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CLASSIFICATION OF THE TOPOGRAPHY OF THE MANDIBULAR CANAL IN CASE OF BONE ATROPHY CAUSED BY THE LOSS OF THE MASTICATORY TEETH

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The requirements of a modern clinician are growing not only in updating the available data of normal anatomy but also in filling the gap with new or alternative studies of variant morphology, which can be easily implemented in practical medicine. One of these gaps that we tried to fill in is the study of topographic features of the mandibular canal, changes that occur even with the loss of at least one 4.8 or 3.8 tooth, or the manifestation of their individual bifid and trifid modified variations, the identification of which requires not only morphological but also radiological knowledge during careful analysis at the preclinical stage of treatment.

We analysed 136 digital CT scans of toothless distal segments of atrophied bone tissue of the lower jaw, equally on the left and right sides in male and female Ukrainians aged 25 to 75 years. Morphometric and 3D reconstruction analyses are summarised using the standardised software "Vatech original 2020". Digital analysis was performed using statistical nonparametric research methods.

Having grouped the average values (m) in the studied areas of the left and right sides, in particular, in the projection of 3.6, 3.7, 4.6, 4.7 teeth, we obtained averaged (MM) morphometric indicators by the method of simple mathematical calculation, which characterises the laying of the canal in the toothless distal segments. The results became the basis for developing the classification of the topography of the human mandibular canal in case of bone atrophy caused by the loss of the masticatory teeth.

Key words: *morphometry, lower jaw canal, computed tomography.*

Relationship between the publication and planned research work. The work is a fragment of the research work of the Department of Histology, Cytology and Embryology of Bukovinian State Medical University "Structural and functional features of tissues and organs in ontogenesis, patterns of variant, constitutional, gender, age and comparative human morphology", state registration number 0121U110121.

Introduction. The present realities are initially reflected in the educational process of applicants for higher medical education with the subsequent implementation of the acquired knowledge in practice. Basic curricula are limited to separate traditional sections and are not adequately filled with progressive achievements of the domestic scientific community or the introduction of adopted achievements from abroad.

Practitioners come up with specific difficulties in the clinical analysis of the topographical and anatomical features of the mandibular canal even while using Computed Tomography [1-3]. After all, it is pretty challenging to differentiate structural organomic formations (artery, vein, nerve) and establish the morphostructure of the neurovascular bundle through its degeneration caused by tooth loss and "twisting" caused by atrophic processes in bone tissue. Although methods for determining the density of hard, soft, and connective tissues using the Hounsfield units (Hu) or international conventional greyness units (CGU) are available, scientists' evidence is widely discussed.

When teeth are lost, the neurovascular roots of the same name also undergo pathological changes with reflection on the central neurovascular bundle [4], which lies in the canal of the lower jaw, which should provide nutrition and innervation of its toothless segments and is a frequent ethio-pathogenic factor of irreversible bone atrophy [5, 6]. Therefore, in our proposed classification, the topography of the central mandibular canal is chosen as the fundamental basis, which is always determined when implementing available radiological methods in clinical practice.

The aim of the work is to develop a simplified and informative classification of the topography of the human mandibular canal in case of bone atrophy caused by the loss of the masticatory teeth, available for implementation in daily clinical practice.

Object and methods of research. The research objects for this work were 136 digital studies of the laying of the mandibular canal taken with the extra-oral CT system Vatech PaX-i 3D Green with a 0.5 mm focal spot display (EC60336) on a 14-bit grayscale scale with a size of 0.2/0.3 voxels. Morphometric and 3D reconstruction analysis was performed using Hewlett-SNCPUM1 computer technology with 16.0 g of RAMB, 10 Pro for Workstations, 2019: 00391-70000-00000-AA425, in the standardised computed tomography software "Vatech original 2020" after that, the material was divided according to the age of patients into four groups for each side, namely: the first group (I) – 25-45 years, n=14; the second group (II) – 46-60 years, n=20; the third group (III) 61-75, n=17; the fourth group (IV) – 25-75 years, n=17, people with preserved dentition (as a control group).

In the StatSoft Statistica 10.0 software, digital analysis was performed using nonparametric statistical methods, comparing experimental groups with the control group using the Mann-Whitney U-test. Comparison of groups by age – using the multidimensional the Kruskal–Wallis test as an alternative intergroup analysis of variance, which is used to compare three or more samples to test null hypotheses according to which different samples were taken from the same distribution with similar medians.

All studies were conducted after patients familiarised themselves with and signed informed consent to participate in research in compliance with the main provisions of the GCP (1996), the Council of Europe

Table 1 – Morphometric values (M) and average values (MM) of the topography of the mandibular canal

Groups	I (first group)				II (second group)				III (third group)			
Research areas	*3.6*	*4.6*	*3.7*	*4.7*	*3.6*	*4.6*	*3.7*	*4.7*	*3.6*	*4.6*	*3.7*	*4.7*
RMB, M (mm)	7.36	7.53	6.84	7.07	8.35	7.96	7.49	8.08	8.15	8.18	7.98	8.13
Average values (mm)	7.2				8.0				8.1			
BR, M (mm)	4.35	4.30	5.34	5.14	4.72	4.91	5.55	5.87	4.89	4.75	5.75	5.62
Average values (mm)	4.8				5.3				5.3			
LR, M (mm)	3.09	3.14	2.76	2.74	3.79	3.29	3.46	2.79	3.40	3.57	3.01	3.09
Average values (mm)	2.9				3.3				3.3			

Notes: RMB – distance from the ridge of the mandibular base to the mandibular canal (MC); BR – distance from the ridge of the buccal surface to the MC; LR – distance from the edge of the lingual surface to the MC.

Convention on Human Rights and Biomedicine (dated 04.04.1997), the World Medical Association Declaration of Helsinki on ethical principles for conducting scientific medical research involving human subjects (1964-2013), order of the Ministry of Health of Ukraine No. 690 dated 23.09.2009. The planned direction of these studies was reviewed by the Commission on biomedical ethics of Bukovinian State Medical University and approved by Protocol No. 2 of 21.10.2021.

Research results. Morphological development of the human body, in its various ontogenetic periods, is characterised by individual multifactorial processes and has a particular genetic determination, which is reflected in the macrobiological "model" of a human [7-9]. Therefore, their individuality also characterises all morphological and topographic values [10]. However, the statistical material is comprehensively analysed, summarised in **table 1**, and the resulting digital 3D reconstruction models provide insight into the topography of the mandibular canal with bone atrophy caused by the loss of the masticatory teeth.

Even at first glance, we already notice a difference in the laying of the canal relative to the buccal, lingual sides or the ridge of the mandibular base. Bone tissue acquires "unstable" atrophic manifestations in case of the loss of teeth, particularly the masticatory ones, with their inherent anatomical features of the roots and their location in the alveolar part. Therefore, morphometric values relative to the upper ridge of the alveolar part were not considered in the study. Also, the difference in values between the left and right sides is considered, which can be a practical manifestation due to the difference from the time of tooth loss.

As researchers, we sought to develop the simplest and, at the same time, informative classification of the topography of the human mandibular canal in case of bone atrophy caused by the loss of the masticatory teeth, available in perception and application in daily clinical practice. By grouping the average values (M) in the studied areas of the left and right sides, in particular, in the projection of 3.6, 3.7, 4.6, 4.7 teeth, the average (MM) morphometric values were obtained using a simple mathematical calculation, which characterises the laying of the canal in the toothless distal segments of atrophied bone tissue of the lower jaw. So, in the first study group, the distance from the ridge of the mandibular base to the mandibular canal (MC) is 7.2 mm, from the ridge of the buccal surface to the MC – 4.8 mm, the distance from the ridge of the lingual surface to the MC – 2.9 mm. In the second group of the study, RMB=8.0 mm, BR=5.3 mm, LR=3.3 mm regarding MC. In the third group of the study, RMB=8.1 mm, BR=5.3 MM, LR=3.3 mm relative to MC.

Values of the first group of the study (people aged 25-45 years) significantly differ in their morphological features with a topographic representation of the mandibular canal in toothless defects of the dentition complicated by bone atrophy from the second and third groups. So, we referred them to the first class **(table 2)**.

There are no differences in the MM values of the second (people aged 46-60 years) and the third (61-75 years) groups, which is a positive and refutation-fundamental basis for constructing the classification. Therefore, we have combined the values of the second and third groups and referred them to the second class **(see table 2)**.

Systematic analysis, reduced to a simple and understandable classification of the topography of the human mandibular canal with bone atrophy caused by the loss of the masticatory teeth, provides an opportunity to predict the diagnosis and clinical proposal in the choice of rehabilitation methods, with the immediate restoration of the lost function of the dentition, fixing screw periosteal splints, during osteosynthesis or other reconstructive operations, forensic medical examination, and the like.

Table 2 – Classification of the topography of the human mandibular canal in case of bone atrophy caused by the loss of bone tissue of the masticatory teeth, 2022 (Oshurko AP, Oliinyk IYu & Kuzniak NB)

Class	Age, years	RMB, mm	BR, mm	LR, mm
First class (I-cl)	<45	7.2 (≈ 7.0)	4.8 (≈ 5.0)	2.9 (≈ 3.0)
Second class (II-cl)	>45	8.0	5.3	3.3

Notes: RMB – distance from the ridge of the mandibular base to the mandibular canal (MC); BR – distance from the ridge of the buccal surface to the MC; LR – distance from the edge of the lingual surface to the MC; **(≈…)** – a sign of approaching a specific number.

Discussion of the research results. The more often dental surgeons began to apply and implement progressive reconstructive techniques for the rehabilitation of patients, the more often the manifestation of unpredictable complications was accompanied, perhaps, by a lack of diagnostic understanding [11, 12] or by inadequate differentiation of morphological variations and topographic features of the mandibular canal with the laying of the same neurovascular bundle [13-14].

The presence of an additional lingual canal that simulates a fracture of the lower jaw [15] repeatedly questioned our result, which required repeated clarification, in different positioning of the patient during a computed tomography, which provided us with a visual, evidence-based understanding of the topographic variability of the topography of the mandibular canal, depending on multifactorial pathological factors, including bone atrophy due to the loss of the masticatory teeth.

The updated data on variant anatomy were presented by researchers from the Japanese Odontological University (Elnadoury EA, Gaweesh YSE, Abu El Sadat

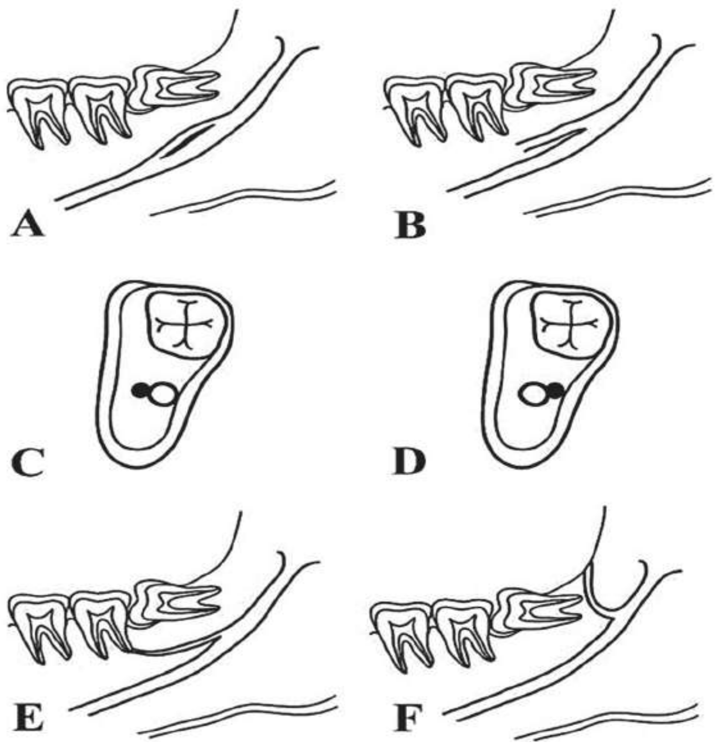

Figure (A-F) – Naito classification: The forward canal is subdivided into confluence (A) or without confluence (B); The buccolingual canal from the buccal or lingual wall (C and D); The dental canal reached the root apex (E); The retromolar canal opened to the retromolar region (F).

SM, Anwar SK, 2022), which are also based on three-dimensional radiological research methods. The authors [16] indicate that of the 278 patients studied (530 parts of the lower jaw), bifurcation of 181 channels (37%) and 46 trifid channels (8.7%) were detected.

A clinical case presented by scientists (Iwanaga J, Wilson C, Simonds E, Vetter M, Kusukawa J, Yamaki KI, Oskouian RJ, Tubbs RS, 2018) in the study [17] should alert clinicians during surgical interventions; the anatomical version of the bifurcated mandibular canal, which contained the nerve and the artery of the same name in the upper branch, and the large inferior alveolar vein in the lower one, which leaves the lower jaw through the lateral lingual canal and flows into the anterior jugular vein. In addition, the detected vein directed individual branches in the direction of the chin opening and the anterior outer surface of the lower jaw, which was confirmed during the pathomorphological examination but did not indicate their exact morphometric ratios.

The study of morphometric characteristics of the mandibular canal (Arias A, Venegas C, Soto N, Montiel I, Farfán C, Navarro P, Fuentes R., 2020) [18] is worth considering. These characteristics vary in individual populations, from the chin opening to the distal part of the first molar, but in a permanent bite in patients with preserved teeth. Morphometric measurements are indicated in five coronal sections of the lower jaw body, taken as the basis of the teeth of the same name, with an orientation to the cortical layers of the lingual surface. The study results are pretty informative, as they include an analysis between the male and female sexes, but make it impossible to compare them with the results of our work, which is aimed at studying toothless segments of atrophied bone tissue in the lower jaw body.

A well-known classification of the variability of laying the mandibular canal by Naito **(fig. A-F)** is a basis in the research by Özlem Okumuş and Asım Dumlu [10]. However, it also does not provide the tasks we set in the same way as it characterises the features of its topography only in individuals with a fully preserved dentition.

The progressiveness of such studies expands scientific and clinical thinking but does not detail morphometric assessment and hinders the choice of available reconstructive methods for the rehabilitation of patients, including those with bone atrophy, as an ethio-pathogenetic factor influencing the features of laying the mandibular canal. Therefore, our study on 68 patients (136 toothless distal segments of the lower jaw) will add to the existing versatile scientific directions, thanks to the classification presented above (2022, Oshurko AP, Oliinyk IYu & Kuzniak NB), which will improve orientation in morphological variations during clinical differential diagnosis and the choice of patient rehabilitation methods.

Conclusions.

1. The tunnel laid from the entrance of the alveolar nerve of the lower jaw to its chin exit is the central canal of the lower jaw and provides the primary function of its morphological purpose and its branches – additional canals.

2**.** The developed classification is a clear and accessible diagnostic criterion, a significant theoretical asset of variant anatomy, and a tool for clinical thinking about features of the topography of the human mandibular canal in case of bone atrophy caused by the loss of the masticatory teeth, in the rehabilitation of patients.

Prospects for further research consist of establishing the features of the topography of the mandibular canal of toothless patients to develop a classification depending on the gender and time of tooth loss.

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КЛАСИФІКАЦІЯ ТОПОГРАФІЇ КАНАЛУ НИЖНЬОЇ ЩЕЛЕПИ ПРИ АТРОФІЇ КІСТКОВОЇ ТКАНИНИ ЗУМОВЛЕНОЇ ВТРАТОЮ ЖУВАЛЬНОЇ ГРУПИ ЗУБІВ

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Резюме. *Вступ.* У даному дослідженні зосереджено увагу на топографічних особливостях каналу нижньої щелепи при атрофії кісткової тканини, зумовленої втратою жувальної групи зубів. Беручи за мету розробити спрощену та інформативну класифікацію топографії каналу нижньої щелепи людини, доступної для імплементації у щоденну клінічну практику, нами проаналізовано 136 цифрових комп'ютерно-томографічних сканувань отриманих з використанням системи екстра-оральної рентгенографії Vatech PaX-I 3D Green. Навіть на перший погляд, ми спостерігали вже відмінність у прокладанні каналу відносно щічної, язикової сторін чи краю основи нижньої щелепи. За умов втрати зубів, зокрема жувальної групи, з притаманними для них анатомічними особливостями коренів та їх розташуванням у комірковій частині, кісткова тканина набувала «не стабільних» атрофічних проявів.

Комп'ютерно-томографічні цифрові зображення опрацьовано стандартизованим рентгенодіагностичним програмним забезпеченням Ez3D-I Original ver.5.1.9.0. Використовуючи інструменти горизонтальної опційної панелі, зокрема клавіші інтерфейсу «профіль», проведено морфометричне дослідження топографії каналу нижньої щелепи як з лівої, так і правої сторін у проекціях 3.7, 3.6, 4.6, 4.7 зубів. Для дослідження якісно однорідних значень нами застосовано непараметричні методи статистичного аналізу та математичного обчислення усереднених (ММ) морфометричних показників, що характеризують прокладання каналу, у беззубих дистальних сегментах атрофованої кісткової тканини нижньої щелепи. Так, у першій групі дослідження відстань від краю основи нижньої щелепи до каналу нижньої щелепи (КНЩ) становить 7.2 мм, від краю щічної поверхні до КНЩ – 4.8 мм, відстань від краю язикової поверхні до КНЩ – 2.9 мм. У другій групі дослідження НК=8.0 мм, ЩК=5.3 мм, ЯК=3.3 мм відносно КНЩ. У третій групі дослідження НК=8.1 мм, ЩК=5.3 мм, ЯК=3.3 мм відносно каналу нижньої щелепи.

Систематизований аналіз, зведений у спрощену та зрозумілу класифікацію топографії каналу нижньої щелепи людини, при атрофії кісткової тканини зумовленої втратою жувальної групи зубів, надає можливість прогнозу щодо діагностики та клінічної пропозиції в обранні методів реабілітації, з першочерговим відновленням втраченої функції зубних рядів, фіксації гвинтових надокісних шин, при остеосинтезі чи інших реконструктивних операціях, при судово-медичній експертизі тощо.

Ключові слова: морфометрія, канал нижньої щелепи, комп'ютерна томографія.

CLASSIFICATION OF THE TOPOGRAPHY OF THE MANDIBULAR CANAL IN CASE OF BONE ATROPHY CAUSED BY THE LOSS OF THE MASTICATORY TEETH

Oshurko A. P., Oliinyk I. Yu., Kuzniak N. B.

Abstract. *Introduction.* This study focuses on the topographic features of the mandibular canal in case of bone atrophy caused by the loss of the masticatory teeth. Taking as a goal to develop a simplified and informative classification of the topography of the human mandibular canal, available for implementation in daily clinical practice, we analysed 136 digital CT scans obtained using the Vatech PaX-i 3D Green extra-oral radiography system. Even at first glance, we already observed a difference in the laying of the canal relative to the buccal, lingual sides or the ridge of the mandibular base. Bone tissue acquires "unstable" atrophic manifestations in case of the loss of teeth, particularly the masticatory ones, with their inherent anatomical features of the roots and their location in the alveolar part.

CT digital images were processed by the standardised X-ray diagnostic software Ez3D-I Original ver.5.1.9.0. Using the tools of the optional horizontal panel, in particular, the "profile" interface keys, a morphometric study of the topography of the mandibular canal on both the left and right sides was performed in projections of 3.7, 3.6, 4.6, 4.7 teeth. To study qualitatively homogeneous values, we used nonparametric methods of statistical analysis and mathematical calculation of the average (MM) morphometric parameters that characterise canal laying in toothless distal segments of atrophied bone tissue of the lower jaw. So, in the first study group, the distance from the ridge of the mandibular base to the mandibular canal (MC) is 7.2 mm, from the ridge of the buccal surface to the MC – 4.8 mm, the distance from the ridge of the lingual surface to the MC – 2.9 mm. In the second group of the study, RMB=8.0 mm, BR=5.3 mm, LR=3.3 mm regarding MC. In the third group of the study, RMB=8.1 mm, BR=5.3 mm, LR=3.3 mm relative to the mandibular canal.

Systematic analysis, reduced to a simplified and understandable classification of the topography of the human mandibular canal with bone atrophy caused by the loss of the masticatory teeth, provides an opportunity to predict the diagnosis and clinical proposal in the choice of rehabilitation methods, with the immediate restoration of the lost function of the dentition, fixing screw periosteal splints, during osteosynthesis or other reconstructive operations, forensic medical examination, and the like.

Key words: morphometry, lower jaw canal, computed tomography.

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This manuscript is based on the observance of moral and ethical norms and has no signs of conflict of interest between the authors and the patient.

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