

## Comparative Analysis of the Effectiveness of Methods of Rehabilitation of Impaired Biomechanics of the Mandible of Patients with Bisphosphonate Osteonecrosis Based on the Results of Neurophysiological Monitoring

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### Abstract

Biomechanical disorders are caused by bisphosphonate osteonecrosis, current problems in the medical community. Until recently, this aspect of the pathogen was studied exclusively in terms of the anatomical integrity of the damaged structure.

The analysis of functional disorders through neurophysiological monitoring of the masticatory muscles, one way or another involved in the pathological process, is no less significant, including for patients. The dynamics of neurophysiological parameters in the comparison groups by the 21st postoperative day had a fundamental difference. Negative neurophysiological parameters in patients of the control group testified to the effectiveness of the positioning device in a number of clinical and laboratory parameters. Correlation of clinical indicators, results of neurophysiological monitoring, terms of rehabilitation indicates the feasibility of using a positioning device that ensures the effective functioning of damaged structures of the dentoalveolar system.

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### Introduction

Effective rehabilitation of patients with volume jaw defects at the present stage of development of science and technology is impossible without a comprehensive analysis of biomechanical disorders and improvement of the technical aspects of operational methods for their elimination.<sup>1,2</sup>

The specific effects of bisphosphonate drugs are initially planned to have a therapeutic effect on bone tissue. However, in some cases, their use leads to the development of a pathological process in it, and subsequently in the adjacent soft tissues, contributing to their functional insolvency. These side effects of bisphosphonate group drugs are more common every year.<sup>3</sup> The growth is due to the expanding

indications for their use in patients with bone pathology, including diseases such as Paget's disease, ossifying dysplasia, metastatic process and others.<sup>4,5</sup> The frequency of osteonecrosis of the jaw bones according to a number of domestic and foreign authors varies between 4-7% per 100 thousand patients.<sup>6,7</sup> Despite the increasing frequency of complications, the pathomorphological mechanisms of the development of bisphosphonate osteonecrosis have no reliable explanation, as there are no explanations for the pathophysiological aspects of the development of biomechanical disorders. Assumptions about the neuro-biochemical basis of biomechanical disorders served as the basis for the study of neurophysiological indicators of the functional activity of the masticatory muscles.<sup>8</sup> To understand the scope of functional disorders and develop ways to prevent them, it is necessary to use specific examination methods, since it is impossible to understand the nature of biomechanical disorders in muscles without studying their neuronal response to stimuli. Currently, the fixation of indicators of motor acts of muscles is possible with the help of electromyography, through which the amplitude of the action potential and the time of muscle

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contraction are determined.<sup>9</sup> The need to assess the structural and potential dependent phenomena occurring in the peripheral nervous system has predetermined the need to study biomechanical disorders through neurophysiological monitoring. Biomechanical disorders in the dental system are manifested by dysfunction of the act of chewing and speech formation.<sup>10</sup> The clinical situation, depending on the extent and localization of the defect, the presence of a secondary infection is accompanied by a restriction of mouth opening, deviation of the lower jaw, varying degrees of pain, pathological tooth erosion and other local manifestations.<sup>11</sup> For the first time, the method of electroneuromyography was carried out by H. Piper in 1907, the successful clinical application of the method was documented by R. Hodes in 1948, who determined the speed of propagation of excitation along the motor fibers of peripheral nerves. Neurophysiological monitoring in the general clinic have been practiced relatively recently; <sup>12,13</sup> 10-15 years ago, researches were carried out only in large research centers. At the moment, research is widely applied among most specialties. In the routine practice of maxillofacial surgeons, it is practically not used. Neurophysiological monitoring makes it possible to study the state of motor units – the actual action potential and visualize the recorded bioelectric potential of muscles, through which it is possible to determine the state of the axons of peripheral nerves and neuromuscular transmission, which determine the biomechanical functional activity or lability of the muscular structures of the maxillary system.<sup>14</sup>

Aim: to analyze the biomechanical activity of the masticatory muscles in patients with bisphosphonate osteonecrosis based on the results of neurophysiological monitoring and the effectiveness of its recovery using various surgical methods.

### Materials and methods

All patients under observation underwent pre-, intraoperative neurophysiological monitoring, and in the postoperative period in accordance with the design of this study. Intraoperative monitoring was carried out by the method of bipolar configuration with needle sensors fixed subcutaneously two on each side on the examined muscle in accordance with the size,

cross-sectional area and the place of fixation. The sensors are installed according to the "10-20" method proposed by Jasper in 1958, recommended for use by the International Federation of Clinical Neurophysiologists. The sensors are installed on the affected side and symmetrically on the conditionally "healthy" side.<sup>15,16</sup>

Neurophysiological monitoring was carried out on the «Nicolet EDX 8-ch» device. Current-stabilized electrical impulses were used, the duration of the stimulus was 0.3 ms, the intensity of stimulation was from 1.5 to 5.0 mA. All the indicators for registration corresponded to the anatomical and morphological features of the muscle unit: its cross-sectional area, volume, which were determined by the results of MS CT or MRT. The grounding electrodes were placed parasagittally, between the frontal lobes, along the hairline, with a step between the electrodes of 10-20°.

For a comparative analysis of the bioelectric activity indicators obtained from the chewing muscles, publicly available known data obtained from a healthy person were taken as normal. To register the indicators, the first sensor was located subcutaneously at the medial edge of the masticatory muscle along the edge of the lower jaw, taking into account the location of the neurovascular bundle, the second was installed in the projection of the lower edge of the zygomatic arch at the point of greatest tension.

Sensors in the projection of the temporal muscle were installed taking into account its architectonics and morphotype. Most often there was a triangular shape of the muscle, in connection with which one of the sensors was installed at the top of the "triangle", which was located 1-1.5 cm below the hairy edge at its highest point. The second sensor was installed at the central point at the base of an abstract "triangle" in the projection of the upper edge of the zygomatic bone.

Sensors for monitoring bioelectric potentials from lateral and medial pterygoid muscles are functionally active only intraoperatively, due to the insignificant volume and cross-sectional area of their muscle fibers. Therefore, for registration in the preoperative and postoperative periods, cutaneous cup-shaped sensors with their smallest diameter were used, this contributed to stable fixation at all stages of monitoring.

In the techniques used, somatosensory

evoked action potentials and motor evoked potentials have no technical differences. Recording programs differ in the method of recording and have differences in the strength and frequency of the electric current. The results of the study depended on the number and frequency of the issued impulses, which ranged from 50 to 3000, as well as on the volume of the muscle fiber, and the chosen method and mode of their fixation.

Registration of the M-response of motor evoked potentials was obtained after stimulation of the precentral gyrus, which is the motor zone of the cerebral cortex and the pyramidal tract in the area of its inner capsule, which is the motor conductor.

It is known that muscle tissue contraction occurs in response to the alpha-motor neuron action potential of the anterior horn of the spinal cord. The response is formed as a consequence of irritation by an electrical impulse, followed by activation of the descending motor pathways by a positive current. Intraoperative activation of the alpha-motor neuron was carried out by means of "train" stimulation, and included several pulses (1-6), which was associated with the action of anesthetic drugs blocking single pulses. For the accuracy of diagnosis, there was a need to exclude the effects of muscle relaxants. 184 patients with bisphosphonate osteonecrosis of the mandibular bone were monitored, of which 112 were men and 72 were women, aged 34 to 76 years. Exclusion criteria: active metastatic process, intraoperative use of anticonvulsants and muscle relaxant drugs. The patients were divided into two groups: the 1st group comprised 60% of the total number of patients under observation, fragments were fixed by a positioning device after resection of the affected area of the mandibular bone, about 40% of patients entered the 2nd group, fragments of the jaw were not fixed after resection. In the preoperative period, all patients underwent general clinical studies, multispiral computed tomography, monitoring of quality of life criteria according to the modified questionnaire "The MOS 36-item Short-Form Hervey", the main criteria were: general health, mental and physical functioning, psychological health and pain intensity. Each of the criteria was evaluated on a scale from 0 to 100 points, according to an objective assessment of patients.

## Results

Clinically, during external examination, the absolute majority of patients had a restriction of mouth opening, up to 2 cm between the frontal group of teeth, with maximum opening, patients noted a clear painful point with dissemination to the periphery, with deviation of the lower jaw to the affected side. Pronounced collateral edema with significant facial asymmetry in 85% of patients is caused by sluggish functioning fistula passages. Palpatory, the masticatory muscles on the side of the lesion are hypertrophied, painful throughout. 20% have a trigger point at the place of fixation of these muscles.

## Discussion

In the oral cavity on the conditionally "healthy" side teeth wear is the 2<sup>nd</sup> degree of mobility, 40% of patients have hypertrophic gingivitis in the projection of preserved teeth, 10% have generalized periodontitis of grade 2 severity, 50% have catarrhal gingivitis in the projection of the lateral group of teeth. Pain according to the subjective feelings of patients in the preoperative period in the range of 75-90 points, general health 25-30 points, mental functioning 30-40 points, physical functioning 20-25 points, psychological health 15-20 points. Neurophysiological parameters of the masticatory muscles on the conditionally "healthy" side in the preoperative period in terms of the amplitude of the action potential exceeded by 6-8 times these indicators on the affected side. The time of muscle contraction on the "healthy" side fluctuated within 0.02 seconds, the act of rest is intermittent, bioelectric activity on the electroneuromyogram has the form of sharply rising peaks of 70 mV. Similar responses are on the side of the pathological process with low organizational activity, with an average current strength of 4.0 mA.

Intraoperative monitoring of neurophysiological parameters had no significant changes in comparison with the preoperative stage. The amplitude of the action potential of the temporal muscles of the conditionally "healthy" side exceeded 4 times the affected one. The contraction time is within 0.02 seconds, the act of rest is 0.005 seconds, bioelectric activity is also in the form of sharply rising peaks of 50 mV, with a lower frequency compared to the masticatory

muscle group. Muscle responses on the side of the pathological process with low organizational activity, with an average current strength of 4.0 mA. Intraoperatively, the above indicators had statistically insignificant deviations, they decreased somewhat, which was obviously due to the lack of postural action (the patient's supine position). The amplitude of the action potential of the medial and lateral pterygoid muscles of the "healthy" side exceeded the indicators of the affected side by 3-4 times. Bioelectric activity had the form of sharply rising continuous peaks of 30 mV, their registration on the affected side had 0 dynamics, the reduction time could not be fixed, due to the lack of response to electric shock irritation.

Indicators in the postoperative period by the 10th day were characterized by positive dynamics. The amplitude of the action potential of the chewing muscles of the "healthy" side also exceeded the initial indicators by 3-4 times. The time of muscle contraction was within the normal range, bioelectric activity was characterized by acute rising peaks of 50 mV, with a moderate act of rest. The amplitude of the action potential of the temporal muscle of the "healthy" side was 2 times higher than the affected one. Bioelectric activity was reflected in the form of towering peaks of 30 mV, with a moderate rest interval, when analyzing electromyograms on the side of the pathological process. During all stages of the examination, the fact of low organizational activity of the muscles was established, with their irritation by an average current strength of 4.0 mA. In the postoperative period, pain according to the subjective sensations of patients and marks in the questionnaire ranged from 30 points, general health 50 points, mental functioning 50-60 points, physical functioning 50-70 points, psychological health 40-50 points.

Indicators in the late postoperative period in patients of the 1<sup>st</sup> group approached the physiological norm on the healthy side and significantly improved on the affected side. In the 2<sup>nd</sup> group, the dynamics of indicators on the side with preserved musculoskeletal structures had sharply negative indicators. On the side with resected tissues, it was characterized by the development of various complications, which significantly reduced the likelihood of any reconstructive measures. The amplitude of the masticatory muscle action potential on the "healthy" side was at least 1.5 times higher than

the initial measurements in all groups and at all stages of the study. The time of muscle contraction corresponded to the optimal readings of the norm, bioelectric activity in the form of sharply elevated peaks, with a moderate act of rest. The amplitude of the action potential of the temporal muscles had bioelectrical activity with a moderate interval of rest and was optimally symmetrical to the norm. The pain index ranged from 5-10 points, general health 80 points, mental functioning 80 points, physical functioning 80-90 points, psychological health 80-90 points.

### Conclusions

Monitoring of parameters of bioelectrical activity of masticatory muscles, with an interval of 40 to 70 mV, on a conditionally "healthy" side in the preoperative period and intraoperatively significantly exceeded those of a healthy person, which vary from 10 to 25 mV and were taken as reference values. Peak values of 70 mV on the conditionally "healthy" side and bioelectrical activity, in most cases, which had a zero value, on the affected side in a comparative aspect prove the functional exhaustion of the muscular system. The noted disharmony of symmetrical muscle groups contributed to the development of dysfunction of the dentition.

The amplitude of the action potential is the equivalent of the force that determines the nature, degree and number of functioning muscle fibers. As rehabilitation measures were carried out, adequate, regular exercise, which was an element of counteracting pathological links, contributed to the optimal progress of the physiological process. Most likely, what happened was possible due to the remodeling of a larger number of morphological units into the physiological process.

Preoperative indicators of bioelectrical rest indicated a high degree of fatigue and dysfunction of non-working muscles, which in a large number of cases led to contracture. In parallel, progressive signs of a functional disorder in the work of the temporomandibular joint were noted. Clinically manifested by hypermobility of the ligamentous apparatus on the "healthy" side. The severity of pain largely depended on the localization and prevalence of the pathological process, the nature of the prevailing biomechanical reactions.

The noted progressive depression of mental

and physical functioning, psychological health corresponded to the volume of clinical manifestations, and the level of fear of the upcoming surgical intervention. The results of neurophysiological monitoring in the preoperative period made it possible to determine the causal relationship of biomechanical disorders in most patients, which in one way or another provoked the suppression of not only local functions, but also contributed to a decrease in physical and psychological health indicators.

The results of the study indicate the effectiveness of surgical treatment using extrafocal positioning devices. The results obtained contributed to the determination of the scope of surgical intervention, the choice of surgical access and the method of fixing the device aimed at achieving optimal functioning of mandibular bone fragments after its partial resection.

By the 21st day of the postoperative period in patients of the 1st group, biomechanical parameters and quality of life criteria tended to normal values. In the 2nd group, the quality of life indicators did not have significant positive indicators. The dynamics of biomechanical parameters was accompanied by an increase in negative values. The results obtained confirm the effectiveness and the need for widespread use of the proposed extrafocal positioning device in patients with mandibular bone defects, regardless of the etiological factor.

Minimally invasive surgical intervention during installation and fixation of an extrafocal positioning device ensures the prevention of secondary infection of surrounding tissues, reduces the risk of surgically caused cicatricial contractures. In addition, it contributes to the rational positioning of fragments of the jaw bones in the optimal three mutually perpendicular planes, which optimizes the speedy restoration of the lost biomechanical balance in the dental system. The results of quality of life indicators obtained in the postoperative period show an acceleration in the rehabilitation of mental and physical health, which predicts a favorable outcome of the underlying disease.

#### Declaration of Interest

The authors report no conflict of interest.

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