



Diagnostic Possibilities of using Non-Invasive Research Methods in the Early Detection of Internal Disorders of the Temporomandibular Joint (TMJ)

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Abstract

This review presents an analysis of the scientific literature devoted to the study of the possibilities of using various instrumental research methods: magnetic resonance tomography (MRT), ultrasound axiography, ultrasonography, - to detect internal disorders of the temporomandibular joint (TMJ) at early stages of their formation; describes the advantages and disadvantages of each of them. MRT is a highly informative non-invasive method to detect all types of internal TMJ disorders. However, the use of MRT is impossible in patients with the presence of any metal implants, claustrophobia, severe bruxism. The use of electronic axiography in functional diagnostics of TMJ dysfunction allows detecting internal disorders in the early stages of their development, as well as evaluating the effectiveness of various treatment methods over time. Ultrasonography is an affordable, simple technique for visualizing the internal structures of TMJ, especially effective for the purposes of diagnosis of ventral dislocation of the articular disc. The possibilities of the method in assessing the motor function of the mandible and posterior articular disc are limited. The most efficient for internal disorders of TMJ is the combined use of MRT, electronic axiography and ultrasonography, but given the high cost of this comprehensive study, patients with internal disorders of TMJ for early detection and determination of treatment tactics can be limited to electronic axiography.

Keywords: Internal TMJ Disorders; Diagnostics; MRT; Ultrasonography; Axiography

Introduction

Diagnostics and treatment of the temporomandibular joint (TMJ) pathology is currently one of the most difficult problems in dentistry and requires the complex use of modern research methods to prevent errors in identifying this pathology, in choosing effective therapy and assessing the prognosis for the disorders [1-6].

In the scientific literature, several terms are used to denote diverse cases of the TMJ pathology. One of them - "internal disorders of TMJ" - is a collective term and includes a number of pathological states relating to all structural elements of the joint [7]. These include abnormal displacement of the articular disc in the form of subluxation, acute and chronic dislocation; it's morphological (structural) changes: dystrophic disorders, partial or complete damage of the disc integrity and adhesion of the disc [8]. Internal TMJ disorders also include disorders of the biomechanical function of the mandible head (acute and chronic dislocations of the man-

dible head) caused by changes in the connective tissue structures of the joint, such as intra-articular ligaments and capsule [9].

Internal disorders of TMJ are a fairly common pathology and occur, according to different authors, in 70-95% of the total number of lesions of this joint [10]. The causes for the development of TMJ internal disorders are quite diverse, however, most often, the occurrence of this pathology is a result of the forced (incorrect) occlusion, which is formed against the background of time-delayed dental-maxillary system disorders [11].

Currently, there are various classifications of the TMJ internal disorders, which is explained both by the high incidence of development of this pathology and certain difficulties in its diagnosis and treatment. One of them, which is of practical interest in terms of diagnosis and selection of effective therapy, was proposed by P.G. Sysolyatin, V.M. Bezrukov and A.A. Ilyin [12]. The authors distinguish 9 main clinical forms of the TMJ internal disorders:

- Chronic dislocation of the mandible head;
- Subluxation of the articular disc;
- Recurrent dislocation of the articular disc;
- Chronic dislocation of the articular disc;
- Chronic dislocation of the articular disc, secondary osteoarthritis;
- Chronic posterior dislocation of the articular disc;
- Chronic dislocation of the mandible head with subluxation of the articular disc;
- Chronic dislocation of the TMJ;
- Habitual dislocation of the TMJ.

Methods

Each of these clinical forms has a specific clinical picture and characteristic changes detected by using additional research methods.

Diagnosis of the TMJ internal disorders is based on anamnesis data and the results of clinical and special research methods: X-ray (orthopantomography, computed tomography, magnetic resonance tomography of TMJ, electromyography of the masticatory muscles), ultrasonography, axiography, arthroscopy.

To visualize the structures of TMJ is most often used X-ray examination methods: radiography, computed tomography, orthopantomography [13].

The most common radiological method is orthopantomography. X-ray examination of patients, as a rule, begins with an orthopantomogram and zonogram in the lateral projection in the usual occlusion and with the patient's mouth wide open. However, the software program available on most orthopantomographs distorts the image of the joint space, since it displays TMJ in an oblique projection. On the other hand, the technique makes it possible to evaluate only the bone structures of the joint, as a result of which its use is mainly limited to the exclusion of obvious pathological changes and painful processes [14].

Computed X-ray tomography (CT) provides details of the state of the bone tissue, allows obtaining images of a large number of "cross-cuts" in different planes with a minimum dose of irradiation [15]. However, this rather expensive study provides a limited understanding of the state of the intra-articular disc and surrounding soft tissues. At the same time, TMJ dysfunction is not always accompanied by morphological disorders, which reduces the informativeness of the method in the diagnosis of this pathology [16]. Since X-rays are used in CT, its repeated use to evaluate the treatment is limited.

Magnetic resonance tomography

MRT provides very detailed and accurate images of both bone and soft tissue [17]. The study provides the most detailed and complete information about the TMJ morphological state. The method is based on the sequential execution of a series of scans passing through the TMJ space in the horizontal and frontal planes using a magnetic resonance tomography [18,19]. When performing MRT, the image of the studied TMJ structures is obtained not by X-rays, but by magnetic radiation.

Studies of recent years [20] have shown that the information content of MRT significantly exceeds all other radiological methods of TMJ imaging. The MRT method is most indicative in assessing the state of connective tissue structures (fibrous and cartilaginous) and muscular elements [21].

MRT scans made in an oblique plane perpendicular to the long axis of the lower jaw with the mouth open and closed as much as possible are most informative in MRT diagnostics of internal disorders of the TMJ [22].

The articular disc and ligamentous apparatus of the temporomandibular joint are visualized on MR images in the form of iso-intensive structures that have clear contours and are separated from the surrounding soft tissues by a hypo-intensive "belt" [23,24]. Bone formations of the TMJ have a homogeneous structure and regular clear contours on tomograms [25]. The MRT clearly visualizes the relative position of all the structural elements of the joint.

When MRT is performed, on tomograms made in sagittal planes, the articular disc has the shape of a biconcave lens located between the mandible head and the posterior slope of the articular tubercle of the temporal bone [26]. The criterion for the correct position of the articular disc is the localization of its posterior edge with respect to the mandible head in the 12 o'clock position of the conditional clock-face relative to the full circumference of the mandible head. In this case, the front edge of the disc is located between the mandible head and the posterior slope of the articular tubercle. Positional variants of the rear edge of the disc within the "11-13 hours" zone are permissible and are not a sign of its dislocation [26]. On the MR-tomograms in the space-coronary planes, the articular disc has the shape of a crescent, located above the articular surface of the mandible head [27].

When the mouth is getting opened, the mandible head moves forward and is visualized at the top of the articular tubercle of the temporal bone. The articular disc shifts with the articular head, but to a smaller distance [28]. All movements of the TMJ intra-articular

structures are clearly recorded in oblique sagittal projections [29]. In the coronary projection a clear contour of the mandible head can be identified [30].

According to a number of authors, MRT is the “gold standard” for diagnosing internal disorders of the TMJ [31], a method that is particularly informative in assessing various displacements of the articular disc [32,33].

The indication for the MRT is: the presence of clinical signs of the TMJ intra-articular disorders not detected on radiography, tomograms and CT; complaints of pain in the parotid-temporal area and masticatory muscles with pain radiating to the occiput and neck area; intra-articular pathology of the TMJ as a result of an injury; suspected degenerative changes in the TMJ articular disc; clinical signs of deformation or destruction of the articular disc and ligament-capsular apparatus of TMJ; signs of displacement of the articular disc of the TMJ; acute and chronic dislocation of the articular disc; the ineffectiveness of the conservative treatment of TMJ pathology; prior surgical treatment of abnormalities and deformations of the TMJ; bruxism; trismus of chewing muscles, resistant to conservative therapy; pain in the area of the TMJ and the face [34].

The contraindication for the MRT is: the presence of intracranial metal clips on the brain vessels; cochlear implants with metal elements; pacemakers; metal prosthetic heart valves; implanted insulin or chemotherapy devices; claustrophobia [34].

The advantage of MRT is the non-invasive nature of the study; no radiation exposure; a possibility of a comprehensive assessment of the state of both bone and soft tissue structures; three-dimensional character of the obtained image, a possibility of repeated dynamic observation. The main advantage of MRT is a clear visualization of the articular disc and intra-articular ligaments in conditions of natural contrast a

The disadvantage of the MRT method is quite a long time required for obtaining images, which leads to the appearance of artifacts during movements; the inability to assess the relative position of the TMJ structures in the process of movement; the inability to identify stones and calcifications; low informativeness in assessing the state of compact bone tissue of trabecular bone structure; the patient's stay in a confined space, which is not always possible (patients suffering from claustrophobia); high cost of research [35].

Axiography

Axiography is a graphical method for the extra-oral registration of movements of the mandible, which makes it possible to record

the trajectory of movement of the transversal hinged axis of the TMJ when the mandible moves in three mutually perpendicular dimension [36].

The examination is carried out using an axiograph (mechanical or electronic), which allows to determine the articulated axis of TMJ and to obtain data used to adjust the articulator, as well as to analyze the movements of the mandible in three dimension.

At present, mechanical and electronic axiography is used to register and evaluate the movement of the mandible.

All mechanical axiographs have a common basic principle [37].

Various types of mechanical axiographs allow one to register the trajectory of mandible movements separately on one side or on both (right and left) simultaneously [38].

The algorithm for examining patients, as well as working with a mechanical axiograph, is a rather time-consuming and effort-consuming procedure, which is not always convenient for patients with TMJ, given the presence of pain of varying severity in most of them. It is also impossible to exclude the risk of inaccuracies when reproducing the position of the hinge axis because of a sufficiently large amount of manual work.

Therefore, at present, electronic axiographs are more commonly used to register the mandible movements [39]. The principle of operation of electronic axiographs is based on ultrasonic measurement of the articulation of the mandible with the subsequent processing of the information obtained using specialized programs [38,39]. Registration of mandible movements is carried out when the ultrasound wave is captured by microphones mounted on a static arc. The source of ultrasound is located on the dynamic arc. The static arc is fixed on the patient's head without taking into account the spatial landmarks, and the dynamic arc is fixed by a magnetic terminal to the para-occlusal spoon attached to the inner surface of the mandible teeth. The electronic axiograph can be used in combination with various types of articulators [40-42].

The presence of ultrasonic sensors and high-frequency ultrasonic detector, in the equipment of electronic axiographs, makes it possible to avoid registration inaccuracies that occur when one uses graphic (mechanical) axiographs.

Analysis of the electronic axiography data allows us to determine with high accuracy the Bennett angles on both sides, the angle of the sagittal articular path, to calculate the curvature of the articular path to adjust the articulator of any type [43,44].

It should be noted that the assessment of temporal parameters of the TMJ movements is only possible with electronic axiogra-

phy. This allows us to identify the dynamic asymmetry of the TMJ [38,39].

The curve of the articular path, the angle of the articular path and the Bennett angle depend on the anatomical and functional state of the intra-articular structures of the TMJ [44,45].

According to a number of authors, the registration and subsequent study of the articular trajectory in patients with TMJ disorders helps to establish the correct diagnosis and also facilitates the differential diagnosis of the joint pathology [46,47]. This technique allows to obtain valuable information in the early stages of the TMJ dysfunction, even before the formation of structural (morphological) changes [48].

At the same time, the graphic registration of the articular path is a fairly simple, non-invasive, safe and relatively inexpensive method, which is an undoubted advantage over other research methods used to identify dysfunctions of the dental system [49].

Evaluation of the amplitude of the mandible head movement contributes to the early detection of various intra-articular disorders of the temporomandibular joint in the form of hypermobility of the mandible head, subluxation (with early and late reposition and without reposition) and dislocation of the TMJ articular disc [50].

In the case of the TMJ ankylosis and intra-articular adhesion a sharp decrease in the amplitude of articular movement of the mandible head is found [51,52].

In the case of the TMJ intra-articular pathology, an increase in the temporal parameters of the mandible head movement, especially during rotation and translation, is found on axiograms [36].

In patients with TMJ dysfunction of varying etiology, both a decrease and an increase in the length of the articular trajectory of the mandible are observed [53]. Reduction in the length of the trajectory indicates a decrease in the mobility of the joints; an increase in the length of the mandible movement trajectory is formed when the ligamentous apparatus is weak as a result of its stretching, the anatomical features of the temporal bone articular tubercle in the form of its small height or gentle slope, and the small depth of the temporal bone mandibular fossa [36].

Thus, an axiographic study in TMJ pathology patients should be carried out:

- To study the functional state of the TMJ;
- To detect internal disorders of the TMJ in the early stages of the disorder;

- To assess the state of TMJ various structures before treatment with occlusive splits;
- As an additional diagnostic method in cases where there is no effect from the treatment of TMJ disorders;
- Before surgery on the jaws, especially if orthopedic or orthodontic correction is expected after such surgery;
- For fine tuning of various types of articulators based on the analysis of the mandible movement trajectories in three dimensions;
- As an additional research method in the framework of the differential diagnosis of the dental system pathology of various types.

The use of the electronic axiography method opens a possibility for:

- Recording and archiving the data on the initial state of the dental system, which is important for dynamic monitoring of the course of the underlying disorder, as well as evaluating the effectiveness of the treatment applied;
- Analysis of the articular path allows the identification of functional disorders in the early stages of its formation, even before the development of morphological changes;
- Carry out dynamic observation and assess the effectiveness of the treatment at different stages, as well as after the end of the therapy course.

Ultrasonography

Ultrasonography of TMJ is a modern and highly efficient method for visualizing the TMJ connective tissue structures. Currently, thanks to the improvement of medical ultrasound technology and the emergence of high-resolution multi-frequency broadband sensors, this method is being used increasingly to diagnose various cases of pathology of the dental system [54].

TMJ ultrasound investigation can be performed using any modern ultrasound scanner that functions in the real time mode. The operating frequency of the linear sensor is usually in the range of 7.5-12 MHz [55].

The following intra-articular structures are visualized during the TMJ ultrasonography [56] the mandible head; articular disc; front and rear pole of the disk; upper joint gap; lower joint gap; lateral pterygoid muscle (upper and lower parts); the anterior and posterior maxillary ligament; anterior and posterior disc ligament; articular capsule; cartilage of the articular surface of the mandible head.

When conducting an ultrasound study, the following parameters are calculated and evaluated: the vertical size of the articular disc and its structure; the thickness of the mandible head cartilage and

its structure; thickness of the posterior part of the joint capsule; subchondral bone structure; anatomical integrity of the upper and lower parts of the lateral pterygoid muscle; anatomical integrity of the posterior disc and posterior maxillary ligaments [56,57].

Ultrasonography provides valuable information about the functional state of the TMJ. The following ratios are estimated: of the articular disc relative to the mandible head; of the articular disc relative to the articular tubercle of the temporal bone; of the mandible heads relative to the articular tubercle of the temporal bone [57].

At an ultrasonography of the TMJ, the joint capsule normally looks like a continuous, homogeneous, hyperechoic linear structure with a width of 0.4 mm. The contours of the capsules are clear and even. The width of the capsule-cervical space does not exceed on average 1.1 ± 0.05 mm. The articular space is visualized as a hypoechoic space located above the surface of the mandible head. The width of the articular space is 1.5-3 mm. The mandible head has a semi-oval shape with a clear and even contour. On echograms, the structure of a compact bone is a narrow, smooth, homogeneous hyperechoic arcuate 1 mm wide line, located along the edge of the mandible head; spongy bone elements of the mandible head are not identified on the echogram. During ultrasonography examination, the disc and the bilaminar area are visualized by indirect indications as a hypoechoic band located between the articular capsule and the surface of the mandible head, which is why the determination of their size, shape and structure is difficult. The lateral-ptyergoid muscle is determined as a hypoechoic soft tissue structure with a longitudinal direction of the muscle fibers. These fibers are separated by thin hyperechoic connective tissue, clearly defined structures [57].

In case of internal disorders of TMJ, the visualization of intra-articular structures, assessment of their morphological and functional status, relative position at rest and during movement becomes especially important for the choice of effective therapy and for the prognosis.

A number of authors who have studied ultrasound data on the anatomical features of the TMJ various structures, have obtained conflicting data regarding the method potential in visualizing the articular disc and some other TMJ structures [57,58]. This is explained by the fact that in an ultrasonography of TMJ, the possibility of complete visualization of the joint is limited by the position of this structure at the base of the skull and the possibility of scanning only from the lateral surface in the sagittal plane. The medial surface of TMJ at an ultrasonography is not definable; the position of

the disc and the bilaminar zone is difficult to assess because of the weak echogenicity of these structures [59].

At the same time, ultrasonography studies in patients with the TMJ internal disorders showed that, despite the difficulties of determining the normal position of the posterior segments of the articular disc and the mandible head, in patients with anterior displacement, visualization of the articular disc and control of the normalization of its position is almost always possible [59,60].

The ultrasonography is high effective method for visualization of connective tissue, muscle and bone structures of TMJ. This method allows to evaluate the movement of the TMJ intra-articular structures and their relative positions [61,62]. In addition, the use of ultrasonography provides an opportunity to conduct dynamic monitoring of the course of TMJ disorders [63]. Important benefits of the method in matter are the patient and medical staff safety in the course of the screening, the simplicity, accessibility and relatively low cost of the study.

Conclusion

It should be noted that each of these instrumental methods has its own indications and advantages in diagnosing internal disorders of TMJ, as well as certain disadvantages; therefore, the highest efficiency in detecting this pathology in the early stages of its formation is provided by the combined use of MRT, ultrasonography research and axiography. Given the high cost of this comprehensive study, patients with internal disorders of TMJ for early detection and determination of treatment tactics can be limited to electronic axiography.

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