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MORPHOLOGICAL SIGNIFICANCE OF BONE ATROPHY FOR TOPOGRAPHIC FEATURES OF THE LEFT MANDIBULAR CANAL

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In clinical practice, when analyzing computed tomography studies, the attention of dental surgeons is attracted by topographic and anatomical changes in the mandibular canal concerning the bilateral loss of molars, which cause bone atrophy, even in individuals without obvious effects of somatic pathology or environmental conditions. In the study, we used the standardized CT software "Vatech original 2020". It was found that while preserving the dentition rows, the topography of the left mandibular canal approaches its lingual surface on the ≈ 1.5 mm; the canal is delimited only by the cortical layer of bone tissue. When the first molars are lost, the mandibular canal is displaced by ≈ 3.1 mm relative to the outer edge of the buccal surface. With acquired terminal dentition defects, "morphological transposition" acquires ≈4.9 mm relative to the buccal surface with a distance to the middle ≈3.0 mm from the edge of the lingual surface of the mandible. The presented description of the absolute morphometric values of the mandibular canal by its average number improves the visual perception of its topographic features with the occurrence of a neurovascular bundle in it and remains a sign drawing up a treatment plan and choosing rehabilitation methods.

Key words: mandible, computed tomography, mandibular canal, bone atrophy.

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МОРФОЛОГІЧНЕ ЗНАЧЕННЯ АТРОФІЇ КІСТКОВОЇ ТКАНИНИ ДЛЯ ОСОБЛИВОСТЕЙ ТОПОГРАФІЇ ЛІВОГО КАНАЛУ НИЖНЬОЇ ЩЕЛЕПИ ЛЮДИНИ

У клінічній практиці, при аналізі комп'ютерно-томографічних досліджень, увагу лікарів стоматологів-хірургів привертають топографоанатомічні зміни каналу нижньої щелепи у взаємозв'язку із двосторонньою втратою молярів, що зумовлює атрофію кісткової тканини навіть у осіб без явних впливів соматичної патології чи умов зовнішнього середовища. У дослідженні використовували комп'ютерно-томографічне стандартизоване програмне забезпеченні "Vatech original 2020". Встановлено, що при збереженні зубних рядів топографія каналу нижньої щелепи зліва пролягає з наближенням до її язикової поверхні на ≈ 1.5 мм; канал відмежований лише кортикальним шаром кісткової тканини. При втраті перших молярів відбувається зміщення каналу нижньої щелепи на ≈ 3.1 мм відносно зовнішнього краю щічної поверхні. При набутих кінцевих дефектах зубних рядів "морфологічна транспозиція" набуває ≈ 4,9 мм відносно щічної поверхні з віддаленням до середини на ≈ 3,0 мм від краю язикової поверхні нижньої щелепи. Поданий опис абсолютних морфометричних значень каналу нижньої щелепи за його середнім числом покращує візуальне сприйняття його топографічних особливостей із заляганням у ньому судинно-нервового пучка, що залишається орієнтиром під час складання плану лікування та вибору методів реабілітації.

Ключові слова: нижня щелепа, комп'ютерна томографія, канал нижньої щелепи, атрофія кісткової тканини.

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The formation of lower jaw bone tissue in human postnatal ontogenesis is the result of histogenesis processes and, in fact, its mineralization [14] even at the early stages of prenatal ontogenesis [4]. The bone tissue of the human mandible is a dynamic system and its composition depends on the course of metabolic processes and the influence of exo- and endogenous factors leading to pathophysiological and morphological changes [9]. That is why, both researchers and clinicians face a twofold problem in choosing diagnostic methods [2, 8] and rehabilitation of such patients [5].

Well-known and affordable methods of flame atomic emission and atomic absorption analysis provide opportunities for modern researchers to study the features of the structure and quality of maxillofacial bones, by considering the content of macro- and microelements [3]. The results of such studies are often crucial for choosing effective methods of prevention and treatment and serve only as a small part of the rehabilitation of dental patients.

The minimally invasive possibilities of X-ray anatomical CT scan are much wider than those of conventional clinical X-ray. The examination can be carried out more thoroughly than taking a series of images or the usual 3D software modelling in various projections or planes, using a considerable arsenal of devices. The use of CT makes it possible to establish the features of the topography of human lower jaw structures, obtain information about the structure of its external and internal cortical plates, and determine densitometric values that indicate qualitative characteristics that reflect the type of bone density, taking into account its age dynamics.

Nevertheless, the key task is the rehabilitation of patients with functional prothetic and aesthetic needs [11, 12]. The use of dental implants seems to solve these tasks quickly and efficiently and allow achieving the goal. However, quite often, the possibilities of using dental implants are limited and accompanied by certain difficulties [1]. First of all, this is due to the close location of important anatomical structures, namely, the neurovascular bundle of the human mandible, the topography of which depends on bone atrophy caused by tooth loss, especially in its distal parts.

The purpose of the work was to study topographic features of the human left mandibular canal with bone atrophy caused by terminal dentition defects.

Material and methods. High-quality images were obtained after paraclinical examination of digital records of 243 CT cone-digital scans taken by the Vatech PaX-I 3D Green extra-oral radiography system with a scan size range of 16x9 cm, which minimize the possibility of artifacts caused by patient movement, a focal spot of 0.5 mm (EC60336) on a 14-bit gray scale with a size of 0.2/0.3 voxels and due to the short scanning time. Sixty-eight scans were selected that provide the best diagnostic capabilities and are properly informative in achieving the aim of this work. The analysis was performed using HEWLETT-SNCPUM1 computer equipment with 16.0 g of RAMB, 10 Pro for Workstations, 2019:00391-70000-00000-AA425, in the computer-tomographic standardized software "Vatech original 2020", after which, by the method of "clinical selection", the material is divided into four age groups, namely: the first group – up to 45 years, the second group – 46–60 years, the third group – 61–75 years and the control group – 25–75 years, persons with a preserved dentition.

In the clinical analysis, a detailed morphometric description of the topographic features of the left mandibular canal was carried out, according to one CT scan from each age group, with their average values.

The study was conducted in compliance with the main provisions of the GCP (1996), the Council of Europe Convention on human rights and biomedicine (dated 04.04.1997), and the World Medical Association Declaration of Helsinki on ethical principles for conducting scientific medical research involving human subjects. According to the order of the Ministry of Healthcare of Ukraine No. 110 dated 14.02.2012, a patient gave informed and voluntary consent for diagnosis, treatment, surgery and anesthesia, the relevant medical documentation was drawn up and certified by the patient's signature. The provisions of the Law of Ukraine of 01.06.2010 No. 2297-VI "On personal data protection" with amendments and additions by the laws of Ukraine dated 23.02.2012 No. 4452-VI, dated 20.11.2012 No. 5491-VI regulating legal relations concerning protection and processing of personal data, and aimed at protecting fundamental human and civil rights and freedoms.

Results of the study and their discussion. The topography of the mandibular canal and its neurovascular bundle is a sign for drawing up a treatment plan and for choosing rehabilitation procedures in patients with tooth loss, following existing and approved protocols [7].

A clear understanding was gained during the analysis of CT scans in the digital format in three planes: frontal, sagittal, axillary.

Using the tools of the horizontal optional panel in the sagittal plane, the mandibular canal was marked, showing its way in the thickness of the bone tissue of the body of the mandible (fig. 1).

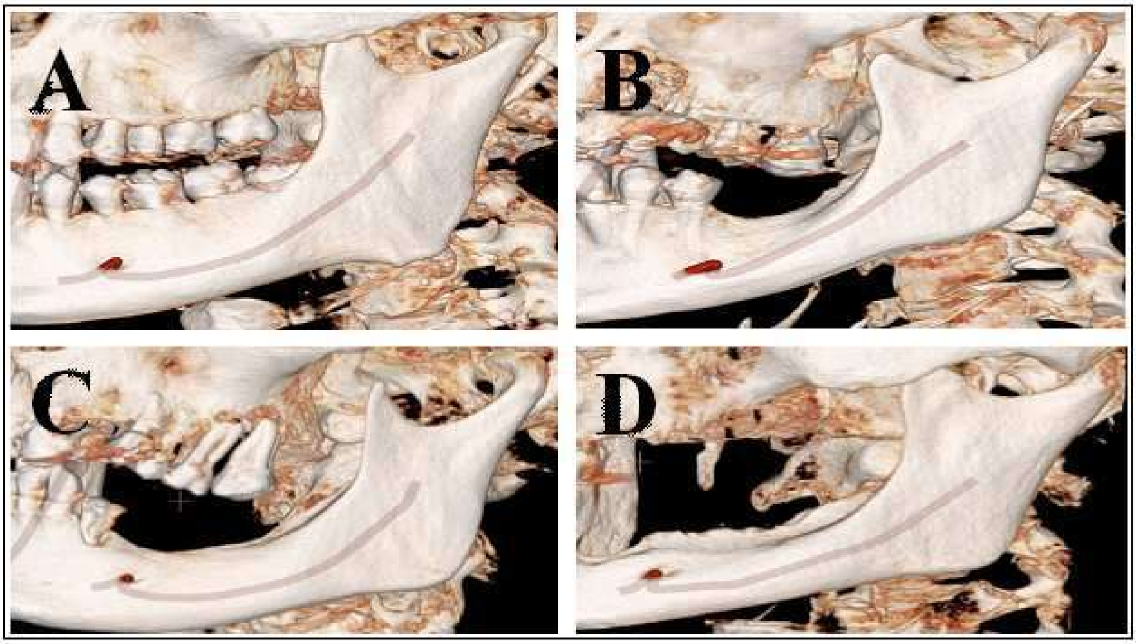

Fig. 1. 3D-reconstruction model of the topography of the left mandibular canal:A) patient of the first study group with a preserved dentition, 48 years old; B) patient of the second study group, terminal dentition defect, 35 years old; C) patient of the third study group, terminal dentition defect, 52 years old; D) patient of the fourth study group, terminal dentition defect, 64 years old.

This 3D-reconstruction model reveals an idea of its topography but does not provide a quantitative definition in relation to the base, lingual and buccal surfaces, as well as the alveolar part of the human mandible, provided that it is preserved. It is most appropriate to conduct morphometric studies of the topography of the mandibular canal in the sagittal section.

Absolute values of the location of the mandibular canal (fig. 2) in a patient of the first study group (control) with a preserved dentition (48 years) in the projection:

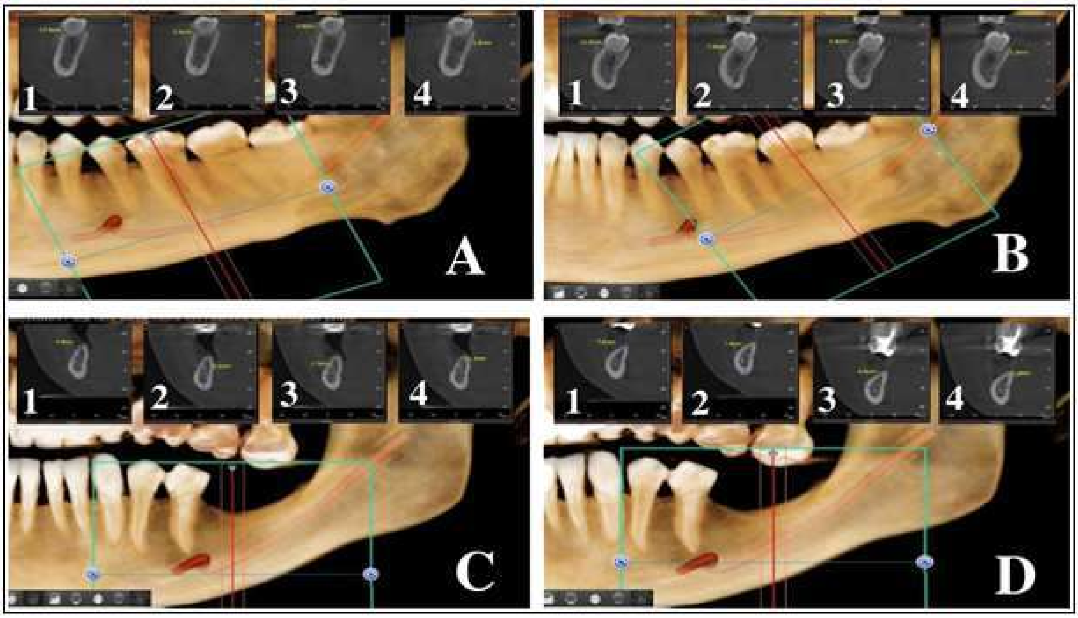

Fig. 2 (A-D). 3D-reconstruction model of the topography of the left mandibular canal: A – Sagittal sections in the projection of 3.6 tooth, 48 years old; B – Sagittal sections in the projection of 3.7 tooth, 48 years old; C – Sagittal sections in the projection of 3.6 tooth, 35 years old; D – Sagittal sections in the projection of 3.7 tooth, 35 years old: 1) value of UE; 2) value of EB; 3) value of BS; 4) value of LS.

1) 3.6 tooth (fig. 2, A) relative to: the upper edge (UE) of the alveolar part of the mandible is 13.3 mm; the edge of the base (EB) of the mandible is 6.6 mm; the buccal surface (BS) of the lower jaw body is 6.5 mm; the lingual surface (LS) of the body of the mandible is 1.9 mm;

2) 3.7 tooth (fig. 2, B) in relation to: UE – 10.3 mm; EB – 7.0 mm; BS – 6.6 mm; LS – 2.3 mm.

In the second study group, a 35-year-old patient with a terminal dentition defect, the topography of the left mandibular canal is characterized by morphometric values in the projection of the missing one:

1) 3.6 tooth (fig. 2, C) in relation to: UE – 9.8 mm; EB – 5.6 mm; BS – 2.7 mm; LS – 2.7 mm;

2) 3.7 tooth (fig. 2, D) in relation to: UE – 7.6 mm; EB – 7.9 mm; BS – 4.0 mm; LS – 2.2 mm.

A 52-year-old patient of the third study group (fig. 3) with a terminal dentition defect, the topography of the left mandibular canal is characterized by morphometric values in the projection of the missing one:

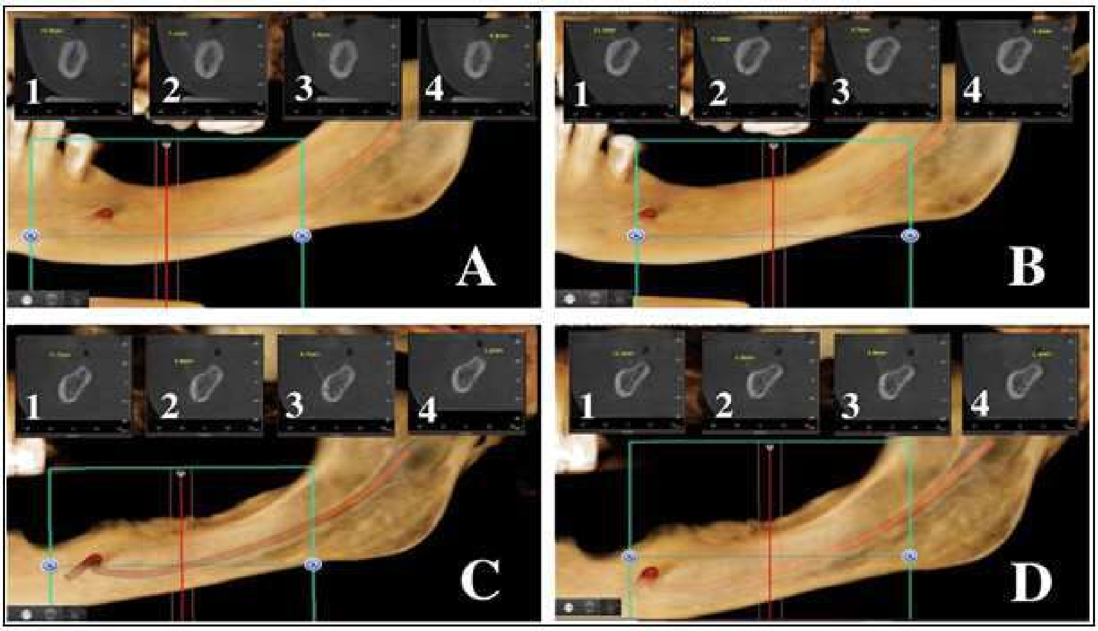

Fig. 3 (A-D). 3D-reconstruction model of the topography of the left mandibular canal: A – Sagittal sections in the projection of 3.6 tooth, 52 years old; B – Sagittal sections in the projection of 3.7 tooth, 52 years old; C – Sagittal sections in the projection of 3.6 tooth, 64 years old; D – Sagittal sections in the projection of 3.7 tooth, 64 years old: 1) value of UE; 2) value of EB; 3) value of BS; 4) value of LS.

1) 3.6 tooth (fig. 3, A) relative to: UE – 10.8 mm; EB – 7.1 mm; BS – 3.9 mm; LS – 4.5 mm;

2) 3.7 tooth (fig. 3, B) relative to: UE – 11.5 mm; EB – 6.2 mm; BS – 4.7 mm; LS – 4.4 mm.

Topographic differences in the left mandibular canal are represented in a 64-year-old patient of the fourth study group with a terminal dentition defect characterized by morphometric values in the projection of the missing:

1) 3.6 tooth (fig. 3, C) relative to: UE – 11.7 mm; EB – 5.8 mm; BS – 5.7 mm; LS – 2.1 mm;

2) 3.7 teeth (fig. 3, D) relative to: UE – 11.1 mm; EB – 6.5 mm; BS – 5.9 mm; LS – 2.4 mm.

We understand that even the analysis of the obtained absolute values does not reveal the corresponding patterns of topographic changes in the mandibular canal, depending on bone atrophy caused by the loss of the masticatory teeth, that is, molars, in different age categories.

However, it encourages a comprehensive study of possible variations, with the expansion of the number of research objects and their statistical analysis based on classical parameters and characteristics of variation series: arithmetic mean – (M), standard error of the studied indicators (m) with a possible confidence interval estimation (P) for (M-2m) and (m+2m).

The work of the authors [6] indicates atrophy of bone tissue due to certain somatic pathology and reveals pathophysiological mechanisms covering various processes, such as resorption, remodelling, sclerosis, corticalization, etc.

The bone tissue of the alveolar part of the lower jaw is characterized by pronounced morphological variability and has a unique ability to rearrange, primarily following the vertical movement of teeth. It is formed around erupted teeth and their periodontal ligaments: the more teeth that erupt, the more voluminous the alveolar part. It is scientifically proven that during life, teeth erupt and migrate in the occlusal and mesial directions to compensate for abrasion, which is an evolutionary trait. After tooth extraction, the alveolar part is remodeled to different degrees and undergoes atrophic processes. According to them, the bone tissue of the alveolar part of the lower jaw represents the condition of the skeletal bones. Due to the rapid metabolic rate (which is the fastest in the entire skeleton), low bone volume density can first be observed here, which even leads to an increased risk of fractures. If the periapical X-ray of the mandibular molars shows dense trabeculation with well-mineralized trabecules and small intertrabecular gaps, it is a reliable sign of normal skeletal bone density and low risk of skeletal bone fractures, while a sparse trabecular pattern indicates osteopenia and a high risk of pathological fractures. The rate of bone rearrangement of the lower jaw is twice as high as that of the upper jaw, and, hypothetically, may play a role in the development of osteonecrosis of the jaw, which is found mainly in the alveolar part of the lower jaw. Since bone remodeling occurs on the endosteal surfaces, where osteoclasts and osteoblasts are most localized.

It is known that the rate of metabolic transformations of the alveolar part of the lower jaw is also affected by hormonal and physiological changes in the body, but it is important to take into account the differences in the load on bone tissue between loaded, semi-loaded and unloaded bones. Bone mass is conditionally redistributed from one place to another, where the force acts. Liquid trabeculation of the lower jaw (large intertrabecular spaces and thin trabeculae) is a reliable sign of osteopenia.

Consequently, the absence of indirect "constant pressure" leads the bone tissue to a state of relative metabolic rest, but also, accordingly, to its emptying. Reduction of the osteoblast and osteocyte forming cells that maintain the level of ionic concentration in the bone interstitial fluid and directly reflect osteonic structure and its volume.

Thus, atrophy of the jaw bone tissue leads to various complications. And this is not only the inability to perform implantation, but also its consequences, such as changes in the bite and shape of the face, speech disorders, difficulty in chewing food, and so on. Unfortunately, the topographic features of the mandibular canal, which in our opinion are also caused by bone atrophy, are covered with some caution in modern scientific sources [13].

The efforts of clinicians-researchers are directed in real-time to select the necessary diagnostic methods and appropriate rehabilitation protocols, taking into account the subjective assessment of functional disorders, and, accordingly, to adjust the patient's treatment, through paraclinical diagnostics of topographical and anatomical features of the left and right mandibular canals, which is also characterized by its individual variability.

The progressiveness of domestic and international scientific researches for patient rehabilitation with bone atrophy is obvious, however, that such a subjective and objective assessment of the above factors affects the adoption of adequate decisions. Although the proposals and their recommendations, in our opinion, are one-sided and do not provide comprehensive information on what concerns the functional integration of aesthetic solutions and our analysis of modern literature sources [10, 15] did not provide a proper understanding of the above-mentioned problems, it was an impetus for a thorough study of the topography of the left mandibular canal in case of bone atrophy caused by terminal dentition defects.

Conclusions

1. While preserving the dentition, the topography of the left mandibular canal, which is covered by the cortical layer of bone tissue, approaches the lingual surface on ≈ 1.5 mm.

2. When the first molars (the first large molars) are lost, the mandibular canal is displaced by ≈ 3.1 mm relative to the outer edge of the buccal surface.

3. With acquired terminal dentition defects, "morphological transposition" acquires ≈ 4.9 mm relative to the buccal surface with a distance to the middle ≈ 3.0 mm from the edge of the lingual surface of the mandible.

4. The obtained average absolute values characterize the existing qualitative morphological transformations, although they require statistical analysis, but can be used in making clinical decisions on the rehabilitation of patients using dental implantation, osteosynthesis, or the use of other reconstructive operations in the maxillofacial region.

Prospects for using the results. The study of the topographic features of the human mandibular canal in case of bone atrophy caused by tooth loss should be proceeded and it will be expedient to establish regularities in the course of these processes with in-depth statistical analysis and development of a three-dimensional model for template application in practical dentistry, in particular, maxillofacial surgery.

References

1. Avetikov DS, Pronina OM, Lokes KP, Bukhanchenko OP. Suchasni uyavlennia pro umovy, shcho obmezhuiut vybir metodu implantatsii zubiv u verkhniy i nyzhniy shchelepakh. Visnyk problem biolohiyi ta medytsyny 2017; 4(3): 20–27. Rezhym dostupu: http://nbuv.gov.ua/UJRN/Vpbm_2017_4% 283%29__8. [in Ukrainian]

2. Rozhko MM, Nespriadko VP. Ortopedychna stomatolohiya: pidruchnyk. Medytsyna; 2020. 720 s. [in Ukrainian]

3. Sohuiko RR, Masna ZZ, Masna-Chala OZ, Chelpanova IV. Analiz shchilnosti i mineralnoho skladu kistkovoi tkanyny nyzhnoi shchelepy shchura ta zakonomirnostei yikh posttravmatychnoi dynamiky. Morphologia. 2019; 13(2): 54–62.Dostupno na: http://nbuv.gov.ua/UJRN/Morphology_2019_13_2_9. [in Ukrainian]

4. Tsyhykalo OV, Popova IS, Kuzniak NB, Palis SIu, Shostenko AA, Dronyk II. Suchasni uyavlennia pro patohenez pryrodzhenykh vad lytsia (ohliad literatury) Bukovynskyi medychnyi visnyk. 2017; 21(1): 230–234. Rezhym dostupu: http://e-bmv.bsmu.edu.ua/issue/view/7071. [in Ukrainian]

5. Cai X, Xing J, Long C, Peng Q, Beth Humphrey M. DOK3 modulates bone remodeling by negatively regulating osteoclastogenesis and positively regulating osteoblastogenesis. J. Bone Miner. Res. November 2017; 32, 11: 2207–2218. doi: 10.1002/jbmr.3205.

6. Chernenko VM, Liubchenko OV, Kochyna ML. Systema pidtrymky pryiniattia rishen likarem shchodo vyboru metoda dentalnoyi implantatsii. Ukrainskyi zhurnal medytsyny, biolohiyi ta sportu. 2019; 4(20): 200–210. doi: 10.26693/jmbs04.04.200. [in Ukrainian]

7. De la Rosa Castolo G, Guevara PSV, Arnoux P-J, Badih L, Bonnet F, Behr M. Implant-supported overdentures with different clinical configurations: mechanical resistance using a numerical approach. The Journal of Prosthetic Dentistry. March 2019; 121(3:) 546.e1–546.e10. doi: https://doi.org/10.1016/j.prosdent.2018.09.023.

8. Driscoll CF (editir), Golden WG (editir). Treating the Complete Denture Patient. Wiley-Blackwell. March 2020. 312 p. doi: https://www.wiley.com/en-lv/Treating+the+Complete+Denture+Patient-p-9781119569565.

9. Ferros I, Mora MJ, Obeso IF, Jimenez P, Martinez-Insua A. The nasomaxillary complex and the cranial base in artificial cranial deformation: relationships from a geometric morphometric study. Eur. J. Orthod. 2015; 37(4): 403–411. doi: 10.1093/ejo/cju066.

10. Khuder T, Yunus N, Sulaiman E, Ibrahim N, Khalid T, Masood M. Association between occlusal force distribution in implant overdenture prostheses and residual ridge resorption. Journal of Oral Rehabilitatiom. 2017. 44(5): 398–404. doi: https://doi.org/10.1111/joor.12504.

11. Kim HS, Cho HA, Kim YY, Shin H. Implant survival and patient satisfaction in completely edentulous patients with immediate placement of implants: a retrospective study. BMC Oral Health. 2018 December 18; Volume 18, Article No. 219. doi: https://doi.org/10.1186/s12903-018-0669-1.

12. Kovacic I, Persic S, Kranjcic J, Lesic N, Celebic A. Rehabilitation of an extremely resorbed edentulous mandible by short and narrow dental implants. Case Reports in Dentistry. Volume 2018, Article ID 7597851, 8 pages. doi: https://doi.org/10.1155/2018/7597851.

13. Meloni SM, Jovanovic SA, Urban I, Canullo L, Pisano M, Tallarico M. Horizontal ridge augmentation using GBR with a native collagen membrane and 1:1 ratio of particulated xenograft and autologous bone: a 1-year prospective clinical study. Clin Implant Dent Relat Res. 2017 Feb; 19(1):38–45. doi: 10.1111/cid.12429.

14. Oshurko AP, Oliinyk IYu, Korkuna OYa. Studying qualitative characteristics of bone tissue of the human maxilla on the quantitative content of trace elements (K, Fe, Co, Sr, Zn) in the dynamics of prenatal ontogenesis. The European Journal of Biomedical and Life Sciences, Premier Publishing s.r.o. Vienna. 2018; 3: 23–37. doi: https://doi.org/10.29013/ELBLS-18-3-23-37.

15. Owen R, Reilly GC. In vitro Models of Bone Remodelling and Associated Disorders. Front. Bioeng. Biotechnol. 11 October 2018. doi: https://doi.org/10.3389/fbioe.2018.00134.

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