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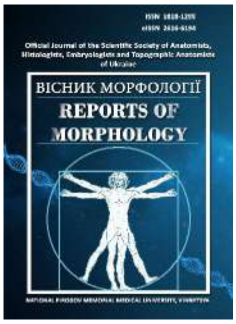

Variant anatomy of the mandibular canal topography

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This paper presents an analysis of 3D reconstruction models of the manifestation of variability of the mandible canal (canals) on both the left and right sides, their laying in the body of the mandible and the location, size and direction of the output canals. After all, the availability of minimally invasive techniques implemented in the research process helps to identify even minor anatomical variants or branches of the mandibular canal, which are quite common and do not allow the clinician to neglect them and require proper scientific evaluation. When planning reconstructive surgery on the mandible, the lack of high predictability to prevent functional complications, which are often irreversible (because the mandibular canal contains motor and sensory nerve fibers), forces us to reconsider the morphological fundamentality of its topography. Therefore, the aim of the work was to review computed tomography digital images, their analysis and identify possible anatomical variants of the canal (channels) of the mandible, as a basis for establishing its topographic features, on the left and right sides. After analyzing 426 digital CT scans of the mandible in males and females aged 25 to 75 years, 68 3D reconstruction models were reproduced using standardized X-ray diagnostic CT software Ez3D-I Original ver.5.1.9.0, used for visualizations of multimodal and multidimensional images, some of which are presented as the results of their own research. It is established that the entrance openings of the mandibular canals on both the left and right sides continue with one canal, however, in the projection of the second molar, the latter can be divided into two or three canals with high frequency. There is a difference in the diameters (Ø) of the canals and their opening - typical (in the projection of premolars on the right side) and atypical openings - in the projection of 3.6, 4.6 molars and central incisors, canines in the direction of the outlet and their location. There is no proper regular systematization of the number, topographic trajectory and size of the mandibular canals, their association or separation, as well as the direction of their exit, which requires additional vigilance not only during research but also in clinical dentistry or reconstructive surgery.

Keywords: *mandibular canal, computed tomography, morphometry, bone atrophy, human.*

Introduction

The question of the variability of complex anatomical structures in the modern scientific interpretation of the morphological norm or its deviation remains debatable [24, 26]. Scientific progress and the availability of minimally invasive techniques implemented in research processes help to identify even minor anatomical variations [6, 18], including the mandibular canal, which until now were considered abnormal manifestations or individual characteristics of the organism. At the same time, such interpretations do not reveal the main content, require understanding of the frequency and distribution of anatomical manifestations depending on sex, their synchronicity between left and right, as well as possible changes - from normal or pathological processes in the body [19, 27].

As scientific and practical experience shows, the anatomical variability of the branches of the mandibular canal is quite common, which does not allow to neglect it and requires proper scientific evaluation [5, 10].

Lack of theoretical experience leads to significant unpredictable functional complications (because the mandibular canal contains motor and sensory nerve fibers), which are often irreversible [14, 15]. An even more difficult problem is to find a solution to eliminate such complications and select methods of rehabilitation of patients that would not compromise their depth, even to the complete loss of function [4, 29].

In response to these questions, priority is given to primary diagnosis using paraclinical radiological methods. Of course, magnetic resonance imaging remains in the first place in terms of the highest reliability, but the method of choice is the minimally invasive method of computed tomography (CT) [25, 30]. This approach reveals the understanding of the laying and length of the channel in the body of the mandible, morphology and configuration of branches as additional - bifid or trifid channels [17, 21]. Identification of the main trunk from the additional ones, with 3D reconstruction, becomes a basic informative support both for their topography [9] and areas of innervation, which extend to the bone of the mandible, teeth, surrounding soft tissues and their blood supply.

No less important tasks that have been left out of research are the effectiveness of traditional methods of local anesthesia, which directly depend on the variant and topographic anatomy of the mandibular canals, namely, their entry, laying and exit - guidelines for creating minimal and effective depot of anesthetics.

Therefore, supplementing existing progressive research with new, in particular, visualized 3D reconstruction models of variant anatomy of the mandibular canals, which formed the basis of this work, will update the views of modern researchers, teachers of morphological disciplines, give confidence to clinicians when planning and conducting reconstructive surgery.

The purpose of the work is to review, identify and analyze certain possible anatomical variants of the mandibular canal, as a fundamental basis in establishing its topographic features, on the left and right sides.

Materials and methods

This study analyzed 426 computed tomographic digital images of the mandible of patients who underwent routine diagnostic examinations and selected only 68 scans, without any changes that would distort the architecture of bone tissue, but had the best opportunities for analysis and provided proper informativeness in the study of possible morphotopographic features of its channel, on the left and right sides of males and females aged 25 to 75 years.

Computed tomography digital scans were performed using HEWLETT-SNCPUM1 computer equipment with 16.0 GB of RAM, 10 Pro for Workstations system software, 2019: 00391-70000-00000-AA425.

3D reconstruction models were reproduced using standardized X-ray diagnostic software Ez3D-I Original ver.5.1.9.0, which is used to visualize multimodal and multidimensional images, some of which are presented as the results of our own research.

Informed and signed by patients Informed consent to their participation in studies in compliance with the basic provisions of the GSR (1996), the Council of Europe Convention on Human Rights and Biomedicine (04.04.1997), the Helsinki Declaration of the World Medical Association on Ethical Principles for Human Scientific Research (1964-2013), orders of the Ministry of Health of Ukraine № 690 from 23.09.2009, № 616 from 03.08.2012 and approved by the decision of the Commission on Biomedical Ethics of Bukovinian State Medical University (Minutes № 2 from 21.10.2021).

Results

Traditionally, the mandibular canal is perceived as a monotubular morphological structure that originates with an inlet on the medial surface of the mandibular ramus and ends on its outer surface in the projection of the first or second premolars with a foramen, followed by intraosseous branching, to provide intraosseous branching to provide innervation and nutrition of the front group of teeth.

Morphological analysis of the materials of this work indicates the identified anatomical variability of the mandibular canal, which differs from the guidelines described in anatomical textbooks and are taken into account when teaching basic disciplines.

The presented 3D reconstruction models (Fig. 1) reveal the content of variant anatomy and provide answers to questions that have been little studied so far and remain far from complete.

Digital image analysis emphasizes the variability and asynchrony of the mandibular canal in a patient with variable

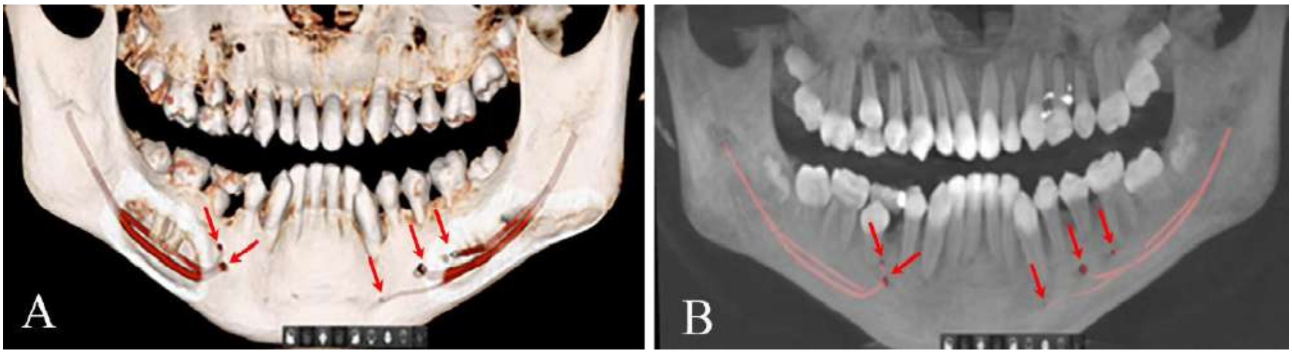

Fig. 1. A) 3D reconstruction model of bifid on the right side and trifide on the left side of the mandibular canal structure, bone image; B) 3D reconstruction model of bifide on the right side and trifide on the left side of the mandibular canal structure, X-ray image.

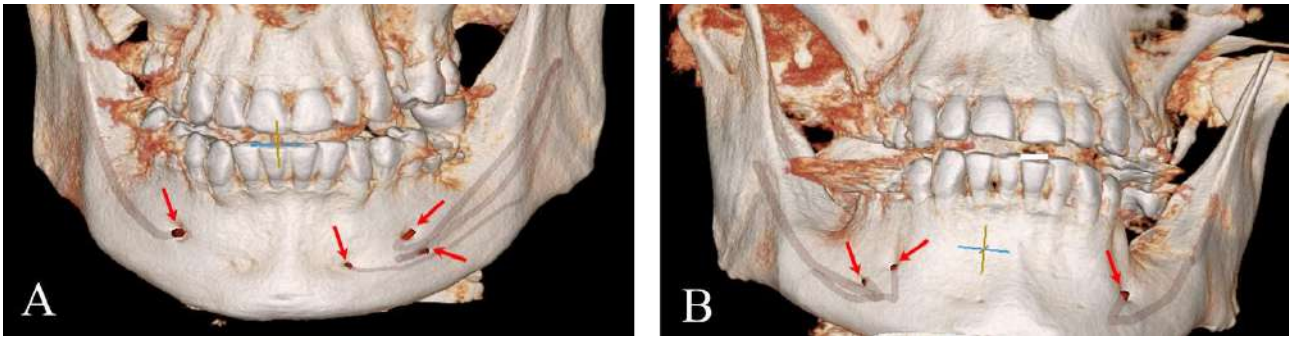

Fig. 2. A) 3D reconstruction model, typical topography on the right side and trifid - on the left side, the structure of the mandibular canals; B) 3D reconstruction model, bifid on the right side and typical on the left side, the structure of the mandibular canals.

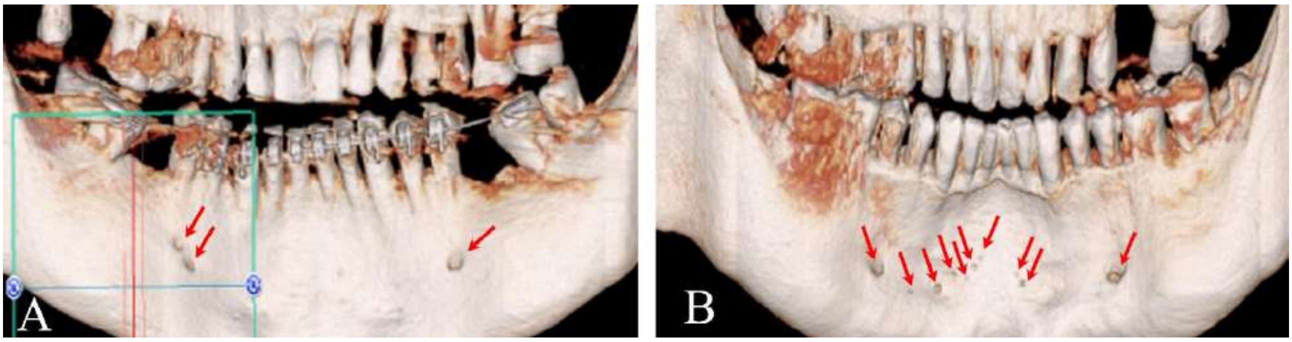

Fig. 3. 3D reconstruction model of variants of the canal foramens (s) of the mandible: A) double foramens on the right side and a single foramen on the left side; B) additional foramens of the mandibular canals in the projection of the central group of teeth.

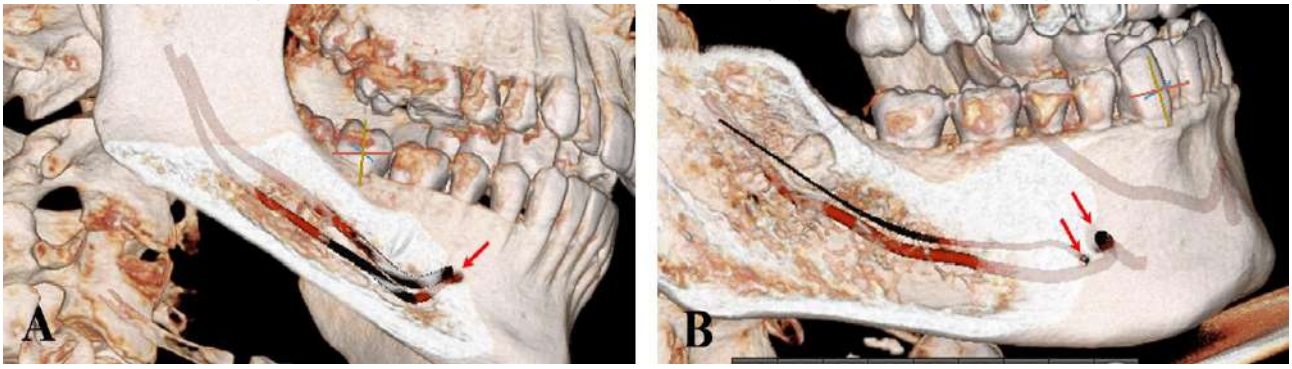

Fig. 4. 3D reconstruction model of modifications of the mandibular canals, their laying and projection of the foramens: A) opening the canals with one foramen; B) opening the channels with two foramens of different diameters and different directions.

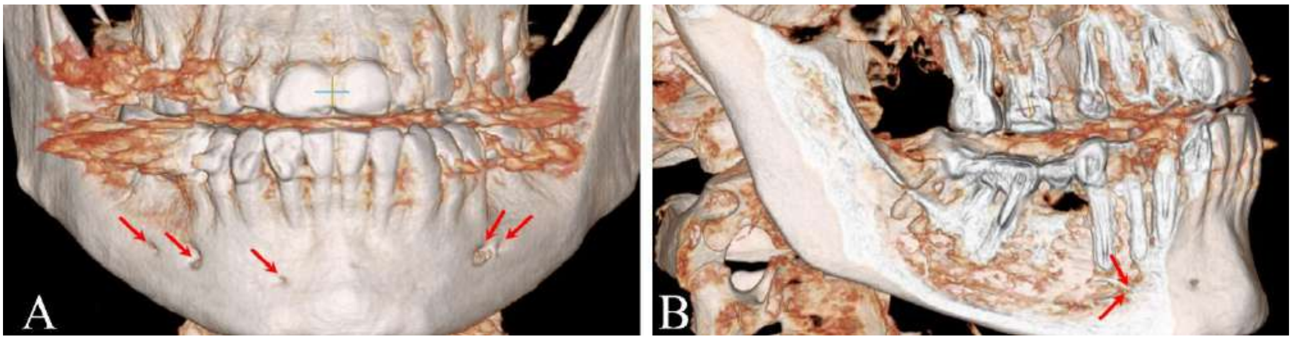

Fig. 5. 3D reconstruction model of variants of projections of foramen openings: A) opening of channels by exit foramens in projection of 4.1, 4.5, 4.6 teeth; B) the association of bifid canals in the body of the mandible with the next one foramen.

occlusion. The entrance openings of the mandibular canals on both the left and right sides continue with one canal, however, in the projection of the second molars they divide on the right side into two, enveloping the roots of the first molar, and on the left side into three canals (see Fig. 1). Also, there is a difference in the diameters (?) of the canals

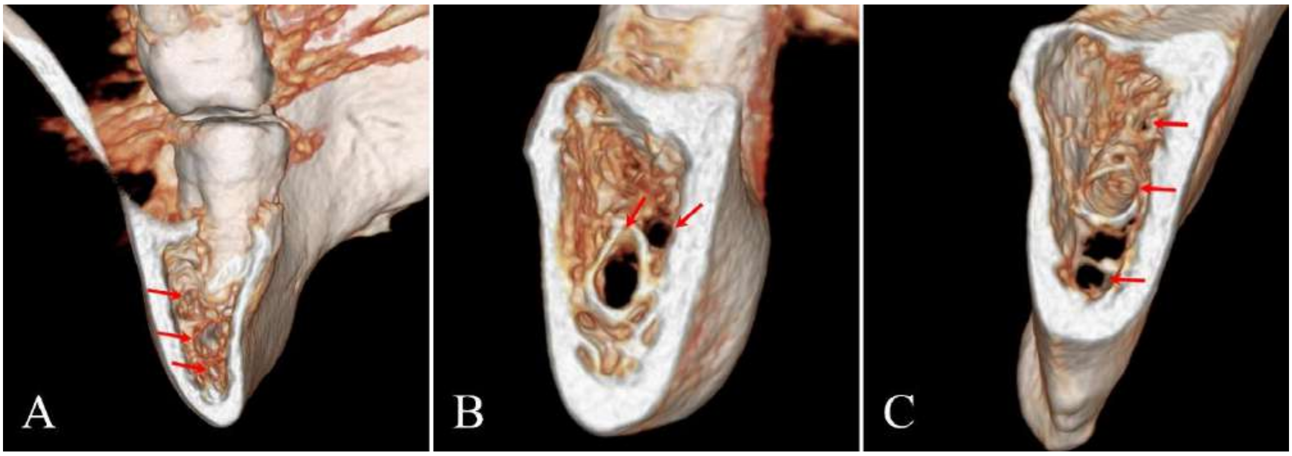

Fig. 6. 3D reconstruction model of the mandibular canals on coronal sections: A) trifid canal of the mandible, a person with a preserved dentition; B) bifid canal of the mandible, persons with loss of masticatory teeth from 6 months to 5 years; C) trifid canal of the mandible, persons with loss of masticatory teeth for more than 5 years.

and their foramens - typical, in the projection of premolars on the right side and atypical foramens, both in the direction of the outlet and their location on the left side.

Presented by computed tomography 3D reconstruction model (Fig. 2) of a patient with permanent occlusion and defects of the dentition confirms the asynchrony of the mandibular canals between the left and right sides, however, on the right side the length of the monochannel originates ends with the approach to the first premolar, and on the left side - one initial inlet and three different diameter channels (see Fig. 2A) and opens with two foramens obliquely in the direction from front to up and back. The third, bending in an arc to the bottom, leaves the body of the lower jaw with the approach to the mental tubercle (tuberculum mentale).

Opposite topographic characteristics of the channel are reflected by a 3D reconstruction model created by computed tomography (see Fig. 2B), originating left and right with single inlets and a typical outlet on the left side of the mandible and two different foramens on the right side, getting bifurcation only in the projection of the first molar.

It is impossible to determine a certain regularity of topographic features of the mandibular canal during survey digital CT scans due to their pronounced variability both in laying and in the location and diameters of the outlets (Fig. 3).

In most cases, the traditional morphological literature describes the projection of the exit opening of the mandibular canal only with a focus on premolars and possible branching of the canal in the body of the mandible, without leaving it. However, we have identified variants with numerous additional foramens (see Fig. 3B), which have a certain organizational morphological structure of small tubules, to provide innervation and nutrition of both hard and adjacent soft tissues.

There is no proper systematization of the specific topographic trajectory and size of the mandibular canals, their union or separation, and the direction of their exit, which requires additional vigilance not only during research but also in clinical dentistry (Fig. 4).

This confirmation is a 3D reconstruction model created by computed tomography (Fig. 5) of a patient with a restored defect of the dentition on the lower jaw on the right side. The location of one of the outlets of the canals (see Fig. 5A) is projected closer to the root of the second incisor, the others - between the first and second premolars and the third foramen in the projection of the medial root of the first molar.

It is important to note that a significant number of canals are combined in the body of the mandible into one, continuing and leaving it with one outlet (see Fig. 5B).

We also emphasize that the structure of the mandibular canals, in particular the surrounding tubular cortical layer, depends on the type of bone density and their "morphological form" - the time of tooth loss as an irreversible pathological factor leading to bone tissues atrophy (Fig. 6).

Discussion

Many scientific works are aimed at studying the morphological variations of the mandibular canal [2, 3, 31], which are substantiated in the studies and have proper evidence and confirmed by modern, even simple, radiological methods [8, 15]. However, attempts to differentiate the presence of specific anatomical structures (such as arteries, veins, nerves) in the existing mandibular canals by radiological methods are problematic, and the results are questionable, although there are clinical concerns about the invasiveness of surgery [16, 22].

It is known that the ramus of the mandible, which extends from its body at an obtuse angle upwards, on the inner surface contains a pterygoid tuberosity (tuberositas pterygoidea), just above which you can see the upward mandibular foramen (foramen mandibulae). From the inner surface it is limited by the lingula of the mandible (lingula mandibulae). This hole leads to the canal of the mandible,

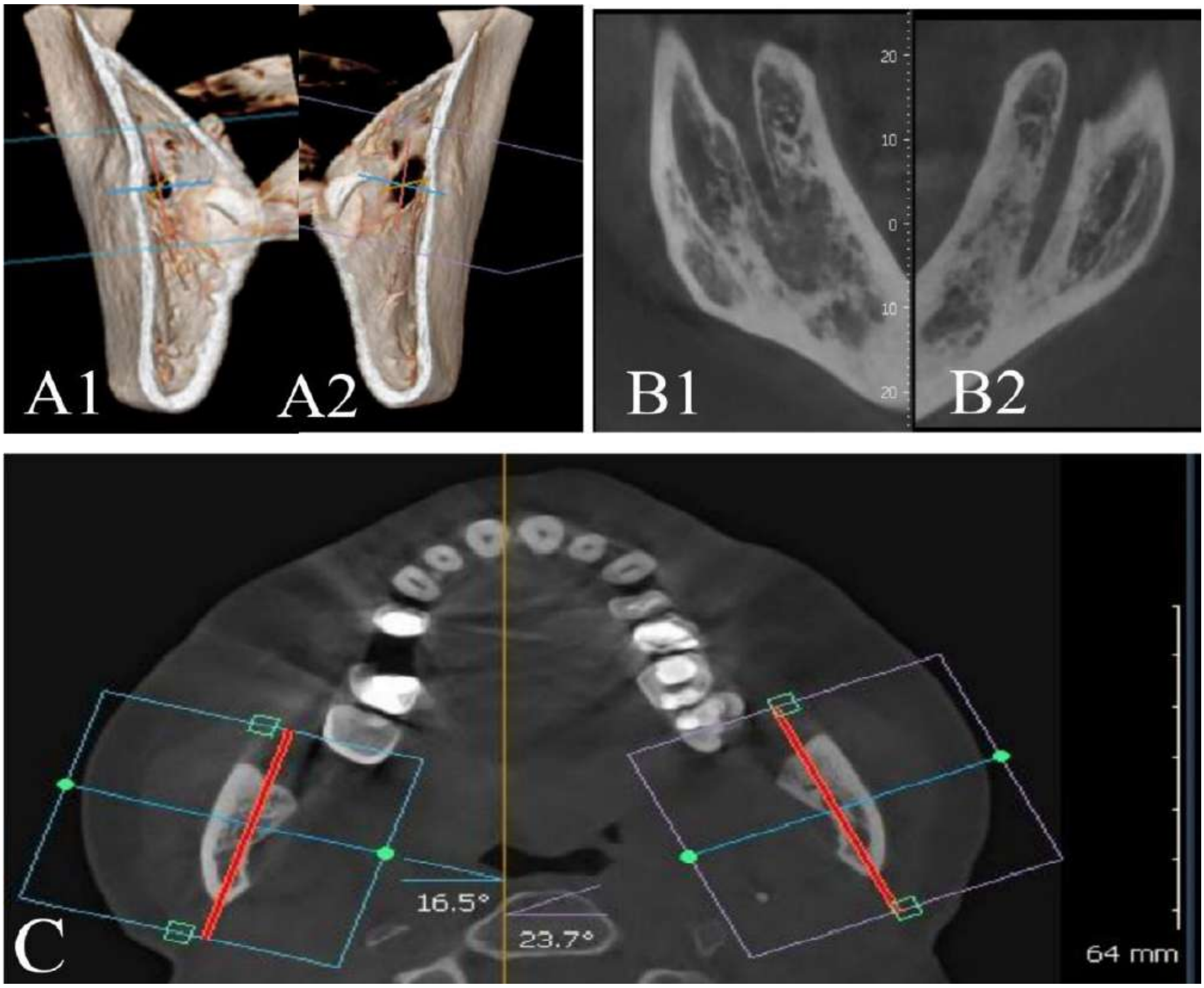

Fig. 7. X-ray method of research of the direction of mandibular canal laying, Ø°: A1, A2 - coronal section of the mandible; B1, B2 - coronal (smart) section; C - axillary (axial) section of the mandible.

which is laid in her body and ends on the outer surface of the chin hole, forming a through "tunnel" [8, 13, 16].

Bone atrophy leads to irreversible physiological processes, which are negatively reflected in the topographic features of the mandibular canal, even in relation to the most stable morphological structures, such as the angle of the mandible [20]. This study comprehensively characterizes the topographic variability of the mandibular canal in atrophy of bone tissue due to loss of the masticatory group of teeth.

We want to draw the researchers' attention to the fact that even asymmetric loss of one tooth leads to significant atrophy from inactivity on the corresponding side [7, 28] and is reflected, respectively, by changing the degree (Ø°) of the initial direction of the mandibular canal (Fig. 7). especially with end defects of the dentition, as a pathogenetic factor of bone atrophy.

These differences in topographic features and variability of channels should be taken into account, first, when analyzing digital images of both sides of the mandible, to increase the effectiveness of local anesthesia [11], as the initial stage of treatment, osteosynthesis, osteotomy and other reconstructive surgery.

The issues of formation of bone tissue of the mandible [12] as a fundamental platform for laying the canal (channels) of the mandible, the impact of somatic pathology [23] on its topographic variability and changes in morphometric values [1], morphological variability of channels, dependent from atrophy of bone tissue due to loss of the masticatory group of teeth.

Prospects for further research are the morphological identification of mandibular canals and their structures by functional purpose.

Conclusion

1. Variant anatomy of canal (channels) bifurcation of the mandible is manifested on both the left and right sides of the mandible.

2. The main canal of the mandible is well surrounded by a cortical layer, forming a rounded, slightly flattened (from the predominance of atrophic processes of bone tissue) tubular tunnel and clearly visualized during X-ray examinations.

3. The system of peripheral canals, tubules (branches) depends on the atrophy of bone tissue caused by tooth loss and is subject to "morphological degeneration from inactivity".

4. The variability of canal (channels) foramens of the mandible is differentiated by location, number, direction and size.

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ВАРІАНТНА АНАТОМІЯ ТОПОГРАФІЇ КАНАЛУ НИЖНЬОЇ ЩЕЛЕПИ

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У даній роботі представлено аналіз 3D реконструкційних моделей прояву варіативності каналу (каналів) нижньої щелепи як з лівої, так і з правої сторони, їх прокладання у тілі нижньої щелепи та локалізацію, розміри і напрямки вихідних каналів. Адже, доступність малоінвазивних технік, імплементованих у процеси дослідження, сприяють виявленню навіть незначних анатомічних варіантів чи розгалужень каналу нижньої щелепи, що є доволі частими і не дозволяють клініцисту нехтувати ними та потребують належної наукової оцінки. Під час планування реконструктивних хірургічних утручань на нижній щелепі брак високої прогностичності щодо запобігання функціональних ускладнень, які доволі часто бувають незворотними (через те, що канал нижньої щелепи містить рухові та чутливі нервові волокна), змушує переглядати морфологічну фундаментальність особливостей його топографії. Тому, метою роботи було проведення огляду комп'ютерно-томографічних цифрових зображень, їх аналізу та виявлення можливих анатомічних варіантів прокладання каналу (каналів) нижньої щелепи, як основи у встановленні його топографічних особливостей, із лівої та правої сторін. Після проведеного аналізу 426 цифрових КТ-сканувань нижніх щелеп в осіб чоловічої та жіночої статі віком від 25 до 75 років відтворено 68 3D реконстукційних моделей за допомогою стандартизованого рентгено-діагностичного КТ-програмного забезпечення Ez3D-I Original ver.5.1.9.0, що застосовується для візуалізації мультимодальних і багатовимірних зображень, окремі з яких подані як результати власних досліджень. Встановлено, що вхідні отвори нижньощелепних каналів як із лівої, так із правої сторін продовжуються одним каналом, проте, у проекції других великих корінних зубів, останні із великою частотою можуть розділятися на добре проектовані два-три канали. Наявна відмінність у діаметрах (Ø) каналів та їх відкриттям - типовим (у проекції малих корінних зубів з правої сторони) і нетиповим відкриттям - у проекції 3.6, 4.6 великих корінних зубів та центральних різців, іклів як за напрямком вихідного отвору, так і за їх розташуванням. Не прослідковується належної закономірної систематизації, щодо кількості топографічної траєкторії та розміру каналів нижньої щелепи, об'єднання чи їх розділення, а також напрямку їх виходу, що потребує додаткової пильності не лише під час дослідницьких робіт, а й навіть у клінічній стоматології чи реконструктивній хірургії.

Ключові слова: *канал нижньої щелепи, комп'ютерна томографія, морфометрія, атрофія кісткової тканини, людина.*