

ORIGINAL ARTICLE

MORPHOMETRIC ANALYSIS OF TOPOGRAPHIC VARIABILITY OF THE LEFT AND RIGHT MANDIBULAR CANALS IN CASE OF LOSS OF THE MASTICATORY TEETH

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ABSTRACT

The aim: To study the topographic variability of the left and right mandibular canals in case of bone atrophy caused by the loss of the masticatory teeth.

Materials and methods: 136 digital scans were selected for morphometric analysis, 68 for each side taken with the Vatech PaX-i 3D Green extra-oral radiography system. The readout of absolute morphometric values, laying the left and right MC was performed in the projection of 3.7, 3.6, 4.6, 4.7 teeth using standardized Ez3D-I software.

Results: The alveolar part is characterized by distance to the alveolar ridge, and primarily exposed to pronounced atrophic processes of bone tissue. Distance to the lingual ridge directly proportionally indicates the morphological transposition vector of the mandibular canals for the distance to the buccal ridge, by the same length to its reduction. Morphometric analysis on a short toothless segment determines the variability of laying the mandibular canals but it is characterized by constant regular values of the ridge of the mandibular base.

Conclusions: Dentition defects, moving towards the missing teeth, lead to a decrease in the biophysical stimulus on bone tissue, causing pronounced morphological changes with the loss of significant volume and restructuring of its trabecular layer, which synchronously affects the topographic variability of the left and right MC.

KEY WORDS: mandible, computed tomography, mandibular canal, bone atrophy

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INTRODUCTION

Early tooth loss in the distal parts of the lower jaw is the most common manifestation of dental pathology, which in turn is complicated by segmental deformity of the antagonizing dentition and «disuse atrophy» of bone tissue, in general. This pathophysiological mechanism of the defect circle triggers a whole cascade of irreversible processes in the restructuring of the architectonics of bone tissue with all its components, including the mandibular canal (MC). After all, an indicator of the normal functioning of the maxillary system, first of all, is the integrity of the dentition, which through the masticatory muscles, teeth and periodontium, in particular, transmit proper pressure to bone tissue in the form of a mechanical stimulus, to which a biological reaction occurs from the bone tissue, thereby ensuring the corresponding processes of metabolic transformations. And such a non-stop process of reconstruction is usually called remodelling, with the participation of basic multicellular units of bone structure, that is, areas of bone tissue in which bone restructuring occurs. The number of such points directly depends on the stimulus spreading to its receptors, by regulating the concentration of ions and change of protein levels, as well as factors that stimulate the inhibition of mineralization. Under the opposite conditions, the absence of indirect «constant pressure» forces bone tissue to the status of the relative metabolic rest, and, accordingly, to its devastation. Reduction of the quantity of osteoblast and osteocyte forming cells that maintain the level of ionic concentration in the bone interstitial fluid thereby reduces osteonic structure and its volume. Our study proves this interpretation by comparing segments in projection 3.6, 3.7 teeth of the left side and 4.6, 4.7 teeth of the right side [1]. Defects of the dentition, moving towards the missing teeth, lead to a decrease in the mechanical stimulus on bone tissue, causing pronounced morphological changes with the loss of significant volume and restructuring of its trabecular layer, which synchronously affects the topographic variability of the left and right mandibular canals.

THE AIM

To study the topographic variability of the right and left mandibular canals in case of bone atrophy, due to the loss of the masticatory teeth (lower molars), in individuals aged 25-75 years.

MATERIALS AND METHODS

High-quality images were obtained during a thorough analysis of 243 computed tomography cone-digital scans taken by the Vatech PaX-I 3D Green extra-oral radiography system with a scan size range of 16 x 9 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. For statistical analysis, we selected 136 digital scans, 68 for the left and right sides, in individuals without existing somatic pathology, which would have an indirect effect on the metabolic transformations of bone tissue, which provide the best opportunities for scientific research and have proper information content to achieve the aim of this study.

The analysis was performed using HEWLETT-SNCPUM1 computer equipment with 16.0 GB RAM, 10 Pro Software for Workstations, 2019: 00391-70000-00000-AA425 after that, using the method of «statistical selection» we separated four age groups (Table I), namely: the first study group (I) - 25-45 years, the second study group (II) – 46-60 years, the third study group (III) 61-75, the fourth control group (IV) – 25-75 years, people with preserved dentition.

We obtained the results of absolute morphometric values (Fig. 1) of laying the mandibular canal (MC), using standardized Ez3D-I software ver.5.1.9.0 in the projection of 3.7, 3.6, 4.6, 4.7 teeth relative to: the distance from the ridge of the alveolar part (AR) to the MC – ar-mc (Fig. 1-A); distance from the ridge of the mandibular base (RMB) to the MC – rmb-mc (Fig. 1-B); distance from the ridge of the buccal surface (BR) to the MC – br-mc (Fig. 1-C); distance from the ridge of the lingual surface (LR) to the MC – lr-mc (Fig. 1-D).

To study the topographic variability of the right and left mandibular canals, we used a variational analysis of statistical data with the determination of average morphometric values for each distance, which characterize such data and the standard error of average values, as well as estimates of the reliability of average values and the probability of an error-free forecast between comparison groups.

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. Following the order of the Ministry of Health of Ukraine No. 110 dated 14.02.2012, the informed voluntary patients' consents were obtained to conduct diagnostics, the relevant medical documentation was drawn up and certified by patients' signatures. 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

The result of the processing of statistical data showed absolute figures indicating the size of phenomena and their quantitative characteristics. Although they have a certain cognitive significance, their use is limited. To determine the level of the phenomenon and comparison of the indicator in dynamics we calculated relative values (indicators, coefficients), which are the result of the ratio of statistical values to each other and give an idea of the topographic variability of the left (Fig. 2, Fig. 3) and right mandibular (Fig. 4, Fig. 5) canals in case of bone atrophy under conditions of loss of the masticatory teeth.

What attracts the researcher's attention is that significant morphometric changes are observed in the distance ar-mc, that goes from the AR to the MC in all the study groups and differs significantly from the control group, which is represented by preserved dentition rows.

In the projection of 3.6 tooth with an average number of M=12.72±0.64 in the study groups I-III (S) and M=17.15±0.58 in the comparison control group IV (K), where $p<0,001$, with a decrease in the values of S – M=11.49±0.59, and in K – M=15.36 ±0.49, where $p<0,001$ in the projection of 3.7 tooth.

Topographic variability of the right MC is characterized by a slight asymmetry, however, maintains the tendency of regularity and it is S – M=12.9±0.57 and K – M=17.48±0.58, where $p<0,001$ in the projection of 4.6 tooth with the reflection of atrophic processes of bone tissue, which certainly affect the topography of the canal, and it is confirmed by the values S – M=11.63±0.55 and K – M=15.39±0.52, where $p<0,001$ in the projection of 4.7 tooth.

Another pattern defines the distance lr-mc, which runs from the lingual ridge of the body of the mandible to its channel with constant morphometric values:

S – M=3.46±0.18 in the area of the 3.6 tooth; S – M=3.11±0.18 in the area of the missing 3.7 tooth, and a slight asynchrony of the right canal and is:

Table I. Grouping of data in the study of qualitatively homogeneous aggregates – quantitative indicators that determine the topographical and anatomical features of the mandibular canal in case of bone atrophy caused by the loss of the masticatory teeth

Group	Age (full years)	Number of observations	Lower jaw	
			A - right side	B - left side
I (study group)	25-45	28	14	14
II (study group)	46-60	40	20	20
III (study group)	61-75	34	17	17
IV (control group)	25-75	34	17	17
Total observations	25-75	136	68	68

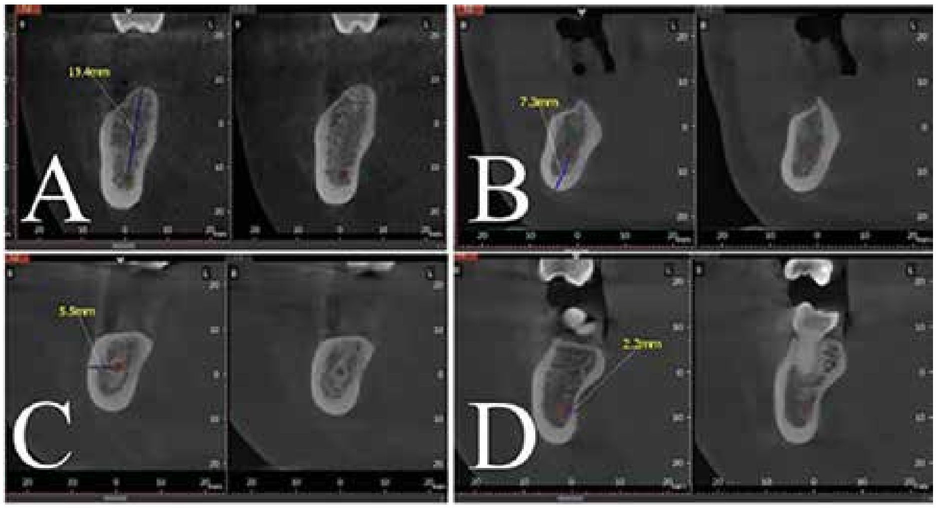
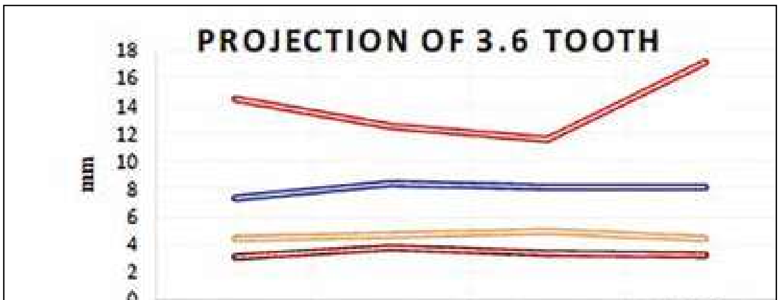
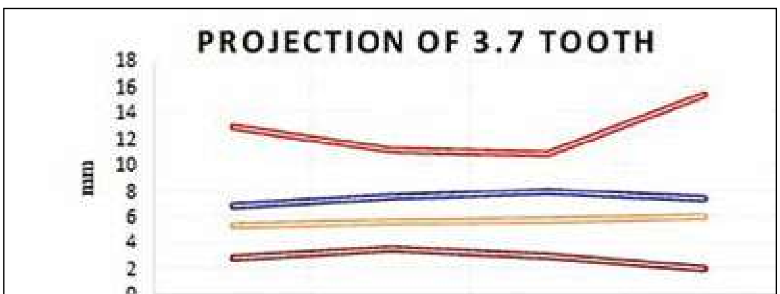


Fig. 1. 3D reconstruction model of the structural topography of the mandibular canal, sections in the sagittal plane:
A) patient of group I, terminal dentition defect, 25-45 years old;
B) patient of group II, terminal dentition defect, 46-60 years old;
C) patient of group III, terminal dentition defect, 61-75 years old;
D) patient of group IV, with a preserved dentition, 25-75 years old.



	I (25-45 years)	II (46-60 years)	III (61-75 years)	IV (25 -75 years, control group)
ar-mc	14,49	12,49	11,52	17,15
rmb-mc	7,36	8,35	8,15	8,09
br-mc	4,35	4,72	4,89	4,44
lr-mc	3,09	3,79	3,4	3,28

Fig. 2. Morphometric analysis (mm) of topographic and anatomical variability of the left MC in case of bone atrophy caused by the loss of the masticatory teeth in people aged 25-75 years, n=68: ar-mc – distance from the ridge of the alveolar part to the MC; rmb-mc – distance from the ridge of the base of the lower jaw to the MC; br-mc – distance from the ridge of the buccal surface to the MC; lr-mc – distance from the ridge of the lingual surface to the MC.



	I (25-45 years)	II (46-60 years)	III (61-75 years)	IV (25 -75 years, control group)
ar-mc	12,84	11,13	10,78	15,36
rmb-mc	6,84	7,49	7,98	7,35
br-mc	5,34	5,55	5,75	5,94
lr-mc	2,76	3,46	3,01	1,93

Fig. 3. Morphometric analysis (mm) of topographic and anatomical variability of the left MC in case of bone atrophy caused by the loss of the masticatory teeth in people aged 25-75 years, n=68: ar-mc – distance from the ridge of the alveolar part to the MC; rmb-mc – distance from the ridge of the base of the lower jaw to the MC; br-mc – distance from the ridge of the buccal surface to the MC; lr-mc – distance from the ridge of the lingual surface to the MC.

S – M=3.34±0.18 in the area of the 4.6 tooth; S – M=2.88±0.18 in the area of the missing 4.7 tooth.

At the same time, the change in distance lr-mc directly proportionally causes the morphological transposition vector for the distance br-mc, which runs from the buccal ridge of the body of the mandible to its channel, for the same length in the direction of its decrease and is characterized by a progressive-uniform curvature of graphic images (see Fig. 2-5).

Detailed morphometric analysis of the topographic features of the left MC and right MC in case of bone atrophy on its short toothless segment determines the variability of its laying, however, it is characterized by constant values by the average number of observations on the distance

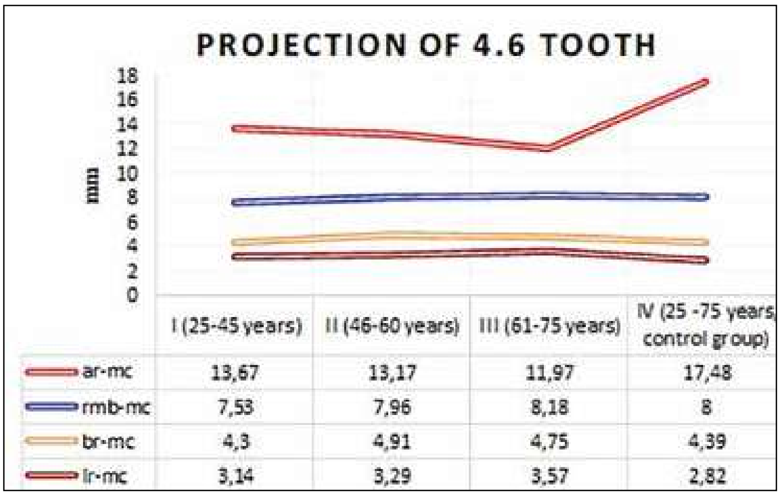


Fig. 5. Morphometric analysis (mm) of topographic and anatomical variability of the right MC in case of bone atrophy caused by the loss of the masticatory teeth in people aged 25-75 years, n=68: ar-mc – distance from the ridge of the alveolar part to the MC; rmb-mc – distance from the ridge of the base of the lower jaw to the MC; br-mc – distance from the ridge of the buccal surface to the MC; lr-mc – distance from the ridge of the lingual surface to the MC.

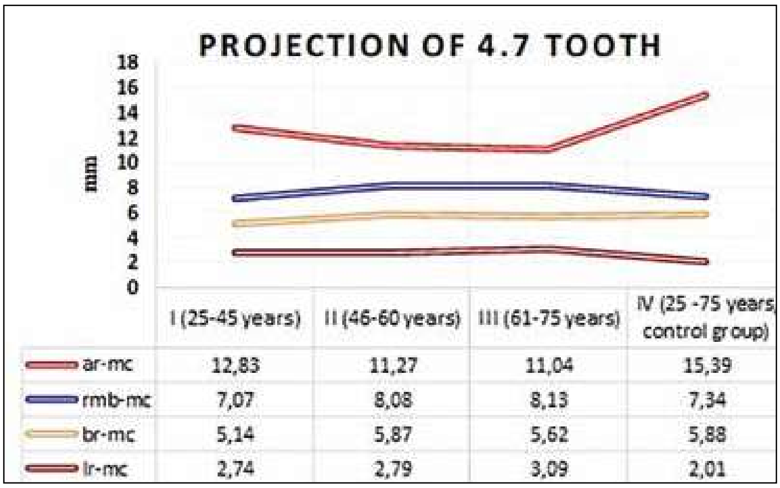


Fig. 4. Morphometric analysis (mm) of topographic and anatomical variability of the right MC in case of bone atrophy caused by the loss of the masticatory teeth in people aged 25-75 years, n=68: ar-mc – distance from the ridge of the alveolar part to the MC; rmb-mc – distance from the ridge of the base of the lower jaw to the MC; br-mc – distance from the ridge of the buccal surface to the MC; lr-mc – distance from the ridge of the lingual surface to the MC.

rmb-mc, which runs from the lower ridge of the base of the mandibular body to the MC.

The average experimental value of rmb-mc is 8.0±0.22 with the same number in the control group – K – M=8.09±0.43 in the area of the 3.6 tooth; S – M=7.47±0.21 and K – M=7.35±0.48 in the area of the missing 3.7 tooth, also represented by a slight asynchrony of the right canal and is:

S – M=7.91±0.21 and K – M=8.0±0.39 in the area of the 4.6 tooth; S – M=7.82±0.22 and K – M=7.34±0.54 in the area of the missing 4.7 tooth.

DISCUSSION

The most significant task and challenge of our time is the rehabilitation of patients with bone atrophy complicated by the topographical and anatomical features of the mandibular canal. Destruction of the trabecular layer, as a consequence of atrophic processes of bone tissue [2, 3], due

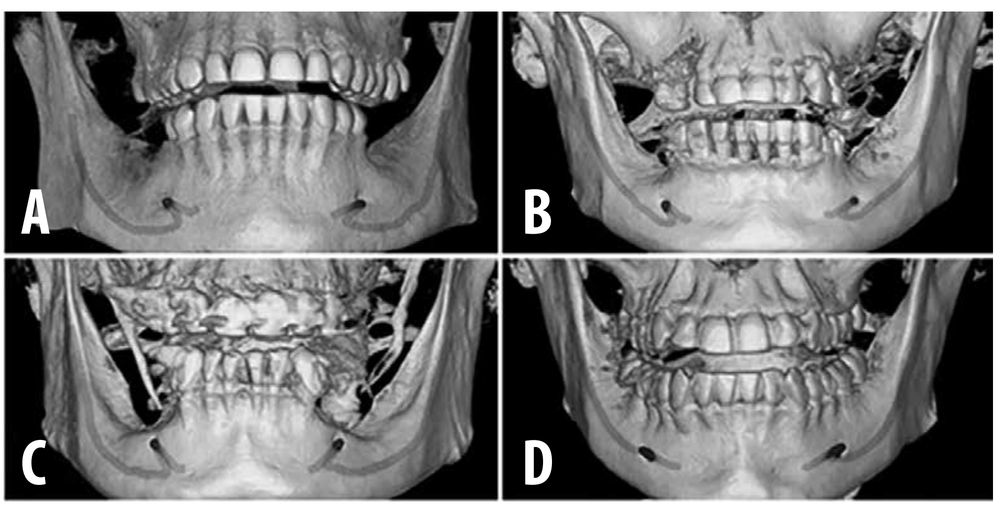


Fig. 6. 3D reconstruction model of the structural topography of the mandibular canal:
A) patient of group I, terminal dentition defect;
B) patient of group II, terminal dentition defect;
C) patient of group III, terminal dentition defect;
D) patient of group IV, with a preserved dentition.

to the loss of the masticatory teeth, leads to topographic variability of the laying of the left MC and right MC, which is presented in the results of the study, but also, accordingly, of the neurovascular bundle, which is already characterized by its morphological variability [4, 5].

In such studies, modern scientists choose digital methods of Computed Tomography as a priority according to ergonomics among similar ones, speed in processing and analysis, and reproduction, that is, visualization (Fig. 6) in the form of 3D reconstruction models [6, 7].

A thorough study with detailed morphometric values ensures a predictable clinical outcome, as the main goal of such studies. However, understanding certain patterns of topographic features described above makes it easier to choose methods of rehabilitation [8] or directed regeneration of bone tissue, before acquiring its normal physiological properties.

But the desire «researcher-patient-clinician» can not always be agreed upon when drawing up a plan for adequate treatment, due to a sequence of objective and subjective circumstances. Although available, promising scientific justifications provide an opportunity to choose effective tools or replace the proposed with similar ones according to the same principle of expediency [9, 10], we face the problem of bone atrophy, which «determines» the topographic variability of the mandibular canal and is the starting point in the rehabilitation [11], which corresponds to the aim and objectives of this work.

Such a detailed morphometric analysis of the topographic variability of the right and left mandibular canals in case of bone atrophy on the example of terminal dentition defects is a new platform for expanding further scientific research and a reliable reference point in the development of a three-dimensional model for template application in practical dentistry, in particular, maxillofacial surgery.

CONCLUSIONS

1. Morphological changes in bone tissue caused by a decrease in the biophysical stimulus through defects in the dentition with their postponement, proportionally affects the volume and restructuring of its trabecular layer and synchronous topographic variability of the left and right mandibular canal.
2. Distance from the ridge of the alveolar part to the mandibular canal of vertical morphometric values of the alveolar part of the lower jaw is characterized by the primary influence of atrophic processes.
3. The change in distance from the ridge of the lingual surface to the mandibular canal direct proportionally causes the vector of morphological transposition of the mandibular canal for the distance BR for the same length in the direction of its decrease.
4. On the toothless segment, with the loss of the masticatory group of teeth, the natural variability of laying the mandibular canal is determined and characterized by constant values based on the average number of observations on a distance of RMB, which runs from the lower ridge of the mandibular body to the mandibular canal.

REFERENCES

1. Oshurko AP, Oliinyk IIu, Kuzniak NB. Osoblyvosti topohrafii pravoho kanalu nyzhnoi shchelepy liudyny pry atrofii kistkovoi tkanyny, zumovlenoi vtratoiu zubiv [Topographic Features of the Right Mandibular Canal in Human Bone Atrophy Caused by Tooth Loss]. Ukrainian Journal of Medicine, Biology and Sports. 2021; 6(5): 35–44. doi: 10.26693 / jmbs06.05. [in Ukrainian].
2. Lee T-H, Jeong M-A, Kim T-H. Feasibility of Assessing Maxillary and Mandibular Bone Mineral Density for Dental Implantation by Using Multidetector Computed Tomography. Implant dentistry. 2019;28(4):367–71.
3. Oshurko AP, Oliinyk IYu, Yaremchuk NI, Makarchuk IS. Morphological features of bone tissue in «disuse atrophy» on the example of a segment of the human lower jaw: clinical experience of treatment. Biomedical and biosocial anthropology. 2021, 42:5–11. doi: 10.31393/bba42-2021-01.
4. Oettlé AC, Fourie J, Human-Baron R. The Midline Mandibular Lingual Canal: Importance in Implant Surgery. Clinical Implant Dentistry and Related Research, 2015; 7(1):93–101. doi 10.1111/cid.12080.
5. Gómez-Román G., Lautner NV. Anterior Loop of the Mandibular canal da Source of Possible Complications. Implant dentistry. 2015;24(5):578–85. doi: 10.1097/ID.0000000000000312.
6. Muñoz G, Dias FJ, Weber B, Betancourt P, Borie E. Anatomic relationships of mandibular canal. A cone beam CT study. Int. J. Morphol., 2017;5(4):1243–8.
7. Smanaliyev MD, Smanaliyeva D, Mavledov I. 3D-planirovanie – "zolotoy standart" diagnostiki dentalnoy implantatsii. [3D planning is the «gold standard» of dental implantation diagnostics.] Scientific research in the Kyrgyz Republic. 2018;1:23–30. [in Russian].
8. Felice P, Barausse C, Pistilli R, Ippolito DR, Esposito M. Five-year results from a randomised controlled trial comparing prostheses supported by 5-mm long implants or by longer implants in augmented bone in posterior atrophic edentulous jaws. Int. J. oral Implant. 2019;12:25–37.
9. Vares YaE, Gudzan YaS, Student VO, Vares YaYa. Possibilities of dental implants installation «bypassing» inferior alveolar nerve: Results of CBCT analysis and own experience. J. Cranio-Maxillofac. Implant Dir., 2020; 14(2):165–74.
10. Heitz-Mayfield LJ, Aaboe M, Araujo M, Carrión JB, Cavalcanti R, Cionca N, et al. Group 4 ITI Consensus Report: Risks and biologic complications associated with implant dentistry. Clinical oral implants research. 2018;29:351–8.
11. Varga JrE, Antal M, Major L, Kiscsatári R, Braunitzer G, Piffkó J. Guidance means accuracy: A randomized clinical trial on freehand versus guided dental implantation. Clinical Oral Implants Research. 2020;31(5):417–30.

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The Authors declare no conflict of interest.

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