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ASSESSMENT OF INTERALVEOLAR HEIGHT DEFICIENCY USING COMPUTED TOMOGRAPHY IN PATIENTS WITH TMJ DYSFUNCTION IN ARTICULATION-OCCLUSION DISORDERS

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This article reviews the assessment of interalveolar height deficit in morphometric comparison with its projection onto the superior space of the temporomandibular joint (TMJ) using cone-beam computed tomography (CT) of the TMJ. The technique for calculating the gaps between the fossa and the head, determining the coefficients for their comparison, and their correlation with clinical signs of TMJ dysfunction in occlusal and articulatory disorders is described.

The aim - *to determine CT diagnostic criteria for decreased interalveolar height in patients with functional TMJ disorders with occlusal and articulatory disorders at the stage of orthopedic treatment planning.*

Materials and research methods. *An examination was conducted of 150 patients with functional disorders of the chewing apparatus and occlusal disorders, who were included in the experimental group and 30 practically healthy individuals - the control group. Both groups were comparable in age and sex. Cone-beam tomography was performed on the MyRay Hyperion X9 PRO model with iRYS 16.3.1 software. During the clinical dental examination, the occlusion of the dentition was assessed, the reduction of the interalveolar height was determined, the width of the mouth opening was assessed, the mobility of the lower jaw was assessed, the symmetry of the mouth opening was determined, clicking and crunching in the TMJ were determined.*

Research result. *When analyzing cone-beam tomography data, interalveolar height deficiency was classified as a decrease in the proposed coefficient for assessing the size of the upper TMJ space in at least one joint. A decrease in the specified ratio was found in 130 (86.67 %) patients with TMJ dysfunction and occlusal and articulation disorders according to CT data and confirmed by the anatomical and physiological method in 81 (54.00 %) patients, while its moderate decrease was confirmed by measurements by the topographic and physiological method (0.5-2.5 mm) in 62 (76.54 %) people and a significant decrease (more than 2.5 mm) in 19 (23.46 %) people, in 20 (13.33 %) patients, the coincidence of the absence of interalveolar height deficiency according to CT data and the anatomical and physiological method was noted.*

Bilateral reduction of interalveolar height was found in 82 (54.67 %) patients of the study group; 36 (24.00 %) of them had clinically observed pain syndrome. When assessing the deficiency of interalveolar height by the topographic-physiological method, confirmation of its moderate reduction (0.5-2.5 mm) was found in 51 (62.20 %) individuals and a significant reduction (more than 2.5 mm) in 8 (9.75 %) individuals. Unilateral reduction of interalveolar height was found in 48 (32.00 %) patients of the study group; 20 (41.66 %) of them had clinically observed pain syndrome.

Conclusions. *The assessment of the size of the superior articular space in comparison with the average value of the anterior and posterior articular gaps when determining their sizes using cone-beam CT of the TMJ may be a marker of decreased interalveolar height in patients with TMJ dysfunction and occlusal and articulatory disorders*

Keywords: *cone-beam computed tomography, temporomandibular joint dysfunction, occlusal and articulation disorders, interalveolar height*

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1. Introduction

The prevalence of temporomandibular joint pathology is 7–10 % in the population and is primarily found in young and middle-aged patients [1–3]. Modern concepts of treatment of TMJ dysfunction suggest stabilization of the mandible and, therefore the search for an optimal increase in interalveolar height using a removable occlusal device before starting permanent orthopaedic treatment [4, 5]. TMJ assessment consists of assessing joint and muscle pain, mandibular movements and associated sounds [5, 6]. The lack of convincing evidence confirming the relationship between a decrease in interalveolar height and the pain syndrome of TMJ dysfunction may be explained by the patient's adaptation

masked by existing discomfort. When increasing the interalveolar height in patients with TMJ dysfunction is required, occlusal therapy has a dual goal: stabilizing the mandible and increasing the interalveolar height [4, 7–9]. Based on the adaptation of the patient's dentofacial apparatus to the occlusal device, a permanent restoration with increased interalveolar height can be performed [4, 10].

Therefore, the assessment of interalveolar height deficiency is one of the key parameters in planning the orthopaedic treatment of patients with occlusal and articulation disorders and functional disorders of the dentofacial apparatus. The presence of deficiency, more often, or overestimation of interalveolar height, is closely related to the functional state of the chewing apparatus, is usually a consequence of changes in occlusal relationships due to long-standing excessive abrasion of the chewing surface of the teeth, and often becomes the cause of changes in neuromuscular regulation and a predictor of temporomandibular joint dysfunction, as well as changes in facial aesthetics [11]. Currently, various studies are being conducted to find optimal and rational methods for assessing interalveolar height deficiency in addition to the well-known anthropometric and anatomical-physiological methods. One of the morphometric methods for assessing interalveolar height is the calculation of the Shimbashi index or LVI index, which is based on calculating the "ideal" bite height based on the width of the upper central incisor [12]. Another method is to assess the selected interalveolar height after orthodontic treatment by placing radiopaque markers within the blind fossa of the first permanent molar of the maxilla and mandible [13]. Devices for determining interalveolar height have been proposed [14]. In general, clinical methods for assessing interalveolar height loss, as well as facial morphology, have limited predictability and reliability. Instead, it is proposed that the necessary increase in interalveolar height be determined based on the need to perform satisfactory and aesthetically pleasing restorations, with tooth structure, space available for restoration, occlusal parameters and aesthetics as determining factors [15]. However, this hypothesis does not take into account hidden intra-articular structural and functional disorders of the masticatory apparatus and an increase in the interalveolar height and irrationally modelled occlusal surfaces of orthopedic structures without taking into account the position of the heads of the mandible in the TMJ may lead to the manifestation of the pain syndrome of already existing TMJ dysfunction or lead to functional disorders of the masticatory apparatus.

Therefore, the issue of diagnosing changes and finding the optimal value of the interalveolar height remains debatable in modern orthopedic dentistry. And the issue of determining the position of the lower jaw, clear parameters of the projection of the interalveolar height in the diagnostic algorithm of TMJ dysfunction and the creation of appropriate strategies in planning orthopedic treatment and assessing its effectiveness is relevant.

The aim of the research was to determine CT diagnostic criteria for decreased interalveolar height in patients with functional TMJ disorders with occlusal and articulatory disorders at the stage of orthopedic treatment planning.

2. Materials and research methods

To solve the tasks set, an examination of 150 patients with functional disorders of the chewing apparatus and occlusal disorders, who were included in the experimental group and 30 practically healthy individuals – the control group, was carried out in the period 2015–2024. Both groups were comparable in age and sex. As a radiological examination of the TMJ structures, cone beam tomography was performed on the MyRay Hyperion X9 PRO device with iRYS 16.3.1 software. During the clinical dental examination, the occlusion of the dentition was assessed, the reduction of the interalveolar height was determined, the width of the mouth opening was assessed, the mobility of the lower jaw was assessed, the symmetry of the mouth opening was determined, clicking and crunching in the TMJ were determined. Palpation determined the presence of pain in both the TMJ and the masticatory muscles, trigger points, hypertonicity, and hypertrophy in the masticatory muscles. The first stage of determining the interalveolar height was to examine the patient in the dental chair. Particular attention was paid to the patient's position. As is known, with different body positions, the spatial position of the lower jaw changes. For example, with the support of the back of the head and the inclination of the dental headrest by more than 45 degrees, the point of centred load and support is located in the area of the upper cervical vertebrae. At the same time, the lower jaw is slightly shifted back and down. This directly affects the determination of the real fixed interalveolar height and gives errors for further studies. Therefore, we used exclusively the vertical position of the upper body with the point of support around the dentition. Using the widely known anatomical and physiological method, the interalveolar height was determined. Points were fixed: 1 – in the area of the base of the nasal septum, 2 – in the area of the projection of the chin protrusion onto soft tissue landmarks. The obtained data were recorded in the patient's medical record in mm. Next, the height with full figured-cumbular closure of the teeth in central occlusion was estimated. The difference between the height of physiological rest and interocclusal height was subtracted. The physiological interval of the norm was taken as a difference of 0.5–1.5 mm. In patients of the experimental group, the height deficit was determined as follows: (height of physiological rest - interocclusal height) – 1=x, where 1 is the average reference value of the norm indicator for possible subsequent selective grinding of individual teeth.

Statistical analysis was performed using the R statistical programming (r-project.org, ver. 4.0). Welch's t-test was used for statistical data processing. Results were considered statistically significant at $p<0.05$. The effect size was determined by the odds ratio (OR, 95 % confidence interval).

The study was approved by the Commission on Bioethical Expertise and Ethics of Scientific Research of the Bogomolets National Medical University, protocol No. 185, dated 05/27/2024. We emphasize that all studies conducted by us were conducted after patients had read and signed an informed voluntary consent to participate in the studies in compliance with the World Medical Association Declaration on Ethical Principles in Medical Research Involving Human Subjects (2000, Helsinki), as

well as the well-known provisions of the Council of Europe Convention on Human Rights (1997).

3. Research results

The presence of TMJ dysfunction was primarily determined according to the Hamburg protocol:

1 – pain during palpation of the joints – dull, aching pain was present in 30 (20.00 %) patients;

2 – pain during palpation of the masticatory muscles was present in 43 (28.67 %) patients;

3 – presence of noises in the joints - crunching or clicking in the TMJ was detected in 93 (62.00 %) patients;

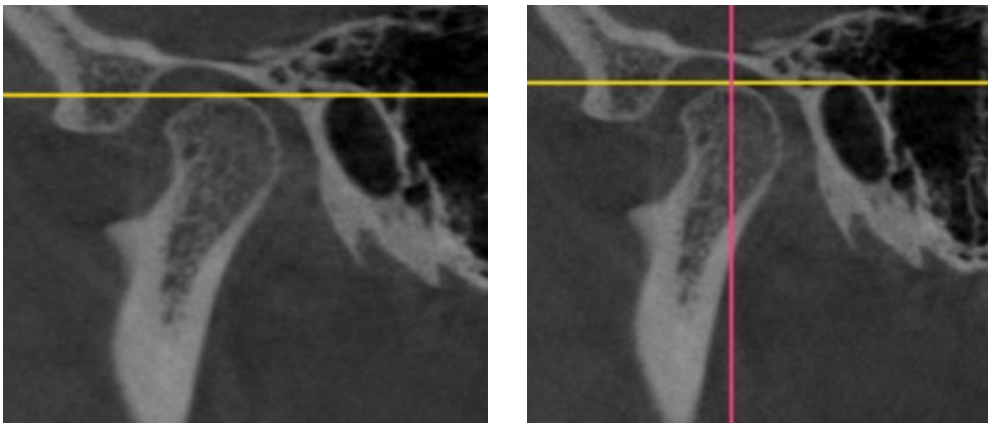
4 – violation of the trajectory of mouth opening - deviation or deflection was detected in 74 (49.33 %) patients of the experimental group;

5 – limited mouth opening - in 52 (32.67 %) patients;

6 – eccentric occlusion, premature contacts - the presence of supracontacts was in 145 (96.67 %).

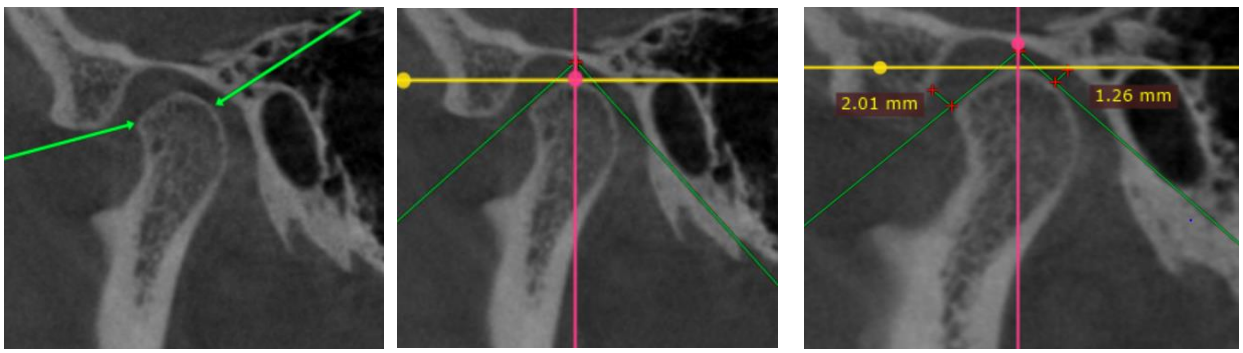
60 patients (40.00 %) complained of pain in the TMJ, masticatory muscles, or headache, and 19 (31.67 %) of them had complaints of pain for more than 6 months. Bimanual palpation revealed hypertonicity of the masticatory muscles – 94 – 62.67 % with their hypertrophy – 46 – 30.67 %, both unilateral and bilateral, which were observed simultaneously with parafunction of the masticatory muscles (34 – 22.67 %). Palpatory functional, stable displacement of the lower jaw was determined in 135 (90.00 %) patients of the experimental group, in 57 (42.22 %) of them significant and the presence of pain syndrome in 46 (80.70 %). At the same time, limitation of mouth opening in 52 (32.67 %) patients; deficiency of interalveolar height, determined by the anatomical-physiological method in the oral cavity: moderate (0.5–2.5 mm – 67 – 44.67 %), significant (2.5 mm and more – 22–21.67 %).

During cone-beam tomography, the position of the articular heads was assessed in 2 planes – sagittal and coronal. To measure the upper joint space in mm, the position of the mandibular heads in the sagittal projection was assessed. The size of the upper joint space was determined by drawing a perpendicular through the upper part of the joint fossa and a horizontal line along the most protruding edge of the mandibular head (Fig. 1, *a, b*). The width of the anterior and posterior joint spaces was determined by drawing a perpendicular through the tangent lines at the most convex part of the heads to the walls of the joint fossa, the apex of which is the projection point of the upper edge of the head onto the upper edge of the joint fossa (Fig. 2, *b, c*).



a *b*

Fig. 1. Tomograms of the TMJ, performed in sagittal projection on the left: *a* – horizontal to the most prominent edge of the head; *b* – perpendicular to the apex of the articular fossa



a *б* *c*

Fig. 2. Tomograms of the TMJ, performed in sagittal projection on the left: *a* – tangents to the anterior and posterior surfaces of the articular head; *b* – perpendiculars to the walls of the articular fossa; *c* – size of the anterior and posterior articular gaps

To be able to determine the projection of the interalveolar height, the size of the upper gap was estimated in the sagittal plane, and the ratio of the upper divided by the average value of the anterior and posterior joint gaps in each individual joint (upper/ (anterior+posterior)/2 L and upper/(anterior+posterior)/2 R) was compared with the same ratio in the control group (Table 1). Changing the indicator of the proposed ratio allowed it to be used as a marker for assessing the deficiency or overestimation of the interalveolar height both at the stage of planning orthopedic treatment and at the stages of assessing its effectiveness. The reference value was taken as the ratio of the upper divided by the average value of the anterior and posterior joint gaps in each individual joint in the control group: 1.32±0.25 95 % CI 1.22-1.41 R, 1.37±0.26 95 % CI 1.27-1.47 L.

Table 1

Anterior/posterior joint space ratio indicators in the study groups, M±m

Experimental ratios of TMJ joint gaps according to cone-beam CT	Patients with occlusal and articulatory disorders and, TMJ dysfunction and reduced interalveolar height (n=130)	Control group (n=30)	Statistical significance
ratio superior/(anterior+posterior)/ 2-joint gap R	0.98±0.14	1.32±0.25 95 % CI 1.22–1.41	t=–7.15 p-value=2.698e-08
ratio superior/(anterior+posterior)/ 2-joint gap L	0.97±0.19	1.37±0.26 95 % CI 1.27–1.47	t=–7.75 p-value=2.923e-09

Therefore, values below the lower limit of the 95 % confidence interval were considered to be a decrease in the interalveolar height for each joint, respectively (1.22 R (right TMJ), 1.27 L (left TMJ)), and above the upper limit of the 95 % confidence interval were considered to be an increase in the interalveolar height for each joint, respectively (1.42 R (right TMJ), 1.47 L (left TMJ)).

When analyzing cone-beam tomography data, interalveolar height deficiency was classified as a decrease in the proposed coefficient for assessing the size of the upper TMJ cleft in at least one joint. A decrease in the specified ratio was found in 130 (86.67 %) patients with TMJ dysfunction and occlusal and articulation disorders according to CT data and confirmed by the anatomical and physiological method in 81 (54.00 %) patients, while its moderate decrease was confirmed by measurements by the topographic and physiological method (0.5–2.5 mm) in 62 (76.54 %) people and a significant decrease (more than 2.5 mm) in 19 (23.46 %) people, in 20 (13.33 %) patients, the coincidence of the absence of interalveolar height deficiency according to CT data and the anatomical and physiological method was noted.

4. Discussion of research results

Currently, various studies are being conducted to find optimal and rational methods for assessing the deficit of interalveolar height in addition to the well-known anthropometric and anatomical-physiological methods. Another method is to assess the selected interalveolar height after orthopedic treatment by placing radiopaque markers within the blind fossa of the first permanent molar of the upper and lower jaws [12]. One of the morphometric methods for assessing interalveolar height is the calculation of the Shimbashi index or LVI index, which is based on the calculation of the "ideal" bite height based on the width of the upper central incisor [13]. In general, clinical methods for assessing the loss of interalveolar height, as well as the assessment of facial morphology, have limited predictability and reliability. Instead, it is proposed that the necessary increase in interalveolar height be determined based on the need to perform satisfactory and aesthetically appealing restorations, with tooth structure, space available for restoration, occlusal parameters, and aesthetics being considered as determining factors. However, this hypothesis does not take into account hidden intra-articular structural and functional disorders of the masticatory apparatus, and an increase in the interalveolar height and irrationally modelled occlusal surfaces of orthopedic structures without taking into account the position of the heads of the lower jaw in the TMJ can lead to the manifestation of the pain syndrome of an already existing TMJ dysfunction or lead to functional disorders of the masticatory apparatus.

In modern conditions, cone-beam CT has become widespread due to its high image quality and minimal radiation exposure. The possibility of three-dimensional and multiplanar reconstructions, visualization of bone structures with a step of 0.2–5 mm allow the active use of this method in patients with various complicated anomalies of the dentofacial system [14].

The difference in the measurement of the interalveolar height deficit according to CT data and the anatomical-physiological method in 32.67 % is apparently due to the possibility of more accurately measuring the projection of this value on tomograms and the difficulties of accurately measuring the interalveolar height deficit by the topographic-physiological method, because with its significant deficit, the coincidence was recorded in all cases, and in 20 (13.33 %) patients, the coincidence of the absence of interalveolar height deficit was noted.

Bilateral reduction of interalveolar height was established in 82 (54.67 %) patients of the experimental group; 36 (24.00 %) of them clinically observed pain syndrome. At the same time, among these patients, 51 (62.20 %) individuals observed bilateral distal displacement of the lower jaw according to the assessment of the ratio of the anterior/posterior articular gaps (such calculations are described in detail in our previous studies). When assessing the deficit of the interalveolar height by the topographic-physiological method, confirmation of its moderate decrease (0.5-2.5 mm) was established in 51 (62.20 %) individuals and a significant decrease (more than 2.5 mm) in 8 (9.75 %) individuals.

Unilateral decrease in the interalveolar height was established in 48 (32.00 %) patients of the experimental group; 20 (41.66 %) of them had clinically observed pain syndrome. At the same time, among these patients, 27 (56.25 %) individuals had a more pronounced distal displacement of the lower jaw on the side of the decrease in the interalveolar height.

This may indicate the reliability and greater accuracy of assessing the deficit of the interalveolar height by the cone-beam tomography method.

Study limitations: small sample of observations – Welch's t-test or t-test of unequal variances was used, which is more reliable when two samples have unequal variances or unequal sample sizes, different anatomical structure of the heads of the lower jaw and the shape and size of the fossa of the temporomandibular joint, inaccuracy in measuring the size of the gaps on the tomograms, settings of the tomograph itself - all studies were conducted on the same tomograph, calculations were performed three times to obtain the most accurate result.

Prospects for further research. Creation of a simple online calculator that will help determine the presence of intra-articular displacement, its direction and degree, and the presence of a decrease in interalveolar height based on joint gap measurements.

5. Conclusions

The assessment of the size of the upper joint gap in comparison with the average value of the anterior and posterior joint gaps when determining their sizes using cone-beam CT of the TMJ may be a marker of a decrease in interalveolar height in patients with TMJ dysfunction and occlusal and articulatory disorders (compared to controls - 1.32±0.25 R, 1.37±0.26 L, p=0.000). A decrease in the indicated ratio was found in 130 (86.67 %) patients with TMJ dysfunction and occlusal and articulatory disorders according to CT data and confirmed by the anatomical-physiological method in 81 (54.00 %) patients, while its moderate decrease was confirmed by measurements by the topographic-physiological method (0.5–2.5 mm) in 62 (76.54 %) people and a significant decrease (more than 2.5 mm) in 19 (23.46 %) people, in 20 (13.33 %) patients, the coincidence of the absence of interalveolar height deficiency according to CT data and the anatomical-physiological method was noted. Such a discrepancy is apparently due to the possibility of more accurately measuring the projection of this value on tomograms and the difficulties of accurately measuring the interalveolar height deficiency by the topographic-physiological method.

Conflict of interests

The authors declare that they have no conflict of interest regarding this study, including financial, personal, authorship, or other, that could influence the study and its results presented in this article.

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Data availability

The manuscript has no associated data.

Use of artificial intelligence

The author confirms that he did not use artificial intelligence technologies to create the submitted work.

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