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MEMORIAL
Karl Landsteiner

PROBLEMS OF FIGHTING HUMAN AND ANIMAL DISEASES IN TERMS OF THE BIOSPHERE CONDITIONS DETERIORATION

Peer-reviewed materials digest (collective monograph) published following the results of the CXIX International Research and Practice Conference and I stage of the Medicine and Pharmaceutics, Biology, Veterinary Medicine and Agriculture.
(London, March 23 - March 29, 2016)

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MODELING OF THE TENSION OF ARTICULAR TUBERCLE BONE TISSUE IN THE TREATMENT OF HABITUAL DISLOCATION OF THE MANDIBULAR BONE IN PATIENTS WITH ANATOMICAL INSTABILITY OF TEMPOROMANDIBULAR JOINT

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It was studied the state of stress in the articular tubercle bone tissue of the temporo-mandibular joint in the treatment of habitual dislocation. The change in stress depending on the angle of implant-limiter and the height of the tubercle was established.
Keywords: *temporomandibular joint, incomplete dislocation, implant, bone stress, end elements.*

In modern literature, there are several theories of the development of the instability of the temporomandibular joint (TMJ). The most common and accepted is the theory according to which the TMJ anatomical instability is seen in some cases as a jet, in others - as a pathological condition.

Pathological condition has unique clinical presentation, reflecting the characteristic changes: a defect of the support function of the articular surfaces, uncontrolled displacement of the mandible, the occurrence of unusual articular displacement of the mandible head due to discoordination work of masseter muscles and inadequate movements of contacting joint surfaces, the occurrence of gross intra-joint noise, the development of pain syndrome [2, 7].

Dislocation of the joint, as an evidence of the instability in the relationship of it anatomical structures, is the result of violations of the spatial location of its internal components in relation to each other in all three planes. This leads to the development of stress-strain state of the articular tissues as a result of changes in head position of the mandible in relation to the articular cavity and the articular tubercle, as well as due to the changes in the mechanical properties of the capsule and ligaments, articular tubercle defect [5].

Surgical treatment of TMJ instability in most cases is focused on the removal of specific defects. To do this, it was conducted the condylotomy [4], immobilization of the disk with lavsan thread weaving [8], the introduction of Tantalum limit screws in the bone tissue of the articular tubercles tops [3], restrictive ligation of the edge of the zygomatic arch with the edge of the mandible [9], plastic of the articular tubercle with cortical-bone matrix [1].

However, these interventions do not lead to long-term post-operative joint stabilization; hereinafter its hypermobility has developed.

The aim of our study was to examine the stress in the articular tubercle bone tissue in the treatment of habitual dislocation of the mandible in patients with anatomical instability of TMJ.

Materials and methods. Based on the X-ray zonography image of TMJ (**Fig. 1**) with the help of SolidWorks software there were built the models of the temporomandibular joint in the sagittal plane, which have been exported to program complex ANSYS Workbench 14.0.

When constructing a mathematical model it was taken into account that the elastic modulus of the subchondral bone (Ec) is 6890 MPa, spongy (Er) - 689 MPa [10,11].

The following boundary conditions were taken for the calculations: the thickness of compact bone - from 2 mm and up, the constant cartilage thickness - 2 mm, the contact between the articular cartilage of cavity and the head is provided with 5 contact elements; a compact, spongy bone and articular cartilage was considered as homogeneous components (isotropic).

The calculation of this model was made for medium and low altitude of the articular tubercle. The head of the lower jaw in two versions is installed in accordance with the norm. In a similar model we studied the effect of the orientation of the head of eminoprosthesis-limiter of articular tubercle on the stress-strain state of the area of the articular surface. It was decided that the leg of eminoprosthesis-limiter was installed in the interior of the temporal bone, and the angulation of the head-limiter varies within the limits: 45^0, 60^0, 75^0. Titanium was used as an implant-limiter.

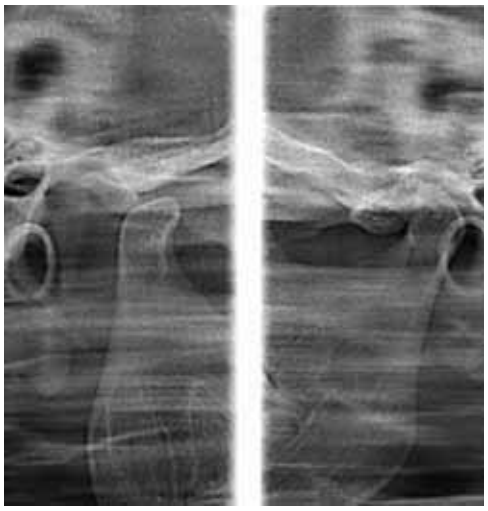

Fig.1. Zonogram of temporomandibular joint

We studied the stress in the cortical and spongy bone tissue of the tubercle of the temporal bone under the location of titanium implant-limiter at a different angulation and the effect of the articular tubercle height on this process.

To characterize the state of stress and at the same time taking into account all the components of the stress fields (normal and tangential) the von-Mises equivalent stress in MPa was used.

The results of study. Flat mathematical model allows realizing the stress caused during mouth opening and lateral movements. Each part of the object (the temporal bone, the head of the mandible) in its coordinate system allows to vary their relative positions.

Calculations have shown that the angle of inclination of the implant-limiter significantly affects the state of stress in the articular tubercle of the temporal bone.

Increase of the angulation of the head-limiter from 60^0 to 75^0 causes an increase in the compressive stress in the upper part of the articular tubercle. Stress concentration occurs in the area of "support" of the edge of the head-limiter on the top of the articular tubercle. Similarly, the stress in spongy bone increases. When placing the titanium implant under the angle of 75^0, the maximum intensity bordering on the limit arises, in the result of which bone destruction may occur.

The orientation of titanium implant under the angle of 45^0 causes high tensile stresses in spongy bone, especially in the medial part of the mandibular cavity. In our opinion, this state of spongy bone, especially long-lasting, can cause its destruction.

The results of the study showed that the height of the tubercle is of great importance in the mechanical stress redistribution and protects the spongy bone of the high compressive stress.

By reducing the height of the tubercle the stresses zone in the spongy bone significantly extends, their dimension increases 1.75 times. During loads that excess physiological, the further growth of stress can cause bone resorption around the top of tubercle and instability of other joint components.

The basis of the formation of TMJ instability (both occlusive and anatomical) is the violations of biomechanical conditions of work of its structural components. These violations contribute to a false load distribution, which leads to local overloading of the joint elements, damage of structural-functional relationships and the formation of mechanism of incomplete unilateral habitual dislocation of the mandible. Dysplastic changed tissues have a smaller range of compensatory and adaptive capacities, reduced the "safety margin" of TMJ components.

This will gradually lead to the formation of biomechanical irregularities in the form of uneven load distribution on articular surfaces and further promotes instability [6]. Existing methods of surgical treatment of joint hypermobility, that can lead to the habitual dislocation, are intended to limit its mobility without consideration the factors of bone tissue tension. This leads to a short-term positive result in the postoperative period.

Conclusions. The results of our study showed that the boundary positions of the head of the titanium implant increase the mechanical stress of the system "bone-limiter", that may impair its stability. The optimal position of the endoprosthesis socket is its inclination to the horizontal at an angle of 60^o, there may be the variation of angle more than 45^0, but less than 75^0. To prevent the increase of damaging stresses in the articular tubercle it is needed a plastic providing the increase of its height.

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