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Technique for assessing a patient's temporomandibular joint's functional status.

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Abstract. A method is proposed for determining the condition of the temporomandibular joint using radiation examination and

measurement of the articular head and slit, when the transverse areas of the articular head and slit are determined in the images

obtained, the anatomically optimal area of the transverse size of the articular gap is calculated, and compared with the area of

the transverse size of the articular gap defined in the image.

Keywords: temporomandibular joint, cone-beam computed tomography, functional state, radiation research methods, articular

cleft, articular head.

Temporomandibular joint (TMJ) disorders are common and diverse. According to various authors, this pathology is diagnosed in 27–76% of patients seeking dental care [3, 15]. TMJ disorders are among the most complex in dental practice, both in terms of timely and accurate diagnosis [13], and effective treatment [2].

Accurate diagnosis of TMJ disorders significantly impacts treatment success and prognosis for recovery and long-term remission. Currently, the use of imaging methods in TMJ pathology is widely accepted and is extensively covered in available domestic and foreign specialized literature [3, 14]. However, only a limited number of publications compare different imaging techniques for patients with TMJ disorders.

Furthermore, these comparisons are usually descriptive in nature [6]. Studies that present factual data comparing imaging techniques for TMJ pathology either do not encompass the full spectrum of known methods or lack information on

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comparing known imaging techniques in individuals with a specific TMJ disease entity.

Known methods for determining the dimensions of temporomandibular joint elements and their ratios involve radiographic measurements of the joint head and space, leading to conclusions about the presence or absence of pathology in the examined joint elements [1, 7, 8]. However, these methods have the following drawbacks:

- They do not consider the cross-sectional area of the joint head and the cross-sectional area of the joint space and their ratio to each other both at rest and during function as the relative positions of the joint elements change; this is crucial because early in the pathological process (preclinical stage), the area of the joint space is involved, determining the subsequent degree of compression of the articular disc [4, 6].

- They fail to take into account that the joint space area of each joint is an integral indicator, characterizing the degree of normal or pathological function within the enclosed volume of the following TMJ components: the articular capsule of the condyle, the ramus of the mandible, and the glenoid fossa of the temporal bone [4, 9].

- They do not provide data on the soft tissue elements of the joint.

- They do not consider the relative positions of the jaws to each other and to other parts of the cranial and facial skull [1, 8].

Each of these facts, as well as all of them collectively, strongly demonstrate the relevance of the research topic chosen by the author.

Objective: the aim of the study is to develop a method for determining the functional state of the TMJ in a patient using imaging techniques.

Materials and methods: the study was preceded by a positive opinion from the bioethics committee of Samarkand State Medical University.

The research was conducted in accordance with the main bioethical norms of the World Medical Association's Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects, as amended (2000, amended 2008), the Universal Declaration on Bioethics and Human Rights (1997), and the Council of Europe Convention on Human Rights and Biomedicine (1997) [5]. All necessary measures were taken to ensure the anonymity of patients.

The study involved 30 individuals aged 35-52 years (24 women (80%) and 6 men (20%)), each of whom provided informed consent to participate in this research.

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We, based on their outpatient clinical research, found that anthropometrically determined TMJ function occurs with an optimal ratio of the cross-sectional area of the joint space to the cross-sectional area of the joint head. The position of the joint head relative to the joint space plays a less significant role.

This is clearly seen in the example of bite pathology and joint diseases. Many patients have bite pathology but do not complain about function or have any negative sensations in the joint area. With bite pathology, the shape and position of the joint elements change. For example, in a distal bite, the joint head will be positioned posteriorly in the articulation, while in a mesial bite, it will be positioned anteriorly. At the same time, patients with a neutral bite often complain of both functional impairment and negative sensations in the TMJ area [7, 8].

The role of orthodontics and reconstructive surgery in the development of joint pathology is considered separately.

There are reports indicating the appearance of TMJ dysfunction symptoms after reconstructive surgeries on the jaw bones. The cause of dysfunction after such interventions is the change in the position of the mandibular condyle and its relationships with other elements of the TMJ [8-10]. This means that the changes occurring in the joint during bite changes depend on the level of pathology (skeletal, gnathic and tooth-alveolar) and the form of pathology (hereditary or acquired).

In the hereditary form of bite pathology, the disturbance will be at the skeletal or gnathic level, hence genetically programmed changes both at the level of the jaw bones and in all elements of the joint, and the patient will not complain of discomfort in the TMJ area. It follows that the changes occurring during orthodontic treatment will also affect the joint area, genetically programmed elements that are in a compensated state in relation to the jaw bones and their ligaments, which will be the basis for complaints after or during treatment. Conversely, in the tooth-alveolar form, bite pathology is acquired, and in the process of growth, the elements of the joint were correctly formed. In the tooth-alveolar form of bite pathology, changes occurring in the TMJ will be secondary. And, consequently, orthodontic treatment of patients will contribute to the normalization of the joint.

With a neutral bite and no complaints about the TMJ, there is an optimal ratio between the joint space and the joint head. The shape of the joint head approaches a semi-oval. The area of the semi-oval is determined by the formula:

$$S = \pi * \text{transverse diameter} * \text{longitudinal diameter} / 2, \text{ where } \pi = 3.14.$$

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The average transverse diameter of the joint head is 8.0–9.0 mm (8.5 mm). The average height of the joint head is 8.0–10.0 mm (9.0 mm). The area of the transverse diameter of the joint head with an average value is determined as follows:

*S of the transverse diameter of the joint head with an average value = π*8.5 mm*20.0 mm / 2*

The shape of the complex, joint head and joint space, also approximates a semi-oval.

The longitudinal dimension of the complex consists of the width of the space in the anterior part of the joint, the width of the space in the posterior part of the joint, and the longitudinal dimension of the TMJ head.

The transverse dimension of the complex consists of the width of the space in the upper part of the joint and the transverse dimension of the joint head. Knowing the average values (width of the space in the anterior part 2.0–3.0 mm (2.5 mm), in the upper part – 3.0–4.0 mm (3.5 mm), in the posterior part – 3.0–4.0 mm (3.5 mm), average transverse dimension of the joint head 8.0–9.0 mm (8.5 mm), average height of the joint head 8.0–10.0 mm (9.0 mm)), it is possible to determine the area of the complex "joint space + joint head" (using the formula for determining the area of a semi-oval), and subtract the area of the transverse dimension of the head from the area of the complex "joint space + joint head". Thus, it is possible to obtain the area of the joint space.

The obtained data prove that the key factor in the optimal physiological functioning of the joint is the ratio of the area of the transverse dimension of the joint space to the area of the transverse dimension of the joint head.

Results and Discussion. A total of 21 patients were assessed for differences in the area of joint elements.

• 46.7% (14 patients) exhibited a difference in area less than 10 mm², indicating normal relative positioning of joint elements.

• 30% (9 patients) demonstrated a difference in area between 10 and 20 mm², suggesting a low risk of developing functional joint disorders. These patients require clinical monitoring every 6 months.

• 16.7% (5 patients) had a difference in area between 20 and 30 mm², indicating a higher risk of developing functional disorders. These patients necessitate clinical monitoring every 3 months.

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• 6.7% (2 patients) showed a difference in area exceeding 30 mm², which is suggestive of a compensated functional state with existing temporomandibular joint (TMJ) functional disorders. These patients require comprehensive treatment.

Clinical example 1

Patient A., 42 years old, complains of negative sensations in the TMJ area – clicks and soreness when opening his mouth. It is necessary, based on the data of radiation research methods, to determine the area of the transverse size of the articular gap in order to compare it with the anatomically optimal area of the transverse size of the articular gap and on this basis to build a further treatment plan for the patient.

According to the claimed method, the patient is subjected to cone beam computed tomography (CBCT), in the images of which the size of the TMJ elements is determined, followed by calculation of the difference in the area of the transverse size of the articular gap and the area of the transverse size of the articular gap, which should be at an optimal ratio of the articular gap and the articular head.

The area of the transverse size of the head of the average value is determined:

S of the transverse head size of the media. significant. = N*8.5 mm*9.0 mm / 2 = 120.1 mm2.

The area of the "slot – head" complex is determined by the average values:

S = 3,1*(2,5+3,5+8,5)*(9,0+3,5) / 2 = 284,6 mm2.

Next, the value of the area of the transverse size of the articular gap of the average values is obtained: S of the articular gap of the media. significant. = 284.6 mm2 – 120.1 mm2 = 164.5 mm2.

In this patient, the following dimensions of the joint elements were determined: the transverse size of the head is 8.2 mm, the height of the head is 8.6 mm, the anterior section of the slit is 3.2 mm, the upper one is 4.1 mm, the posterior one is 4.1 mm.

Next, the area of the articular head is calculated: S = 3.1 * 8.2 mm * 8.6 mm / 2 = 110.7 mm2.

The area of the articular "slit – head" complex is: S = 3,1(8,2+3,2+4,1)*(8,6+4,1) / 2 = 309,1 mm2.

Then the area of the articular gap of the patient is determined: S = 309.1 – 110.7 = 198.4 mm2.

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Then the proper area of the articular gap in this patient is calculated:

164.5 mm2 X

120.1 mm2 110.7 mm2.

X = 151.6 mm2

After that, the difference in the area of the transverse size of the articular gap of the patient and the area of the transverse size of the articular gap, which should have been at the optimal ratio of the articular gap and the articular head, is determined: 198.3 mm2 – 151.6 mm2 = 46.74 mm2.

In this patient, the difference in areas is 46.7 mm2, which indicates a compensated functional state with the presence of functional TMJ disorders requiring complex treatment.

Clinical example 2

Patient B., 45 years old, complains of negative sensations in the TMJ area – periodic clicks when opening the mouth, appearing several times a day. It is necessary, based on the data of radiation research methods, to determine the area of the transverse size of the articular gap in order to compare it with the anatomically optimal area of the transverse size of the articular gap and on this basis to build a further treatment plan for the patient.

According to the proposed method, a CT scan is performed on the patient, in the images of which the dimensions of the TMJ elements are measured, followed by the calculation of the difference in the area of the transverse size of the articular gap and the area of the transverse size of the articular gap, which should have been at an optimal ratio of the articular gap and the articular head.

The area of the transverse size of the head of the average value is determined:

S is the transverse size of the media head. sign.= N*8.5 mm*9.0 mm / 2 = 120.1 mm2.

The area of the "slot – head" complex is determined by the average values:

S = 3,1*(2,5+3,5+8,5)*(9,0+3,5) / 2 = 284,6 mm2.

Next, the value of the area of the transverse size of the articular gap of the average values is obtained: S of the articular gap of the average values = 284.6 mm2 – 120.1 mm2 = 164.5 mm2.

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In this patient, the following dimensions of the joint elements were determined: transverse head size – 8.9 mm, head height – 8.9 mm, anterior slit – 2.9 mm, upper – 3.9 mm, posterior – 3.9 mm.

Next, the area of the articular head is calculated:

S = 3.1 * 8.9 mm * 8.9 mm / 2 = 124.4 mm.

The area of the joint gap–head complex is: S = 3,1(8,9+2,9+3,9)*(8,9+3,9) / 2 =315,5 mm2.

The area of the articular gap of the patient is determined: S = 315.5 – 124.4 = 191.1 mm2.

Then the proper area of the articular gap in this patient is calculated:

164.5 mm2	X
120.1 mm2	124.4 mm2

X = 170.3 mm2

After that, the difference in the area of the transverse size of the articular gap of the patient and the area of the transverse size of the articular gap, which should have been at the optimal ratio of the articular gap and the articular head, is determined: 191.1 mm2 – 170.3 mm2 = 20.8 mm2.

In this patient, the difference in areas is 20.8 mm2, which indicates a high risk of developing functional disorders requiring clinical observation at intervals of 3 months.

Clinical example 3

Patient C., 52 years old, complains of negative sensations in the TMJ area – clicks when opening his mouth wide. It is necessary, based on the data of radiation research methods, to determine the area of the transverse size of the articular gap in order to compare it with the anatomically optimal area of the transverse size of the articular gap and on this basis to build a further treatment plan for the patient.

In accordance with the proposed method, a CT scan is performed on the patient, in the images of which the elements of the TMJ are measured, followed by the calculation of the difference in the area of the transverse size of the articular gap and the area of the transverse size of the articular gap, which should be at an optimal ratio of the articular gap and the articular head.

The area of the transverse size of the head of the average value is determined:

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S is the transverse size of the media head. significant. = N*8.5 mm*9.0 mm / 2 = 120.1 mm2.

The area of the "slot – head" complex is determined by the average values: S = 3,1*(2,5+3,5+8,5)*(9,0+3,5) / 2 = 284,6 mm2.

Next, the value of the area of the transverse size of the articular gap of the average values is obtained:

S articular cleft media. significant. = 284.6 mm2 – 120.1 mm2 = 164.5 mm2.

In this patient, the following dimensions of the joint elements were determined: transverse head size – 8.7 mm, head height – 8.3 mm, anterior slit – 2.8 mm, upper – 3.6 mm, posterior – 3.5 mm.

Then the area of the articular head was calculated:

S = 3.1*8.7 mm*8.3 mm / 2 = 113.4 mm2.

The area of the joint gap – head complex is: S = 3,1*(8,7+2,8+3,5)*(8,3+3,6) / 2 = 280,2 mm2.

Next, the area of the articular gap of the patient is determined:

S = 280.3 – 113.4 = 166.9 mm2.

Then the proper area of the articular gap in this patient is calculated:

164.5 mm2	X
120.1 mm2	113.4 mm2

X = 155.2 mm2

After that, the difference in the area of the transverse size of the articular gap of the patient and the area of the transverse size of the articular gap, which should have been at the optimal ratio of the articular gap and the articular head, is determined: 166.9 mm2 – 155.2 mm2 = 11.7 mm2.

In this patient, the difference in areas is 11.7 mm2, which indicates a low risk of developing functional joint disorders requiring clinical observation at intervals of 6 months.

Clinical example 4

Patient G., 37 years old, does not complain about TMJ. In accordance with the proposed method, a CT scan is performed on the patient, in the images of which the elements of the TMJ are measured, followed by the calculation of the difference in the area of the transverse size of the articular gap and the area of the transverse

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size of the articular gap, which should have been at an optimal ratio of the articular gap and the articular head.

The area of the transverse size of the head of the average value is determined:

S is transverse. r-ra heads of media. significant. = N*8.5 mm*9.0 mm / 2 = 120.1 mm2.

The area of the "slot – head" complex is determined by the average values:

S = 3,1*(2,5+3,5+8,5)*(9,0+3,5) / 2 = 284,6 mm2.

Next, the value of the area of the transverse size of the articular gap of the average values is obtained:

S of the articular gap of the media. sign. = 284.6 mm2 – 120.1 mm2 = 164.5 mm2.

In this patient, the following dimensions of the joint elements were determined: transverse head size – 8.4 mm, head height – 8.9 mm, anterior slit – 2.8 mm, upper – 3.5 mm, posterior – 3.4 mm.

Then the area of the articular head is calculated:

S = 3.1 * 8.4 mm* 8.9 mm / 2 = 117.4 mm2.

The area of the joint gap – head complex is:

S = 3,1*(8,4+2,8+3,4)*(8,9+3,5) / 2 = 284,2 mm2.

Next, the area of the articular gap of the patient is determined:

S = 309.1 – 110.7 = 166.8 mm2.

Then the proper area of the articular gap in this patient is calculated:

164.5 mm2	X
120.1 mm2	117.4 mm2

X = 160.7 mm2.

After that, the difference in the area of the transverse size of the articular gap of the patient and the area of the transverse size of the articular gap, which should have been at the optimal ratio of the articular gap and the articular head, is determined: 166.8 mm2 – 160.7 mm2 = 6.1 mm2.

In this patient, the difference in area is 6.1 mm2, this indicates a normal mutual arrangement of the elements of the TMJ, which does not require complex treatment.

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Considering the presented material from the point of view that TMJ pathology is largely represented by diseases characterized by deterioration of the articular surfaces and simultaneous remodeling of the underlying bone tissue, which is consistent with the data of Sh. Shahidi et al. (2018) [11] and does not contradict the information of R. Emshoff et al. (2021) [12], the diagnostic and, consequently, the practical significance of the presented diagnostic method, which allows timely prescribing adequate treatment and obtaining a satisfactory functional and aesthetic result, becomes obvious.

Conclusion. Thus, the proposed method for determining the functional state of the TMJ makes it possible to define the optimal ratio between the articular gap and the articular head, therefore, to improve diagnosis diseases of the specified joint, including at the preclinical stage, and timely apply therapeutic and rehabilitation measures, which corresponds to the basic principle of medicine – preventive.

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