw.

The aim of the study. To analyze the data of scientific literature on the problem of the formation of non-gunshot fractures of the mandible.

Materials and methods. The bibliosemantic method was used to analyze the results of previous research based on literature sources and electronic databases: Pubmed, Wiley, Research Gate and National Repository of academic texts.

Results. As a result of the study, a clear pattern was established: fractures were formed either in the area of impact to the mandible or in the area adjacent to the impact site; depending on the impact site, the number of fractures that occurred as a result of impact varied; in no case did impact to the same area cause exactly the same set of fractures, and the location of fractures that occurred at points other than the impact site also varied significantly.

Conclusions. Distinct patterns of fracture were identified: fractures emerged either where the mandible was struck or in adjacent regions; the number of fractures varied based on the point of impact; no two impacts to the same area resulted in an identical fracture pattern, and variations were consistently noted in fractures located away from the impact site. The structural geometry of the mandible indicates that fractures typically occur in biomechanically vulnerable areas, notably around the necks of the articular processes, the corners, and the mental foramina. When the jaws are closed, compression fractures were noted on the outer surface, while tensile fractures formed on the inner surface, where primary fractures arise and a fracture zone develops at the contact point; when the jaws are opened, indirect fractures were observed on the opposite side.

Key words: mandible fracture; non-gunshot fracture; AOCMF classification; direct fracture; indirect fracture.

Introduction. Mandibular fractures are diagnosed most often (in 70-80 % of cases) among all traumatic injuries of the maxillofacial region [1]. At the same time, American researchers note a decrease in mandibular injuries from 82 % to 63 % [2].

A fracture of the mandible can occur at any location due to its intricate structure and arched shape. Fractures are categorized based on the number of sites affected, such as single, double, or triple fractures of different localization [3-6].

Retrospective studies often lack control over impact conditions, as patients may not recall or be aware of the precise impact site, angle, or force involved. Clinical investigations offer insights into the relationship between fracture types and trauma scenarios [7-12], yet they also face limitations since the actual impact conditions remain unknown, and biomechanical studies provide limited details on fracture patterns [13-15].

Experimental research allows for direct observation of fracture processes, but inconsistencies exist regarding impact sites across studies. Some authors focus on the mandibular body [15, 16, 17], others on the angle [17, 18], or the condylar region [19, 20], complicating cross-study comparisons. Accurate identification of the number and location of impacts during blunt trauma is vital for understanding fracture mechanisms, but current experimental data remain scarce.

The aim of the study. To analyze the data of scientific literature on the problem of the formation of non-fire fractures of the mandible.

Materials and methods. The bibliosemantic method was used to analyze the results of previous research based on literature sources and electronic databases: Pubmed, Wiley, Research Gate and National Repository of academic texts.

Results of the study. Analysis of fracture localization reveals that the chin (mental area) accounts for approximately 43 % of cases, while the angle region is involved in about 32 % of incidents across both sexes. Men predominantly experience single (52 %) and double (47 %) mandibular fractures, whereas women more frequently have double fractures (47 %). Notably, multiple fractures are over four times more common in women than in men [21, 22].

Other retrospective investigation shows that symphysis fractures are the most prevalent of all patients (53 %), unilateral condyle (37%), angle (36 %), bilateral condyle (9 %), body (8 %), and coronoid (2 %). The most common cause of fracture was daily-life activity (58 %), followed by violence (30 %), traffic accidents (8 %), and syncope (4 %) [4].

The most prevalent fracture types are transverse and oblique (32 % and 41 %, respectively), while comminuted fractures are relatively rare, comprising around 7 % of cases [22].

Typically, single mandibular fractures are found between the second and third molars, at the mandibular angles, near the condylar processes, or between the lateral incisors and canines. Double fractures commonly occur between the canine and condylar process, or between the canine and mandibular angle, as well as across premolars and the angle. Triple fractures tend to involve both condylar processes and the area between the central incisors. These fractures can happen with the mouth open or closed [23].

Achieving proper facial aesthetic and functional recovery hinges on precise evaluation, diagnosis, and treatment of mandibular fractures. Extensive retrospective, clinical, and experimental research has been carried out to better understand these injuries. Retrospective studies have linked the causes of mandibular fractures – including road accidents, assaults, domestic violence, falls, sports, occupational injuries, ballistic trauma, and pathological conditions – to specific injury mechanisms [6, 24-27]. Factors such as age, gender, socioeconomic status, and injury mechanism influence both the cause and severity of fractures.

An interesting experimental investigation showed simulation of mechanical blunt trauma to the mandible in a controlled environment. Authors documented fracture locations and investigated the correlation between impact site and fracture pattern, considering impact direction and jaw positioning to better understand bone damage mechanisms [28].

For the experiments, intact, embalmed human skulls from deceased men aged 45 to 50 were used. Before testing, skulls were CT-scanned to ensure no significant pre-existing injuries or pathologies. The specimens were stored at -20°C and thawed at room temperature prior to testing to preserve the biomechanical properties of bone tissue [29, 30].

The experimental setup involved delivering impacts to a vertical skull with free movement post-impact, mimicking real-world blunt force scenarios [28]. A specially designed pneumatic impact system was employed to produce consistent blows [29] (Fig. 1).

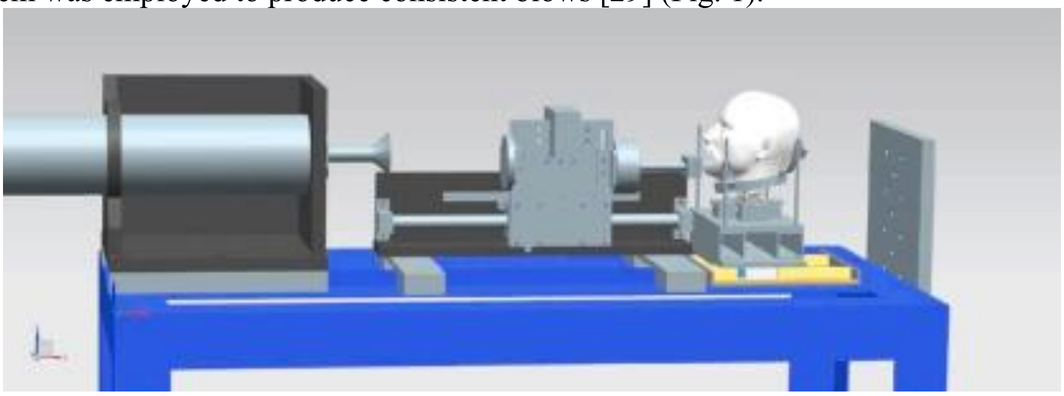

Figure 1. Display of a customized pneumatic system in preparation for a midline impact on the mandible [29].

The system managed the release of compressed nitrogen gas to generate initial velocity for a guide carriage holding the impactor. According to previous research [28], a setup with a mass of 6-7 kg was propelled at about 5 m/s, successfully producing skull fractures. The pneumatic system was calibrated so that impact pressure corresponded to this velocity before testing mandibular fractures [29]. For this study, all impact tests were performed at 80 PSI pressure, aiming for a velocity close to 5 m/s. During each impact, the head was positioned with the impact surface facing vertically. The impact mass included both the impactor and the guide carriage, totaling approximately 6.5 kg for skull fracture experiments [28, 29].

Impacts targeted five specific points on the mandible: the midline (n=3), anterior body (n=2), middle body (n=2), posterior body (n=2), and mandibular ramus with processes (n=2) (Fig. 2).

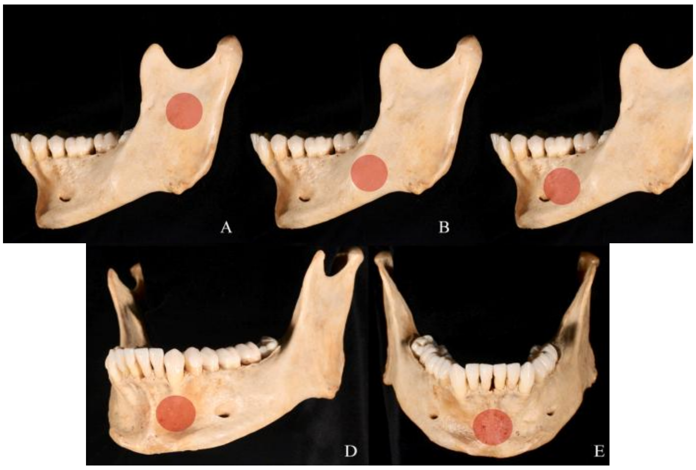

Figure 2. Impact areas of the mandible. From the left to the right [28, 29].

As depicted in Fig. 2, the mandibular impact zones were divided into five regions: zone (A) covered the ramus and processes, while the mandibular body was split into four zones: posterior (B), middle (C), anterior (D), and medial (E). The impact sites were marked with red circles.

To standardize impact locations, the following landmarks were used: midline (center of chin protuberance), anterior (teeth 33, 32), middle (teeth 35, 36), posterior (teeth 37 or 38 if present), and branch area (between the mandibular notch and the angle). The impact was centered on the alveolar bone within each region [29].

Post-impact, the mandibles were dissected and cleaned of soft tissue residues by maceration in warm water [30, 31]. The bones were carefully separated manually and then placed in gauze bags for further maceration in hot water [31].

All bone surfaces were examined meticulously for fractures, which were documented on standardized maps. Both internal and external views of each mandible were used to analyze fracture types and locations, accounting for differences in fracture patterns across surfaces. Each specimen was evaluated for the total number of fractures, their precise locations according to the AO CMF classification scheme [32], and whether they were complete or incomplete. The scheme divides the mandible into nine key regions: the left and right condylar processes, coronoid processes, ramus (angle), body, and symphysis, along with transition zones between these regions (Fig. 3). This classification was selected due to its clinical relevance and clear regional definitions.

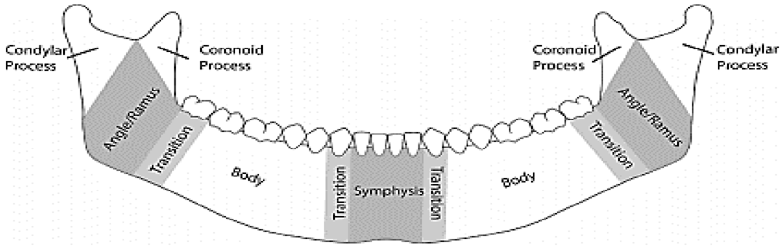

Figure 3. Nine mandibular areas and four transition zones according to the AOCMF definition [32].

All impacts resulted in fractures, with an average initial velocity of 7.8 m/s, delivering roughly 201.3 joules of energy. Most fractures occurred along the midline, with variations in the number and type of fracture lines – some being direct, others indirect. For example, one specimen exhibited five fracture sites: a fracture in the head of the right condylar process, vertical fractures of the right mandibular body at the level corresponding to teeth 41, 42 with internal and external branches, a vertical symphyseal fracture with internal branches, vertical fractures of the left body at teeth 31, 32, and fracture in the left condyle [29].

The second most affected area was the mandibular body – fractures in the left submandibular area, just beneath the impact site. These were located inferior to the midline fractures and extended backward below the mandibular notch. Additionally, horizontal fractures involved the left condylar process with outward branching and the coronoid process with inward branching. An indirect fracture of the right mandibular body was also noted [28].

The third frequent site of fractures involved blows to the posterior mandibular body, both occurring in the left posterior region near the angle. A symphyseal fracture was also observed, characterized by incomplete fractures with fragments on both the inner and outer surfaces [29].

It's well known that the mandible's arched form influences fracture susceptibility. Its cross-section is generally thin around the corners, molars, rami, and the base of the condylar processes, but it widens significantly in the anteroposterior direction in these regions [23]. This anatomical design makes these areas susceptible to fractures even under minor lateral impacts.

In lateral blows, the canine region is the area of lowest resistance in the lower jaw. Conversely, during impacts from front to back, the weakest point is the superior condyle area. Fractures in lateral impacts are quite rare in this region and tend to follow an oblique path from top to bottom, from inside to outside, usually near the base of the articular process [13].

The direction of an impact greatly influences where fractures occur. When struck from the front, back, or side, the articular processes – specifically the base and neck – the mandibular angles, and the alveolus of the last molars and canines are the most vulnerable points [14].

For impacts from the front, the mandible's horseshoe shape causes the force to split into two components, with the articular processes absorbing about half of the load, thus protecting them from frequent damage. When a lateral force is applied, both direct and indirect fractures can happen due to this force distribution [13].

The type of fracture also depends on the jaw's position during trauma (whether jaws are open or closed) [33]. Typically, a blunt object striking the lateral part of the mandible with closed jaws causes a fracture on the outer surface, where compression occurs, and a primary tear on the inner surface, which is stretched. This combination often results in transverse, oblique, or comminuted fractures [23].

A blow from the side and below tends to shift the fracture zone downward, affecting the lower edge of the mandible, while the actual fracture often occurs at the upper edge. Oblique fractures are common with lateral impacts on the lower jaw. A severe comminuted fracture frequently occurs near the canine when struck from the side, especially if the impact is closer to the chin and directed downward. However, it's challenging to replicate double comminuted fractures between the canines, which typically require a wide-area impact on the chin, the region where the mandible is weakest [3, 23].

A forceful, sharp impact to the chin with the jaws open from front to top can produce symmetrical fractures at the second and third molar levels, along with fractures of the necks of the condylar processes on one or both sides [9].

Lateral impacts to the mandibular body usually produce a single fracture characterized by stretching of the inner surface and compression of the outer surface of the jaw. Often, a bending mechanism causes a fracture on the opposite side at the level of the canine and first premolar. Additionally, a fracture of the condylar neck can occur at the point of impact on the opposite side [23].

When the angle of the mandible is struck, two fractures are typically observed: one at the point of direct force application (a result of extension), and another near the lateral incisor and canine (caused by flexion).

In examining the mechanisms of injury to the mandible, the relationship between the mandible and maxilla is crucial [14, 15]. When the jaws are closed, their relative stability is maintained, dependent on tooth occlusion and the specific bite type. An impact to the side of the mandible directly affects the lower jaw. This context gives rise to two categories of mandibular injuries:

1. With the jaws in a closed position, the upper and lower teeth secure the mandible, preventing lateral movement. In this scenario, injuries manifest on one side, potentially leading to the formation of a bone fragment or the crumbling of bone in cases of non-displaced fractures.

2. Conversely, when the jaws are open, the chin rotates towards the force acting upon them, pivoting around the articular processes. Consequently, fractures tend to appear in the neck region of the mandible, typically on the opposite side of the initial force, although significant trauma can also cause fractures on the side where the force is applied [23].

It is important to note that injuries to the lower jaw can still occur even with closed jaws, particularly in cases where teeth are absent. When force is applied to the angle of the mandible, fractures typically occur on the opposite side of the impact rather than on the side receiving the blow. In cases of direct impact to the chin or nearby areas, damage can extend to the articular processes and the alveolar portion of the mandible [33].

Conclusions. The distinct patterns of fracture formation were identified: fractures emerged either where the mandible was struck or in adjacent regions; the number of fractures varied based on the point of impact; no two impacts to the same area resulted in an identical fracture pattern, and variations were consistently noted in fractures located away from the impact site. The structural geometry of the mandible indicates that fractures typically occur in biomechanically vulnerable areas, notably around the necks of the articular processes, the corners, and the mental foramina. When the jaws are closed, compression fractures were noted on the outer surface, while tensile fractures formed on the inner surface, where primary fractures arise and a fracture zone develops at the contact point; when the jaws are opened, indirect fractures were observed on the opposite side.

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АНАЛІЗ УТВОРЕННЯ НЕВОГНЕПАЛЬНИХ ПЕРЕЛОМІВ НИЖНЬОЇ ЩЕЛЕПИ (ОГЛЯД ЛІТЕРАТУРИ)

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Резюме. У статті представлені результати клінічних, ретроспективних та експериментальних досліджень щодо утворення невогнепальних переломів нижньої щелепи залежно від напрямку та кута удару, особливостей руйнування її поверхні під час розмикання щелепи.

Мета дослідження. Проаналізувати дані наукової літератури щодо утворення невогнепальних переломів нижньої щелепи.

Матеріали та методи. Було використано бібліосемантичний метод для аналізу результатів досліджень на основі джерел літератури та електронних баз даних: Pubmed, Wiley, Research Gate та Національного репозиторію академічних текстів.

Результати. У результаті дослідження було встановлено чітку закономірність:

переломи утворювалися або в ділянці удару по нижній щелепі, або в ділянці, що прилягає до місця удару; залежно від місця удару кількість переломів, що виникли, варіювалася; у жодному випадку удар по одній і тій самій ділянці не спричиняв абсолютно однаковий набір переломів, а розташування переломів, що виникли в точках, відмінних від місця удару, також суттєво відрізнялося.

Висновки. Було виявлено чіткі закономірності утворення переломів: або в місці удару по нижній щелепі, або в сусідніх ділянках. Кількість переломів змінювалася залежно від місця удару. Жоден з двох ударів в одну й ту саму ділянку не спричиняв ідентичної картини, і послідовно спостерігалися варіації в переломах, розташованих далеко від місця удару. Структурна геометрія нижньої щелепи вказує на те, що переломи зазвичай виникають у біомеханічно вразливих ділянках, зокрема у ділянках шийок суглобових відростків, кутів та підборідних отворів. Коли щелепи зімкнуті, компресійні переломи спостерігалися на зовнішній поверхні, у той час як переломи внаслідок згинання утворювалися на внутрішній поверхні щелепи. Коли щелепи не були зімкнені, утворювалися непрямі переломи на протилежному боці щелепи.

Ключові слова: перелом нижньої щелепи; не вогнепальний перелом; класифікація AOCMF; прямий перелом; непрямий перелом.

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