НАУЧНЫЙ ОБЗОР

RADIOLOGY OF TEMPROMANDIBULAR JOINT AFTER THE ORTHODONTIC TREATMENT

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The problem of choosing a method of examination in the pathology of the temporomandibular joint (TMJ) is one of the most difficult issues in modern radiology and maxillofacial surgery. In particular, the question of radiology methods usage in the study of the TMJ state after orthodontic treatment remains unexplored. When examining patients with suspected TMJ pathology, a wide range of methods are used: from ultrasound to high-tech methods – computed and magnetic resonance imaging, however, the lack of a single examination algorithm and the ambiguity in the choice of treatment for patients after orthodontic treatment indicates the high relevance of this problem.

A review of the literature on radiology of the TMJ after orthodontic treatment is presented, the advantages and limitations of various methods are identified, indicating the features of the research technique. Information on functional methods of TMJ research is also presented.

Keywords: X-ray diagnostics, TMJ, orthopantomography, MSCT, CBCT, orthodontic treatment, dentistry.

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ЛУЧЕВАЯ ДИАГНОСТИКА ИЗМЕНЕНИЙ ВИСОЧНО-НИЖНЕЧЕЛЮСТНОГО СУСТАВА ПОСЛЕ ОРТОДОНТИЧЕСКОГО ЛЕЧЕНИЯ

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На сегодняшний день проблема выбора метода обследования при патологии височно-нижнечелюстного сустава (ВНЧС) является одним из самых сложных вопросов в современной лучевой диагностике и челюстно-лицевой хирургии. В особенности, остается неизученным вопрос применения методов лучевой диагностики при исследовании состояния ВНЧС после ортодонтического лечения. При обследовании пациентов с подозрением на патологию ВНЧС применяется широкий спектр методов лучевой диагностики: от ультразвукового исследования до высокотехнологичных методов – компьютерной и магнитно-резонансной томографии, однако, отсутствие единого алгоритма обследования и неоднознач-

ность выбора лечения пациентов после ортодонтического лечения говорит о высокой актуальности данной проблемы.

Представлен обзор литературы по лучевой диагностике ВНЧС после ортодонтического лечения, определены преимущества и ограничения различных методов лучевой диагностики с указанием особенностей техники проведения исследований. Также представлена информация по функциональным методикам исследования ВНЧС.

Ключевые слова: лучевая диагностика, ВНЧС, ортопантомография, МСКТ, КЛКТ, ортодонтическое лечение, стоматология.

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Introduction.

TMJ is an acronym that stands for temporomandibular joint. Temporomandibular joints are located on both sides of the face, in front of your ears (Fig. 1). Temporomandibular joints are hinges that connects jaw to the temporal bones of the skull [1].

Problems with the jaw and the TMJ's muscles are known as temporomandibular disorders (TMD). This refers to any dysfunction of the TMJ. Many people use the terms TMJ and TMD interchangeably.

The prevalence of pathology of the temporomandibular joint (TMJ), according to various sources, ranges from 40 to 95%. TMJ dysfunctions occur in children and adolescents in 14-20% of cases, and with age, their frequency increases significantly due to loss of teeth, irrational prosthetics or orthodontic treatment, lowering the height of the lower third of the face, etc [2, 3].

TMJ dysfunction occurs when the muscles and ligaments around your jaw joints become inflamed or irritated. The condition may be acute or chronic, and the resulting pain may be mild or severe.

TMJ dysfunction is associated with a change in the relative position of the TMJ elements, trauma to the cartilaginous surfaces, meniscus, and compression of the bilaminar

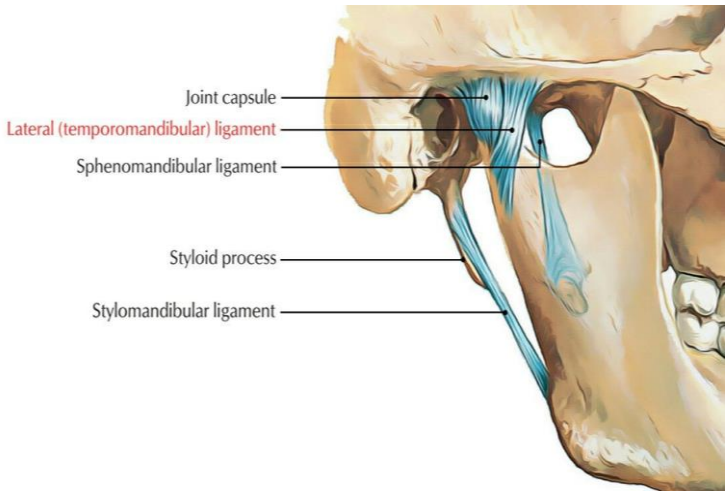

Fig. 1 a (Рис. 1 а)

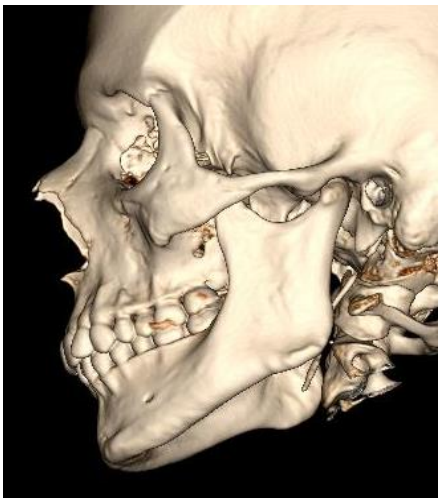

Fig. 1 b (Рис. 1 б)

Fig. 1. A – Representation of TMJ, B – MSCT, 3D model of facial skeleton.

Рис. 1. А – Изображение височно-нижнечелюстного сустава, Б – МСКТ, 3D- модель лицевого скелета.

zone. Early diagnosis of TMJ dysfunctions is difficult due to the paucity of characteristic clinical manifestations. Pathology is localized mainly in the articular disc, capsular-ligamentous apparatus and is first manifested by functional disorders. Then, the bone structures of the joint are involved in the pathological process.

The relationship between Temporomandibular Disorders (TMD) and malocclusion is an extremely critical issue in dentistry nowadays. Contrary to the old concept that malocclusion causes TMD, occlusal changes, especially those observed as sudden, may be secondary and reflect joint or muscle disorders due to the obvious connection between these structures and the dental occlusion [3, 4].

What is malocclusion?

A malocclusion is a misalignment or incorrect relation between the teeth of the two dental arches when they approach each other as the jaws close (Fig. 2) [4].

There are several different treatment modalities for malocclusion, depending on the type of malocclusion and the severity of the problem, these include:

• fixed appliances (braces) to fix the incorrect position of the teeth,

• tooth extraction to alleviate overcrowding,

• capping, bonding, or reshaping teeth,

• surgery to shorten the jaw or reshape it (performed by a maxillofacial surgeon),

• plates or wires to stabilize the jaw bone,

• removable mouth appliances to maintain a new position of the teeth (such as after braces), or in some cases to promote the growth of the jaws for an improvement in the alignment of the bite.

Orthodontic treatment is a way of straightening or moving teeth, to improve the appearance of the teeth and how they work. It can also help to look after the long-term health of your teeth, gums and jaw joints, by spreading the biting pressure over all your teeth.

The main aim of orthodontic treatment is to correct malocclusion, in order, to achieve functionally appropriate occlusion and optimum dental and facial aesthetics to eliminate functional problems that may predispose a patient to TMD [5-7].

Types of orthodontic treatment.

If the patient has a skeletal discrepancy, there are three main approaches to orthodontic treatment:

1. Growth modification – growth is used to correct the skeletal discrepancy. To correct a skeletal discrepancy using growth modification, the patient needs to be growing so this type of treatment is best carried out in the late mixed or early permanent dentition. Growth modification treatment can involve the use of a functional appliance and/ or headgear

2. Camouflage treatment. If the patient is near or at the end of growth, mild or moderate skeletal discrepancies may be treated with camouflage treatment that involves the use of fixed orthodontic appliances, often in combination with extractions, to move the teeth so as to disguise the skeletal discrepancy

3. A combination of orthodontic treatment and orthognathic surgery to correct the malocclusion and underlying skeletal discrepancy. If the skeletal discrepancy is severe and the patient is at the end of growth, then the malocclusion and underlying skeletal discrepancy can be treated using a combination of orthodontics and orthognathic surgery [5-8].

Orthodontic appliances.

Orthodontic treatment uses appliances to correct the position of teeth. The 4 main types are:

• fixed braces – a brace you cannot remove which is made up of brackets that are glued to the front of each tooth and linked with wires

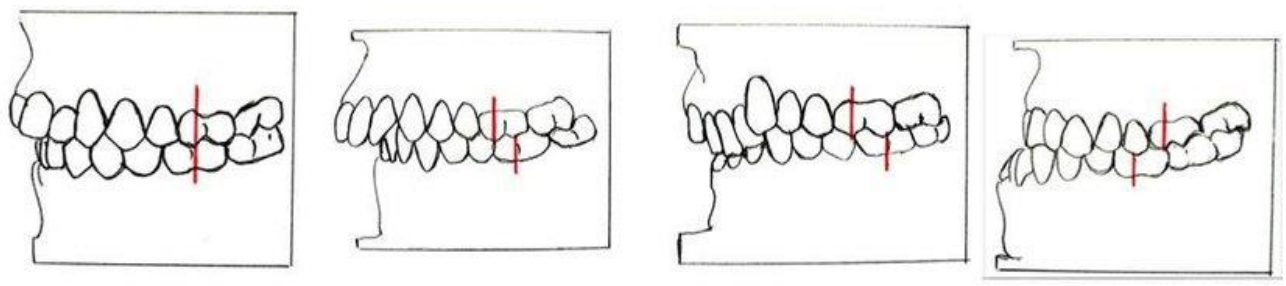

Fig. 2 (Рис. 2)

Fig. 2. **Scheme. Angle's classifications for malocclusion [4].**

Рис. 2. **Схема сагиттальных аномалий прикуса по Энглу [4].**

• removable braces – usually plastic plates that cover the roof of the mouth and clip on to some teeth; these can only be used to achieve very limited tooth movements

• functional appliances – usually a pair of removable plastic braces that are joined together or designed to interact together and fit on to both the upper and lower teeth

• headgear – this is not an orthodontic appliance, but it can be used with other appliances and is usually worn at night [6-8].

Does malocclusion cause TMD?

Malocclusal interferences have been considered as risk factors for TMD. An electromyographic (EMG) study done by Ramfjord on 34 patients stated that «The most common occlusal factor in bruxism is a discrepancy between centric relation and centric occlusion; invariably such discrepancy is accompanied by asynchronous contraction or sustained strain in the temporal and masseter muscles during swallowing». Therefore, he suggested occlusal equilibration to provide muscular balance and to eliminate the bruxism. The proposed causal chain of events suggested that interference acts as a trigger for bruxism, which in turn may result in overload of the masticatory muscle, tenderness, pain and TMJ clicking [7-10].

Orthodontic treatment and TMD.

Orthodontists believed that malocclusion caused the posterior and superior displacement of the condyle. Hence, there was the need to bring downward and forward the condyle by freeing up the trapped mandible. Since then, various malocclusions have been associated with TMD signs or symptoms. In 1988, Greene and Laskin published a list of 10 myths in this field that, surprisingly after 20 years, are still a matter of debate among orthodontists [8-12]:

• People with certain types of untreated malocclusion (for example, Class II Division 2, deep overbite, crossbite) are more likely to develop TMD.

• People with excessive incisal guidance, or people totally lacking incisal guidance (open bite), are more likely to develop TMD.

• People with gross maxillo-mandibular disharmonies are more likely to develop TMD.

• Pre-treatment radiographs of both TMJs should be taken before starting orthodontic treatment. The position of each condyle in its fossa should be assessed, and orthodontic treatment should be directed at producing a good relationship at the end. ("good" position usually was defined as being a concentric placement of the condyle in the fossa).

• Orthodontic treatment, when properly done, reduces the likelihood of subsequently developing TMD.

• Finishing orthodontic cases according to specific functional occlusion guidelines (e.g. gnathologic principles) reduces the likelihood of subsequently developing TMD.

• The use of certain traditional orthodontic procedures and/or appliances may increase the likelihood of subsequently developing TMD.

• Adult patients who have some type of occlusal 'disharmony' along with the presence of TMD symptoms will probably require some form of occlusal correction to get well and stay well.

• Retrusion of the mandible because of natural causes or after treatment procedures is a major factor in the aetiology of TMD.

• When the mandible is distalized, the articular disc may slip off the front of the condyle [5, 6, 11-13].

What are the signs and symptoms?

A variety of symptoms may be linked to TMJ disorders. Pain, particularly in the chewing muscles and/or jaw joint, is the most common symptom. Other likely symptoms include:

• radiating pain in the face, jaw, or neck,

• jaw muscle stiffness,

• limited movement or locking of the jaw,

• painful clicking, popping or grating in the jaw joint when opening, or closing the mouth

• a change in the way the upper and lower teeth fit together [7, 8, 11-13].

Imaging of TMD.

There are number of methods that are used to visualize TMD. The radiograph plays an important role in assessing the dentition, but is not very informative for the functional analysis of the temporomandibular joints, since the joint space is not visible throughout and the assessment is difficult due to the image summation effect, as well as projection distortion [14].

To examine the joint, it is possible to use a tomographic study. This method has advantages over the classical radiograph in the possibility of more accurate visualization of the joint space, articular surfaces. But it requires multiple X-ray studies and does not provide an opportunity to fully determine functional disorders.

With the advent of high-tech research methods (MSCT, CBCT, MRI), diagnosis has become more accurate. The data obtained from classical these methods studies provide a good image quality of the anatomical structures of the temporomandibular joints and their relationship to each other, but do not allow one to directly judge the degree of violation of the biomechanics of movements in the joints [15].

In the field of dentistry today there are two general indications for the use of imaging procedures: exclusion of primary diseases of the

joint and visualization and documentation of adaptations. Examination of the TMJ through imaging procedures is further complicated by the combination of medical and legal considerations, plus an incomplete understanding of exactly what diagnostic procedures are relevant to treatment planning. From a purely medical standpoint, the indications for imaging procedures are simply to separate primary joint diseases from functional problems, to identify adaptations, and to describe the positional relationships between disk and condyle [16].

Orthopantomography.

Orthopantomography is a technique that allows to get an image of the teeth and jaws, TMJ and lower parts of the maxillary sinuses in one picture. Using this technique, it is possible to diagnose pathological bone processes in all parts of the dentition, determine the condition of the teeth and dentition, bone elements of the TMJ, alveolar parts of the maxillary sinuses, identify injuries, post-traumatic and congenital deformities of the jaws, evaluate the treatment results. The TMJ is displayed simultaneously in two projections, which makes it possible to assess the state of the bone elements of the joints, but causes an unreliable transmission of intra-articular relationships [14, 15].

Since orthopantomograms always show image size distortions, measurement results from these images are unreliable. Orthopantomograms contain many additional shadows formed by the air space of the oropharynx, bone massifs of the facial and brain skull, cervical spine, soft tissues of the face and mouth.

The implementation of this technique should be carried out with strict observance of the methodological techniques specified in the instructions attached to the orthopantomographs. Even minor errors performing the installation of the patient's head cause a decrease in the clarity of the transfer of teeth and bone structure, the summation of the shadows of the crowns of the teeth, the layering of a wide intense vertical shadow of the spinal column on the frontal sections of the jaws, the asymmetry of the image of the halves of the jaws. These factors that reduce image quality can equally affect the objectivity of X-ray diagnostics (Fig. 3) [15, 16, 17].

Advantages:

• Increased coverage of supporting structures of the oral cavity

• Simple procedure to perform.

• Requires minimal patient instruction and cooperation.

• Can be performed in less time than the exposure of a full mouth series of radiographs

Disadvantages:

• Increased image distortion.

• Reduced image sharpness.

• Soft tissue shadows present on the resulting image may mimic pathology.

• Length of exposure time may limit its use on young children and other patients who cannot remain still throughout the exposure

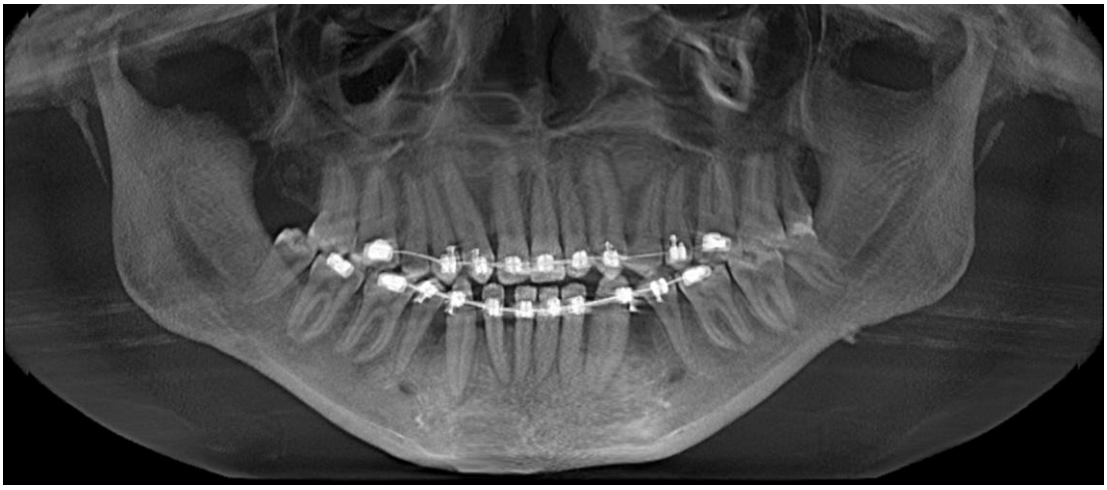

Fig. 3 (Рис. 3)

Fig. 3. Orthopantomogram.

Braces are visualized in the area of the upper and lower jaws. There is an abnormal bite.

Рис. 3. Ортопантомограмма.

В области верхней и нижней челюстей визуализируется брекет-система. Отмечается нарушение нормального прикуса.

cycle [16, 17].

Cone-beam computed tomography (CBCT).

CBCT is a specialized X-ray technique that combines the technical parameters of traditional digital orthopantomography and computed tomography. The fundamental difference between CBCT and computed tomography is the conical shape of the radiation beam [17].

During the examination, the X-ray tube rotates around the patient's head, producing many 2D images. Modern CBCT technologies allow obtaining images with high resolution and diagnostic quality in a very short time. In a modern clinic, it takes no more than 2 minutes to examine a patient.

Image processing takes place at the workstation of the CBCT in bone mode, using multiplanar reconstructions in the axial, coronal and sagittal planes and building 3D models (Fig. 4) [18].

The technical advantages of CBCT include the following characteristics: high quality of images in the bone mode, the possibility of building multiplanar and 3D reconstructions, relatively low radiation exposure and examination time compared to MSCT, convenient (more often in a sitting or standing position) patient positioning, many additional applications and programs for planning and virtual simulation of various types of surgical treatment. The limitation of the method is the almost complete absence of soft tissue differentiation, which results in difficult visualization of soft tissue density structures [19, 20].

Multislice computed tomography.

Advances in computer technology have made it possible to create three-dimensional images from single axial or sagittal slices. This has helped to further improve the ability to

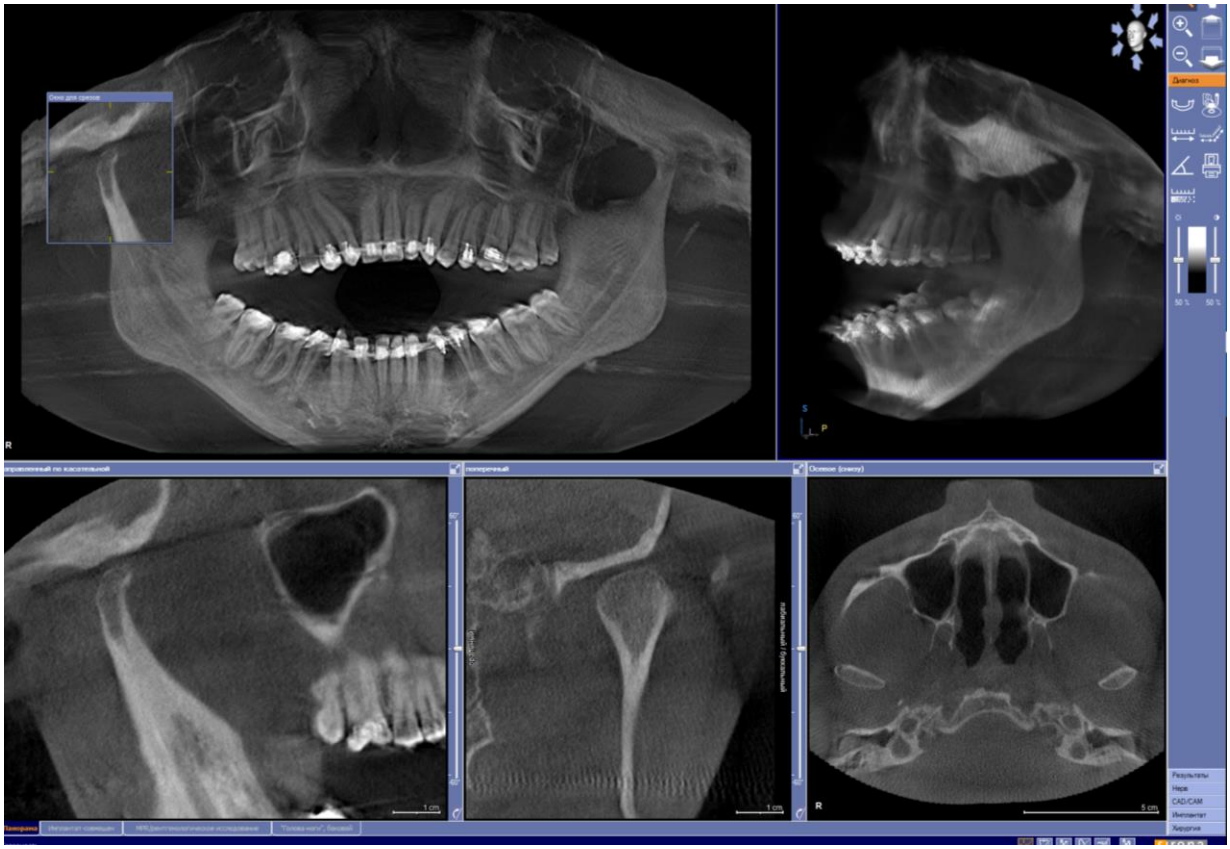

Fig. 4 (Рис. 4)

Fig. 4. CBCT.

Workstation interface: panoramic, 3D, sagittal, coronal, axial reconstructions. The study was conducted with the maximum open mouth.

Рис. 4. КЛКТ.

Интерфейс рабочей станции: панорамная, 3D, сагиттальная, корональная реконструкции, аксиальная проекция. Исследование проведено при максимально открытом рте.

make an accurate diagnosis and to more effectively plan treatment prior to surgery. Multispiral computed tomography (MSCT) is a layer-by-layer X-ray examination with computer reconstruction of the image with a spiral trajectory of rotation of the "X-ray tube-detector" system around the object being examined [17, 18, 20]. Due to the increase in the number of detector rows, modern tomographs have the ability to obtain several sections simultaneously, which makes it possible to obtain high-quality images of the area under study, reduce examination time and reduce radiation exposure. MSCT simultaneously visualizes the bone and soft tissue structures of the maxillofacial region at the pre- and postoperative stages of treatment. With the help of MSCT, it is possible to determine the state of the upper and lower jaws, their alveolar parts, the dentoalveolar system, temporomandibular joints, paranasal sinuses, as well as identify concomitant diseases.

To study the TMJ, a CT scan is performed in the position of habitual occlusion and in the position of the open mouth (Fig. 5, 6) [21].

Advantages:

• When analyzing MSCT images, it is possible to study the study area in layers, measure various values of anatomical structures and density.

• obtaining thin axial CT sections with their transformation into multiplanar and 3D reconstructions

• MSCT simultaneously visualizes bone and soft tissue structures of the maxillofacial region at the pre- and postoperative stages of treatment.

Disadvatages:

• higher radiation exposure compared to X-ray or CBCT

• artifacts from metal structures

• no direct visualization of the disc and TMJ ligaments [17, 18, 21].

Functional MSCT (fMSCT).

The technical result consists in determining the violation of the biomechanical relationships of the structures of the temporomandibular joints due to a detailed assessment of the location of the condylar processes heads of the lower jaw relative to the articular cavities in all

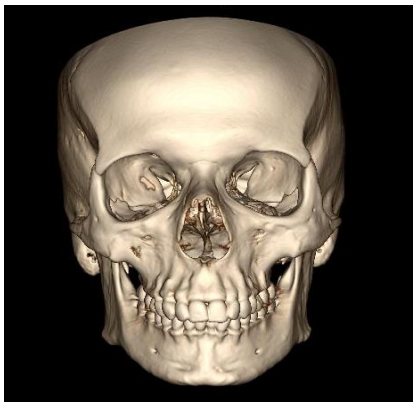

Fig. 5 a (Рис. 5 а)

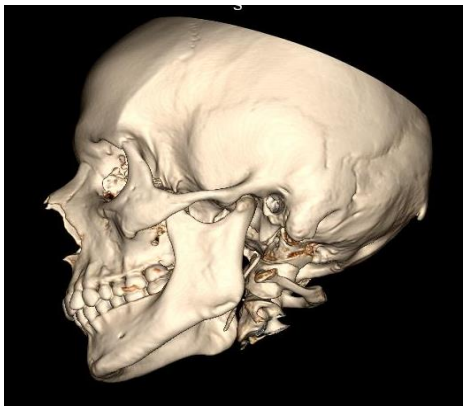

Fig. 5 b (Рис. 5 б)

Fig. 5 c (Рис. 5 в)

Fig. 5 d (Рис. 5 г)

Fig. 5. MSCT, 3D mode.

A, B – close mouth, C – patient with the open mouth, right TMJ, D – patient with open mouth, left TMJ.

Рис. 5. МСКТ, 3D-реконструкция;

А, В – состояние привычной окклюзии, С – исследование правого ВНЧС с максимально открым ртом, D – исследование левого ВНЧС с максимально открытым ртом.

planes, from the moment of habitual occlusion to the state of the maximum open mouth. During the study, the patient performs a gradual opening of the mouth from the position of habitual occlusion [17, 18, 21, 22].

The method of fMSCT in the diagnostics of TMJ dysfunction is carried out in volumetric mode with a slice thickness of 0.5 mm. The

Both TMJs are assessed, their structure, the presence of pathological changes, the relative position of the head of the condylar process of the lower jaw relative to the articular fossa in the position of habitual occlusion are assessed, the displacement of the head relative to the articular tubercle in the sagittal and coronary planes is assessed at all stages of movement

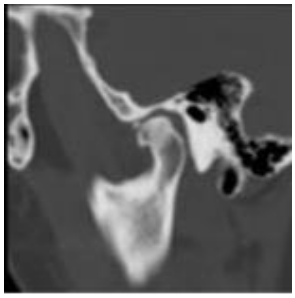

Fig. 6 a (Рис. 6 а)

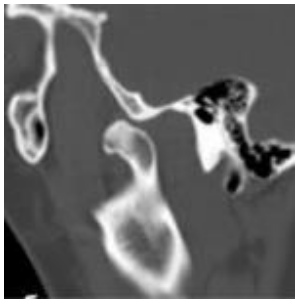

Fig. 6 b (Рис. 6 б)

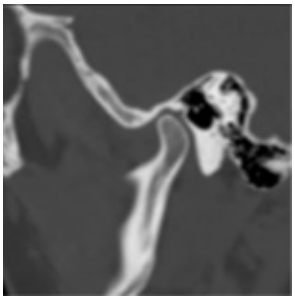

Fig. 6 c (Рис. 6 в)

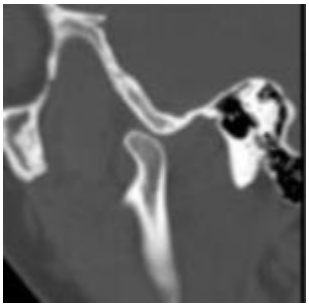

Fig. 6 d (Рис. 6 г)

Fig. 6. MSCT. Multiplanar reconstructions (MPR) of the temporomandibular joints, oblique projections.

A – right TMJ in the position of habitual occlusion; B – right TMJ in the open mouth position; C – left TMJ in position in the position of habitual occlusion; D – left TMJ in the open mouth position. There is a deformation, osteosclerotic transformation of the right TMJ head, subluxation of both TMJs.

Рис. 6. МСКТ. Мультипланарные реконструкции (MPR) височно-нижнечелюстных суставов.

МСКТ. Мультипланарные реконструкции (MPR) височно-нижнечелюстнА – правый ВНЧС в положении привычной окклюзии; В – правый ВНЧС в положении максимально открытого рта; С – левый ВНЧС в положении в положении привычной окклюзии; D – левый ВНЧС в положении максимально открытого рта. Отмечается деформация, остеосклеротическая перестройка головки правого височно-нижнечелюстного сустава, подвывих обоих ВНЧС.

suggested time for the gradual opening of the mouth from the position of habitual occlusion is 9 seconds and is the most optimal for the patient's convenience and the full range of motion in the TMJ. The obtained images are processed with the construction of three-dimensional and multiplanar reconstructions while moving and in a static position. The relative position of the anatomical structures in both temporomandibular joints is assessed at every second out of 9 seconds of the study, at different points and planes, by making appropriate measurements of the width of the joint space at each stage of opening the mouth, and also note the presence or absence of lateral (lateral) displacements of the lower jaw to the right or to the left, which cannot be detected in the above studies of the TMJ. When visualizing the pathological displacement of the head of the condylar process of the lower jaw relative to the articular fossa and articular tubercle, the presence of dysfunction of the temporomandibular joint is ascertained [22].

(each second) and with the mouth as open as possible, the presence or absence of lateral displacement of the lower jaw is noted (Fig. 7, 8) [22].

Magnetic Resonance Imaging.

MRI is an imaging procedure by which not only bone, but also soft-tissue structures can be reproduced in detail by employing static and dynamic magnetic fields. Bloch et al. (1946) and Purcell et al. (1946) were the first to describe the principle of magnetic resonance [17, 23, 24].

Examination is not conveniently extended from one organ to another or from one part of the body to another.

The introduction of MRI in clinical dentistry has opened up new prospects for research into the temporomandibular joints (TMJ). The method allows assessing the integrity and position of the articular disc, displacement of the disc when the mouth is opened, the presence of subluxation in the joint, the condition of the articular surfaces of the bones and articular cartilage, as well as visualizing patho-

Fig. 7 a (Рис. 7 а)

Fig. 7 b (Рис. 7 б)

Fig. 7 c (Рис. 7 в)

Fig. 7 d (Рис. 7 г)

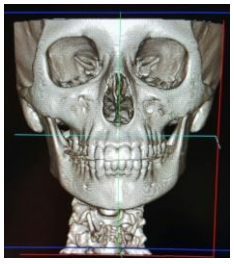

Fig. 8 a (Рис. 8 а)

Fig. 8 b (Рис. 8 б)

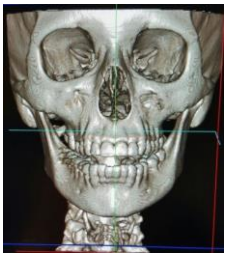

Fig. 8 c (Рис. 8 в)

Fig. 8 d (Рис. 8 г)

Fig. 7,8. fMSCT.

The patient is placed in the supine position. The plane of the physiological horizontal (Frankfur horizontal) is parallel to the tomography plane.

7a-d – during the study, the patient gradually opens his mouth from the position of habitual occlusion to the state of the maximum open mouth. The patient is given 9 seconds to complete the movement.

8a-d – 3D model, in a static form and during movement.

Рис. 7,8. фМСКТ.

Больной находится в положении на спине. Плоскость физиологической горизонтали (франкфуртская горизонталь) параллельна плоскости томографии.

7 а-е – во время исследования пациент постепенно открывает рот от положения привычной окклюзии до состояния максимально открытого рта. На выполнение движения пациенту дается 9 секунд.

8 а-е – 3D-реконструкции, в статичном режиме и при движении.

logical changes in the periarticular soft tissues.

The main advantages of MRI include non-invasiveness, harmlessness (no radiation exposure), three-dimensional nature of imaging, natural contrast from moving blood, no artefacts from bone tissues, high differentiation of soft tissues, the ability to perform MR spectroscopy for in vivo study of tissue metabolism in vivo [17, 23, 24].

The main disadvantages usually include a rather long time required for obtaining images, which leads to the appearance of artifacts from respiratory movements, rhythm disturbances (when examining the heart), the inability to reliably detect stones, calcifications, some types of pathology of bone structures, the rather high cost of equipment and its operation, special requirements for premises, the impossibility of examining patients with claustrophobia, artificial pacemakers, large metal implants made of non-medical metals.

The study protocol includes an assessment of the position of the disc in relation to the head of the lower jaw, the shape and dimensions of the head of the lower jaw, its position in the mandibular fossa of the temporal bone, and the structure of the spongy substance are assessed. With functional MRI, an analysis is made of the displacement of the heads of the lower jaw and the articular disc when the mouth is opened. In practice, the diagnostic method is carried out as follows: the patient is placed in the tomograph in the supine position, head first, using a standard radiofrequency coil for brain examination. The research center is positioned at the level of the temporomandibular joints. For preliminary marking of the study area, a standard localizer for the brain is used. Since both TMJs function as a whole, the study protocol includes a man-

Fig. 9 a (Рис. 9 а)

Fig. 9 b (Рис. 9 б)

Fig. 9. MRI, sagittal planes.

A – the state of the closed mouth (habitual occlusion), B – the state of the maximum open mouth. Anterior dislocation of the left articular disc without reposition when opening the mouth. The arrow indicates the position of the articular disc.

Рис. 9. МРТ, сагиттальные плоскости.

А – состояние закрытого рта (привычной окклюзии), В – состояние максимально открытого рта. Отмечается передняя дислокация левого суставного диска (стрелка) без репозиции при открывании рта.

datory study of the condition of both joints, even if complaints and clinical manifestations of dysfunction are noted in only one of them (Fig. 9) [17, 23, 24].

Advantages:

• non-invasive procedure and the images can be highly sensitive and specific

• The system does not use ionizing radiation and there is little risk associated with application of magnetic field to the majority of people

• Multiplaners anatomical display

• the absence of artifacts due to bone or air.

Disadvatages:

• Spatial Resolution of MR is lower and examination time longer.

• Contact involvement arising from bone tissue are not always demonstrable.

• Patients with pacemakers must be excluded.

• Examination is not conveniently extended from one organ to another or from one part of the body to another [23, 24].

Clinical case 1:

Patient B.: Male 24 years, having braces from July 2021. He first started complaining of pain in the area of TMJ in February 2022, from April 2022 he started felling swelling on his left TMJ and hardening while chewing. He was admitted to the maxilla-facial surgeon and CBCT was carried out to visualize the condition of TMJs and surrounding areas (Fig. 10-12).

After examination the TMJs' subluxation was revealed according to the CBCT images. The patient will be admitted to the dentist for further treatment and adjusting of the braces.

Clinical case 2:

Patient A, 24 y.o., female, were having braces for 2,5 years. After taking off braces she started complaining on the pain in the area of TMJs, more on the right. She wasn't performed with any radiology examination during having braces. She was admitted to the maxilla-facial surgeon and CBCT was carried out to visualize the condition of TMJs and surrounding areas (Fig. 13).

Right TMJ. The position of habitual occlusion. The articular head is 16.5x10.6 mm in size, deformed, along the anterior surface with an irregularly shaped defect, with clear, uneven, sclerotic contours, with approximate dimensions up to 11x4x2.5 mm. There is also a marginal sharpening up to 2 mm. The dimensions of the joint space in its anterior section are 1.2 mm, on average – 3 mm, in the posterior – 2.8 mm. The articular tubercle is not flattened. In the position of the most open mouth:

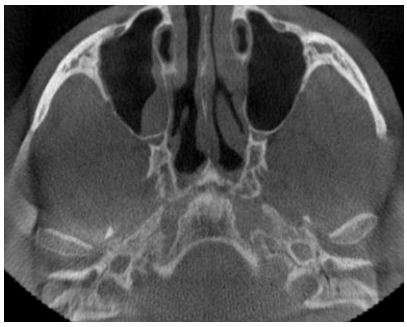

Fig. 10 a (Рис. 10 а)

Fig. 10 b (Рис. 10 б)

Fig. 10 c (Рис. 10 в)

Fig. 10. CBCT. Axial view (A), sagittal reconstructions (B, C).

B – right TMJ in the position of habitual occlusion.

C – left TMJ in the position of habitual occlusion. The heads of the TMJ are of normal shape and structure, the joint spaces are normal.

Рис. 10. КЛКТ. А – Аксиальная проекция, В, С – сагиттальные реконструкции.

В – правый ВНЧС в положении привычной окклюзии.

С – левый ВНЧС в положении привычной окклюзии. Головки ВНЧС нормальной формы и структуры, суставные щели не сужены.

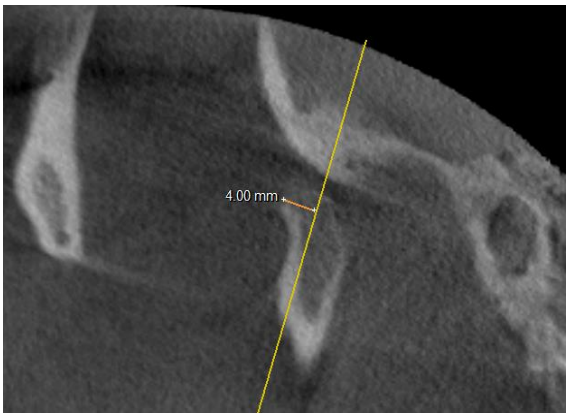

Fig. 11 (Рис. 11)

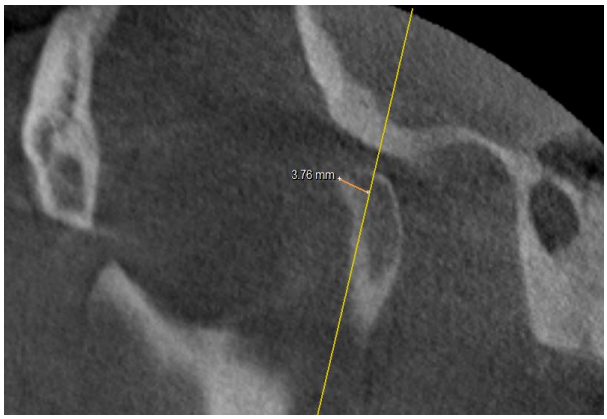

Fig. 12 (Рис. 12)

Fig. 11. CBCT. Right TMJ, sagittal reconstruction (maximum opening of the mouth).

There is a displacement of the right TMJ articular head anteriorly from the top of the articular tubercle by 4 mm.

Рис. 11. КЛКТ правого ВНЧС, сагиттальная реконструкция (положение максимального открытого рта).

Отмечается смещение суставной головки правого мыщелкового отростка нижней челюсти кпереди от верхушки суставного бугорка на 4 мм.

Fig. 12. CBCT. Left TMJ, sagittal reconstruction (maximum opening of the mouth).

There is a displacement of the left TMJ articular head anteriorly from the top of the articular tubercle by 3,8 mm.

Рис. 12. КЛКТ левого ВНЧС, сагиттальная реконструкция (положение максимального открытого рта).

Отмечается смещение суставной головки правого мыщелкового отростка нижней челюсти кпереди от верхушки суставного бугорка на 3,8 мм.

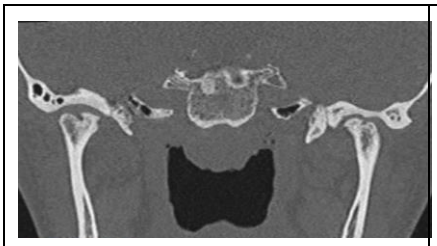

Fig. 13 a (Рис. 13 а)

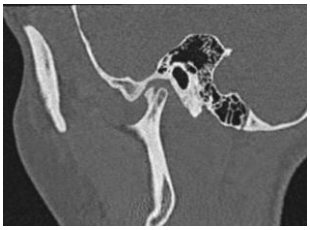

Fig. 13 b (Рис. 13 б)

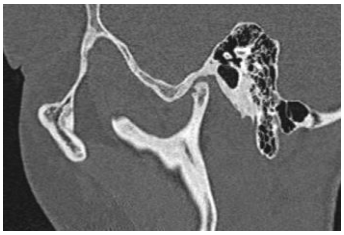

Fig. 13 c (Рис. 13 d)

Fig. 13. MSCT, TMJ. A – coronal reconstruction. B – right TMJ, sagittal reconstruction, C – left TMJ, sagittal reconstruction.

CT-signs of deformity, subchondral sclerosis, marginal defects in both TMJs.

Рис. 13. МСКТ, ВНЧС. А – корональная реконструкция. В – правый ВНЧС, сагиттальная реконструкция, С – левый ВНЧС, сагиттальная реконструкция.

КТ-признаки деформации, субхондрального склероза, краевых дефектов в обоих ВНЧС.

the articular head is displaced downward and anteriorly, with the maximum opening of the mouth, the middle of the head is displaced anteriorly by 4 mm relative to the apex of the articular tubercle.

Left TMJ. The position of habitual occlusion. The articular head is 12.6x5.6 mm in size, not pronouncedly deformed according to the "hook-shaped" type, along the anterior surface it also has an irregularly shaped defect, with clear, uneven, sclerotic contours, with approximate dimensions up to 4.5x2x1.9 mm. There is also a marginal sharpening up to 1 mm. The dimensions of the joint space in its anterior section are 1.2 mm, on average – 2.7 mm, in the posterior – 3.5 mm. The articular tubercle is not flattened. In the position of the most open mouth: the articular head is displaced downward and anteriorly, with the maximum opening of the mouth, the middle of the head is displaced anteriorly by 2.9 mm relative to the top of the articular tubercle.

CT showed signs of arthrosis and dysfunction (subluxation) of both temporomandibular joints, this patient will be admitted to the maxilla-facial department for further treatment and possible surgical intervention.

Conclusion:

Thus, the use of modern, highly informative, high-tech research methods, such as CBCT, MRI, MSCT, fMSCT allows not only to identify the main dysfunctional disorders of the TMJ at the stage of the patient's initial visit, but also to conduct a dynamic study at various stages after complex treatment to assess its effectiveness, especially in cases of TMD after the orthodontic treatment.

Author contribution.

Thereby, all authors made a substantial contribution to the conception of the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work.

Competing interests.

The authors declare that they have no competing interests.

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Consent for publication.

Written consent was obtained from the patient for publication of relevant medical information and all of accompanying images within the manuscript.

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