M.I. Muzikin, A.K. Iordanishvili, E.N. Zharova, O.E. Gurskaya, K.B. Abramov, I.D. Ushnitsky

FEATURES OF THE MANIFESTATION OF THE CHEWING REFLEX IN PATIENTS AFTER DENTAL REHABILIATION WITH DENTURES ON ARTIFICIAL SUPPORTS

DOI 10.25789/YMJ.2021.76.09

УДК 616.716.4-005.273-07

The aim of the presented clinical and pathophysiological study was to study the features of the formation of the chewing reflex in people with missing teeth after dental rehabilitation with orthopedic structures based on dental and / or zygomatic implants. In the course of the study, the indices of the force of compression of the dentition were studied using the method of gnatodynamometry. The indices of resting tone and compression of the masseter muscle were obtained using the method of myotonometry, the effect of occlusion on normal muscle activity was studied using EMG studies. As a result of the work carried out, it was noted that the treatment of complete loss of teeth in one or both jaws with the help of dental and zygomatic implants according to EMG data during the observation period of more than 2 years after the installation of permanent orthopedic structures does not lead to disruption of the neuro-physiological processes of the masticatory-speech apparatus and contributes to the patient's complete adaptation to the restored occlusal relationship, although it is characterized by a slight increase in the resting tone and contraction of the masticatory muscle according to myotonometry data and the force of compression of the dentition according to gnathodynamometry data.

Keywords: osteo-muscular reflex, osteoperception, physiology of the masticatory apparatus, chewing muscles, dental implantation, dental rehabilitation, prosthetics on dental implants.

Introduction. Afferent impulses in the area of the installed (osseointegrated) dental implant comes from the receptors of the jaw bone tissue into which the implant is integrated [4,16]. Taking into consideration the peculiarities and principle of the phenomenon of osseointegration, it can be assumed that the receptor apparatus of the bone tissue on the surface of the implant fully corresponds to the receptor apparatus in the thickness of the jaw bone tissue, due to which the principles of mechanotransduction are realized [1,3,10,18].

In accordance with the theory of chewing links and their functional units, the mechanism of distribution of pressure on the teeth in natural physiological conditions, as well as the generation of the frequency of chewing movements and their amplitude normally depends on the nature of the food taken and other functional indicators (muscle strength, the type of jaw closing, etc.) etc.) [2,5,7,10], and is also regulated by the receptor apparatus of the periodontium [8,14].

Neurophysiological processes in the field of dental and zygomatic implants and orthopedic structures fixed on them have not found wide coverage in modern domestic and foreign literature, although they are characterized by their specificity [2,13,15,17], especially when using full tooth-replacing structures on both jaws [11].

Purpose of the study: to study the features of the formation of the chewing reflex in patients with partial or complete absence of teeth after dental rehabilitation with orthopedic structures on dental and / or zygomatic implants.

Materials and methods: the study of the features of the formation of the chewing reflex after the completion of dental rehabilitation in people with complete absence of teeth on one or both jaws was carried out in the course of a clinical and physiological study, which included several stages. A total of 120 elderly and senile patients were examined, 80 of whom were included in groups 1 and 2 of the study and 40 people in the control group. The distribution of patients into groups is shown in Table 1.

The first part of the study included the study of the features of the functioning of the masticatory link, the supporting part of which on one or both jaws was a dental implant with a fixed orthopedic structure. A comparative analysis of the indices of the compression force of the dentition and the tone of the masticatory muscles was carried out in accordance with the theory of the functional links of the masticatory apparatus of I.S. Rubinov [8].

In the second part of the study, we studied the features of the formation of the chewing reflex after the completion of dental rehabilitation of the complete absence of teeth on one or both jaws with fixed orthopedic structures on dental and / or zygomatic implants. The control group included patients with preserved natural teeth. The first group of the study consisted of patients with included or terminal defects of the dentition, which were replaced by orthopedic structures on artificial supports - dental implants. The period after fixation of the final structure was at least 6 months in order to exclude the adaptation period. The second group of the study included patients with complete absence of teeth on one or both jaws after their replacement with a fixed orthopedic structure supported by dental or zygomatic implants; the period after fixation of the permanent denture structure was at least 2 years. Separately, in this group, clinical cases were identified with complete loss of natural

MUZIKIN Maksim Igorevich – Candidate of Medical Sciences, Lecturer of the Department of Maxillofacial Surgery and Surgical Dentistry of the Military Medical Academy, Russia, Muzikinm@gmail.com SPIN - 7169-1489; ORCID: 0000-0003-1941-7909; **IORDANISHVILI Andrey Konstantinovich** – Doctor of Medical Sciences, Scientific Secretary of MANEB, Professor of the Department of Maxillofacial Surgery and Surgical Dentistry of the Military Medical Academy. Russia, professoraki@mail.ru SPIN - 6752-6698 ORCID: 0000-0003-0052-3277; **ZHAROVA Elena Nikolaevna** – Doctor of Medical Sciences, Head of department of rehabilitation and physiotherapy exercises RNHI them. prof. A.L. Polenov - a branch of the FSBI NMITs named after V.A. Almazov, Ministry of Health of Russia, Russia, ORCID 0000-0002-4060-850X, SPIN - 6765 – 1660; **GURSKAYA Olesya Evgenievna** – Associate Professor of the Department of Pathological Physiology of the Military Medical Academy, Doctor of Medical Sciences; **ABRAMOV Konstantin Borisovich** – Deputy Chief Physician for Treatment FSBI NMITs named after V.A. Almazov, Ministry of Health of Russia, Ph.D, Kalyghanin@mail.ru ORCID 0000-0002-1290-3659., SPIN - 5615 - 4624 – д.м.н., проф., зав. кафедрой Медицинского института СВФУ им. М.К. Аммосова.

teeth in one jaw and their preservation in the other (Table 1), since this could significantly affect the results of the study (preservation of the periodontal-muscular reflex of the teeth of one of the jaws).

In the course of the study, using an electronic gnatodynamometer "Vizir-E1000" (Russia) by the method of gnatodynamometry, the indices of the force of compression of the dentition were studied. The probe of the device was placed between the teeth within the studied chewing unit, and it was suggested to clench the teeth until unpleasant sensations appeared [5, 8]. The values were determined in the area of the anterior group of teeth, premolars and molars.

Indicators of resting tone and compression of the masseter muscle itself were obtained using the myotonometry method using the Myotonometer device (Russia) [2]. All the data obtained were analyzed taking into account the location and nature of the chewing link, namely: "natural tooth - natural tooth", "natural tooth - artificial tooth supported on a dental implant" or "artificial tooth supported on a dental implant - artificial tooth supported on dental implant "(Pic. 1).

In the control group and the second study group, in addition to gnatodynamometry and myotonometry, all patients underwent electroneuromyographic (EMG) examination. Currently, in dentistry, EMG is used to assess muscle tone at rest and during voluntary contraction in order to analyze the dynamics of rehabilitation treatment in cases where it is necessary to assess the general contractile function of the muscle under study, as well as to study the effect of occlusion on normal muscle activity [6,12, 13,14,17].

The examination was carried out on the "Neuro-MEP" apparatus ("Neurosoft", Russia) by the method of surface interference and stimulation EMG. For registration, disposable surface electrodes with an adhesive layer were used. The mean amplitude of the interference EMG at rest and during contraction with mm was analyzed. masseter, temporalis on both sides. In this case, the active skin electrode was located in the projection of the motor zone of the muscle, the reference electrode was located distal, above the muscle tendon [6]. The bioelectrical activity of the masticatory muscles proper and temporal muscles was studied during the period of functional rest of the lower jaw (maximum relaxation of the masticatory muscles, with the appearance of a gap between the dentition, the jaw is held in this position by an anti-gravity reflex) and with maximum compression of the jaws, as well as a turn-amplitude analysis in accordance with domestic and foreign clinical guidelines [6,9,13].

During stimulation EMG, motor responses were obtained with mm. masseter, temporalis on both sides during stimulation of nn.trigeminus (r.mandibularis - nucl.motor.n.trigemini). The obtained values were compared with the norm according to J. Kimura (2001) and the age norm of the comparison group. Beyond stimulation EMG

The significance of differences in the mean values of independent samples was assessed using the parametric Student's test (with a normal distribution law) and the nonparametric Mann-Whitney test (with a difference from the normal distribution). The test for normal distribution was assessed using the Shapiro-Wilks test. For the statistical comparison of the proportions with the assessment of the significance of differences, the Pearson χ2 test was used taking into account the Mantel-Hansel correction for likelihood. In statistical analysis, the achieved level of significance (p) was considered, with a critical significance level of 0.05.

Research results and discussion. The indicators of gnatodynamometry and myotonometry of the masticatory muscles obtained during the examination of the control group were significantly higher in men (Pic. 2) than in women ($p \leq 0.05$), although they corresponded to similar data for older age groups described in the specialized literature [5 ,8,10]. It should also be noted that, regardless of gender, statistically significant differences were not obtained between elderly and old age patients ($p > 0.05$). In this regard, in the course of further research, the average values of the indicators of these two age groups were taken into account together.

The values of gnatodynamometry in

Table 1

Investigation of the features of the manifestation of the chewing reflex in patients with single and total orthopedic constructions on dental implants, pers. (%)

Control group		The first group of the study				Second study group			
Men	Women	Men		Women		Men		Women	
20	20	t/i	i/i	t/i	i/i	ci/r	ci/ci	ci/r	ci/ci
		12	8	10	10	5	12	11	12
20	20	20		20		17		23	
40		40				40			

Note: t – tooth; i – implant; pi – peri-implantitis; ci – complete (total) dental rehabilitation of the jaw on implants; r – jaw with remaining teeth

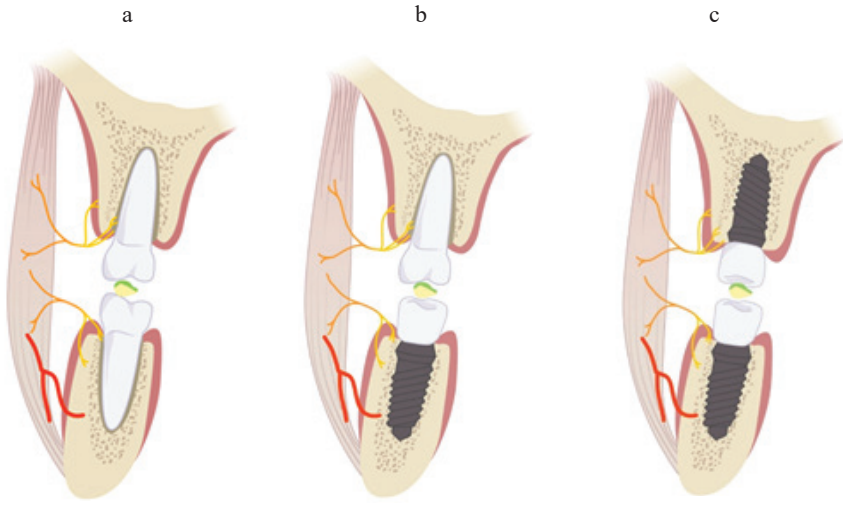

Fig. 1. Schematic representation of the studied chewing links, presented in groups: a) regulation of the function is carried out through periodontal-muscular reflexes from both jaws ("natural tooth - natural tooth"); b) regulation of the function is carried out through the osteo-muscular reflex from the lower jaw ("natural tooth - an artificial tooth supported by a dental implant"); c) regulation of the function is carried out through the osteo-muscular reflex from both jaws ("artificial tooth supported by a dental implant" on both jaws).

the first study group in the area of the frontal group, at the level of the first premolar and the first molar in the presence of masticatory links with natural teeth in these areas of the jaws, corresponded to those in the control group patients (p≥0.05). There were no significant differences in gnathodynamometry indices in patients of both sexes in the control group and the first group of the study when analyzing the masticatory link at the level of the corresponding parts of the jaws, in which a natural tooth was present on one jaw, and on the other there was an orthopedic construction on a dental implant (p≥0, 05), although it should be noted that there is a tendency to higher values in the first group of the study (Pic. 3). Indicators of myotonometry at rest and compression in the first group of the study also did not have statistically significant differences compared with those in the control group (p≥0.05). These facts were most likely associated with the presence of periodontal reflex zones and an afferent signal from them during functional studies in the system "natural tooth - artificial tooth supported on a dental implant" on one of the jaws with the formation of a periodontal-muscular reflex of the masticatory apparatus (according to I S. Rubinov).

The study of masticatory links in patients of the first study group in the presence of single orthopedic constructions on dental intraosseous implants on both jaws, on the contrary, showed that, regardless of gender, the gnatodynamometry indices obtained in all studied areas were significantly higher in relation to the control group (p≤0.05). The indicators of myotonometry, although they had higher values, did not differ statistically in comparison with the control group (p> 0.05).

Thus, according to the nature of the course of neuro-reflex processes in the masticatory link, represented by a dental implant with an artificial crown as its supporting part, as well as bone tissue receptors that perform an afferent and neuro-regulating function - regardless of the location of this masticatory link on the jaw, it is possible talk about the reduced afferentation of sensitive nerve receptors to the force of compression of the masticatory muscles (in this masticatory link) in comparison with the periodontium of natural teeth. By analogy with the terminology of I.S. Rubinov and his teachings on the functional links of the masticatory

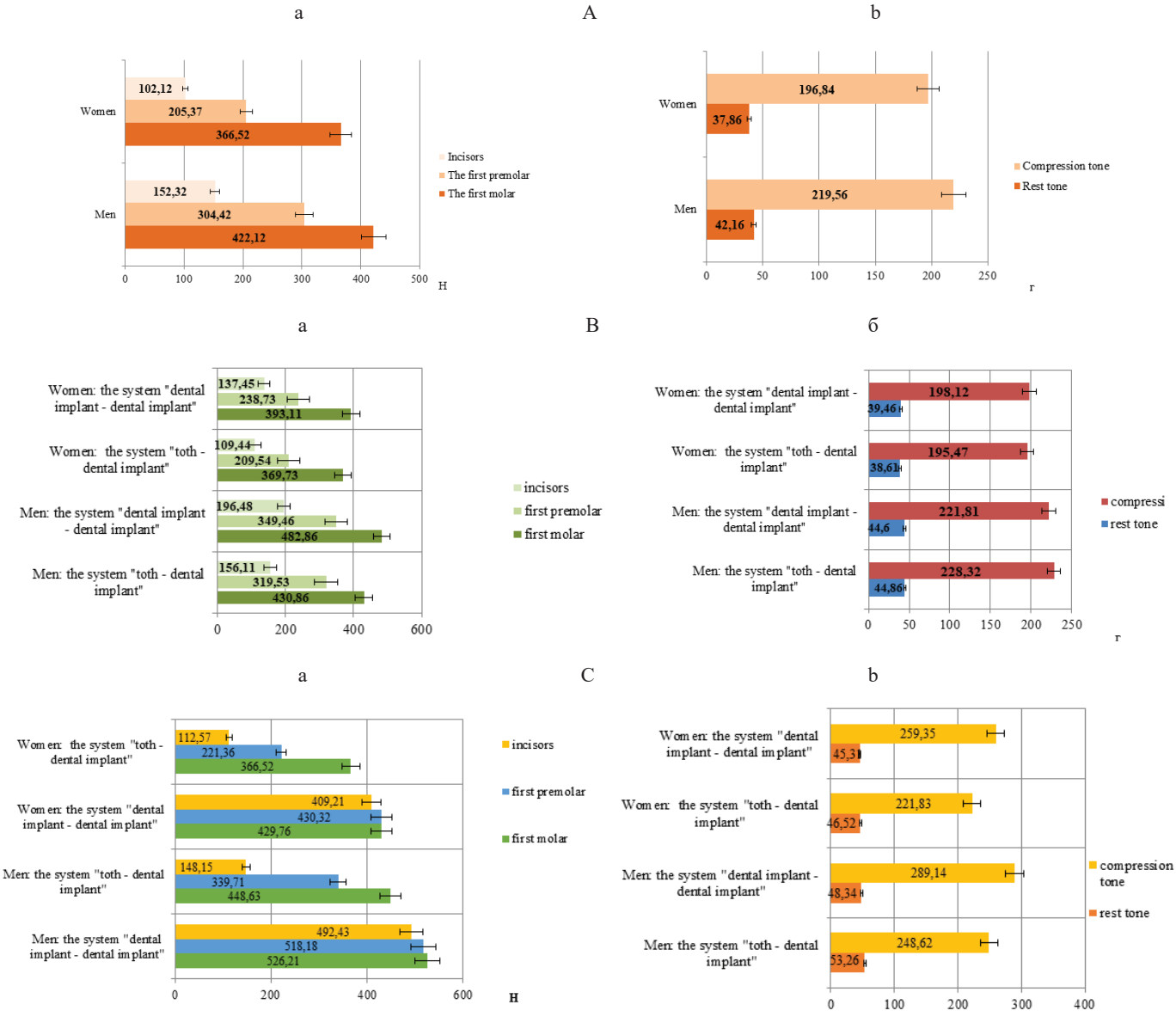

Fig. 2. Values of indicators of gnathodynamometry (a) and myotonometry (b) in patients of the control (A), first (B) and second (C) groups of the study

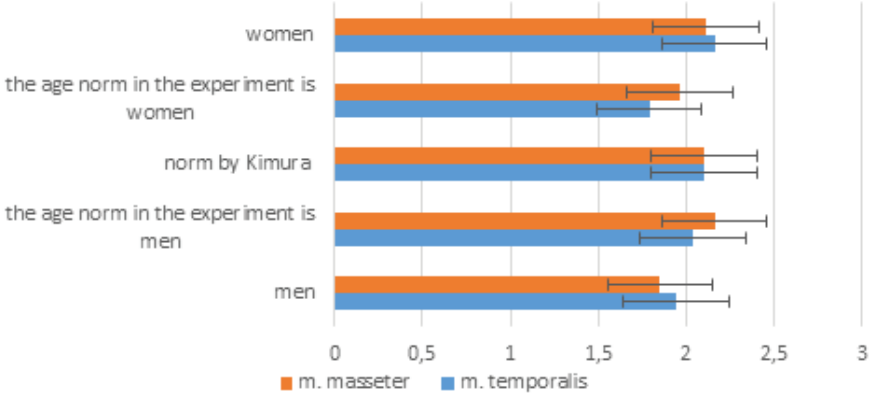

Fig. 3. Indicators of latency of motor responses (diagram men and women)

apparatus, it seems necessary to highlight the features of the manifestation of the masticatory reflex in the case of restoring the continuity of the dentition using dentures on artificial supports (dental implants) as an osteo-muscular physiological reflex. The allocation of this concept is associated with a change in the afferentation of nerve impulses in the presence of an osseointegrated tooth-replacing structure. Good adaptation of patients to different tooth-substituting structures, even after the restructuring of interconnected reflexes with complete prosthetics of both jaws, proves the normal physiological course of nervous processes, despite the increased load during chewing [3,10,11,17]. The process of adaptation of patients after dental rehabilitation to orthopedic structures on artificial supports is carried out with the interaction of a physiological reflex on stretching the masticatory muscles with the paradonto-muscular and osteo-muscular physiological reflexes of the masticatory apparatus.

The study of gnathodynamometry indicators in patients of the study group after dental rehabilitation of complete absence of teeth based on dental and zygomatic implants is shown in Picture4.

In all the presented clinical cases of the study groups, the patients showed a balanced EMG activity during compression of the dentition, which was a sign of good adaptation of the neuro-muscular system of the masticatory-speech apparatus to the occlusive state. In 3 (7.5%) patients (1 man and 2 women), there was a decrease in the amplitude of the response with an increase in its latency on one side in relation to the other side. These facts were a sign of a violation of the conductivity for n. trigeminus (m. masseter). For the purpose of an in-depth examination of these patients, needle electromyography was performed, followed by consultation with neurological specialists. In the course of the study, the data obtained from these patients were not taken into account. Further study of the amplitude and latency indices was carried out without taking into account the side of the motor response.

Picture 5 shows the indicators of the amplitude of motor responses and its latency in comparison with the age indicators of the mean values of the control group and the norm described in the literature according to J. Kimura (2001). The latency of the motor response characterizes the travel time of the impulse from the point of stimulation to the appearance of the motor response of the muscle. The average indicators of latency of motor responses in patients in the study groups did not have statistically significant significant differences. (p> 0.05), which is most likely associated with a similar average distance from the point of stimulation to the fibers of the muscle under study.

In the course of the EMG study in elderly and senile patients in the control group and in the second group of the study, a decrease in the amplitude of the motor response was observed in comparison with the normal values according to J. Kimura (2001). Based on the fact that the amplitude of the motor response characterizes the processes of depolarization and repolarization occurring in the muscle fiber, and also indirectly determines the strength of muscle contraction, the lower value of this indicator was most likely associated with older age groups of the examined patients (elderly and senile age) as follows. as the average data described in the literature are presented without taking into account age characteristics. There were no statistically significant differences between the patients of the control group and the study group in the mean values of the amplitude of motor responses (p> 0.05).

At rest, there was a constant weak tonic tension of the proper chewing and temporal muscles, which is characterized on the electromyogram in the form of an interference curve not exceeding 50 μV in amplitude. During the study of the EMG-pattern of rest, spontaneous bursts of biopotentials were not observed. The average value of biopotentials in the phase of bioelectric rest for 20 s and the phase of compression of the right and left masticatory and tem-

Table 2

Electromyographic indices of masticatory muscles at rest * (M+SD). μV

Indicators to be studied	Muscles under study			
	m. masseter (right)	m. masseter (left)	m. temporalis (right)	m. temporalis (left)
Mean value of amplitude at rest (control group) (μV)	41.3±5.7 43.2±6.1	42.8±6.3 39.5±6.5	38.4±4.2 39.2±5.1	38.6±4.6 39.5±6.3
Average value of amplitude at maximum compression (control group) (μV)	532.3±52.1 542.8±64.9	521.1±59.2 534.5±67.3	502.1±56.2 498.5±47.1	498.8±54.7 511.6±65.3
Average value of amplitude at rest (control group) (μV)	41.1±9.3 45.8±7.5	38.8±8.3 44.3±9.5	37.2±7.8 41.1±9.6	36.2±6.3 39.8±7.1
Average value of amplitude at rest (control group) (μV)	542.3±102.4 557.5±94.3	548.1±115.8 549.2±119.7	493.9±89.5 512.3±114.2	512.9±124.5 503.2±102.8

* In the numerator - the value for women. in the denominator - in men.

poral muscles are presented in Table 2.

The data obtained did not have statistically significant gender differences (p> 0.05). In the control group and the second group of the study, where the dental rehabilitation of complete adentia was performed using fixed structures on dental and zygomatic implants in the study of bioelectric activity and the turn-amplitude analysis of the biopotentials of the studied masticatory muscles, the values were comparable, and their statistical processing did not reveal differences between analyzed indicators (p> 0.05). During the interpretation of EMG indicators in the patients of the study group, no pathological spontaneous activity of the masticatory muscles was revealed, which emphasizes the normal course of neuro-muscular processes in the masticatory muscles and conductive nerves.

Conclusion. In the course of the clinical and pathophysiological study, it was noted that the treatment of complete loss of teeth in one or both jaws with the help of dental and zygomatic implants according to EMG data during a follow-up period of more than 2 years after the installation of permanent orthopedic structures does not lead to a violation of the course of neurophysiological processes of the masticatory-speech apparatus and contributes to the patient's complete adaptation to the restored occlusal relationship, although it is characterized by a slight increase in the resting tone and contraction of the masticatory muscle according to myotonometry data and the force of compression of the dentition according to gnathodynamometry data. Thus, a chewing link with a supporting part in the form of a dental intraosseous implant, in comparison with a chewing link with intact natural teeth, is characterized by a normal physiological course of nervous processes with an increased chewing load.

The results obtained in the course of the study explain the increased abrasion of structures that antagonize with dental implants, possible breakdowns of orthopedic structures, which more often occur when prosthetics supported on implants of both jaws, demonstrate the peculiarities of adaptation to fixed orthopedic structures on implants in total restorations associated with changes in afferentation and restructuring. chewing reflex, while not only justifying the feasibility of using night unloading trays, botulinum toxin injections, providing psychotherapeutic support during the adaptation period, the implementation of physiotherapeutic and other methods to prevent abrasion of natural teeth (antagonists) and excessive load of antagonizing orthopedic structures, their chips, fractures and others factors of premature functional and aesthetic unsuitability, but also prove the need already at the planning stage of the choice of modular tooth replacement structures with high by the same indicators of maintainability.

Reference

1. Аврунин А.С. Старение костной ткани. Теоретическое обоснование новых путей оптимизации процесса механотрансдукции / А.С. Аврунин, Р.М. Тихилов, А.В. Климов // Морфология. -2005; 5:19-28. [Avrunin AS, Tikhilov RM, Klimov AV. Aging of bone tissue. Theoretical substantiation of new ways to optimize the process of mechanotransduction. Morphologia. 2005; 5:19-28 (In Russ.).]

2. Балин В.Н. В развитие научных взглядов проф. И.С. Рубинова и проф. А.К. Иорданишвили на патогенез и лечение болезней пародонта. / В.Н. Балин, Л.В. Васильева // Terra Medika. -2003; №2:16-18. [Balin VN, Vasilyeva LV. In the development of scientific views of Prof. I.S. Rubinov and Prof. A.K. Iordanishvili on the pathogenesis and treatment of periodontal diseases. Terra Medica. -2003; No.2:16-18 9In Russ.).]

3. Балин Д.В. Особенности личностного реагирования при замене съемных зубных протезов на зубопротезные конструкции на искусственных опорах / Д.В. Балин, А.К. Иорданишвили, М.И. Музыкин // Российский вестник дентальной имплантологии. - 2016; №34:46-53. [Balin DV, Iordanishvili AK, Muzikin MI. Features of personal response when replacing removable dentures with denture structures on artificial supports. Rossiyskii Bulleten' dental'noy implantologii. 2016; №34:46-53 (In Russ).]

4. Иорданишвили А.К. Остеомускулярный рефлекс жевательного аппарата и его характеристика / А.К. Иорданишвили, Ф.Ф. Лосев, М.И. Музыкин // Пародонтология. - 2017; № 85(4):9-14. [Iordanishvili AK, Losev FF, Muzikin MI. Osteo-muscular reflex of the chewing apparatus and its characteristics. Parodontologia. 2017; № 85(4):9-14 (In Russ.).]

5. Иорданишвили А.К. Физиология и патофизиология жевательно-речевого аппарата: учебное пособие / Иорданишвили А.К. - СПб.: Изд-во «Человек», 2016;- 68 с. [Iordanishvil AK. Physiology and pathophysiology of the chewing-speech apparatus: a textbook. St. Petersburg: Publishing house "Chelovek". 2016; 68 (In Russ.).]

6. Арсенина О.И. Оценка функционального состояния жевательных мышц у пациентов с мышечно-суставной дисфункцией височно-нижнечелюстного сустава при использовании эластокорректора / О.И. Арсенина, А.В. Комарова, Н.В. Попова, А.В. Попова // Клиническая стоматология. - 2020; 3(95):100-107. doi: 10.37988/1811-153X_2020_3_100. [Arsenina OI, Komarova AV, Popova NV, Popova AV. Assessment of the functional state of the masticatory muscles in patients with musculoskeletal dysfunction of the temporomandibular joint when using an elastocorrector. Clinicheskaia stomatologia. 2020; 3(95):100-107. doi: 10.37988/1811-153X_2020_3_100 (In Russ.).]

7. Реабилитация пациентов с лицевыми невропатиями после хирургического лечения / Е.Н. Жарова, А.Б. Бондаренко, Е.А. Вершинина [и др.] // Известия Российской Военно-медицинской академии. - 2021; 40(S2):45-51. [Zharova EN, Bondarenko AB, Vershinina EA, et al. Rehabilitation of patients with facial neuropathies after surgical treatment. Izvestia Rossiiskoi Voenno - Medisinskoi Academii. 2021; 40(S2):45-51 (In Russ.).]

8. Рубинов И.С. Физиологические основы стоматологии / Рубинов И.С. - Л.: Медицина, 1970; 334 с. [Rubinov IS. Physiological foundations of dentistry. L: Medicine. 1970; 334 (In Russ.).]

9. Castroflorio T, Bracco P, Farina D. Castroflorio T. Surface electromyography in the assessment of jaw elevator muscles. J. Oral Rehabil. 2008; 35(8).:638-645. doi: 10.1111/j.1365-2842.2008.01864.x.

10. Dellavia C. Functional jaw muscle assessment in patients with a full fixed prosthesis on a limited number of implants: a review of the literature. Eur. J. Oral Implantol. 2014; 7(1):155-169.

11. Dellavia C, Francetti L, Rosati R, et al. Electromyographic assessment of jaw muscles in patients with All-on-Four fixed implant-supported prostheses. J Oral Rehabil. 2012; 39(12):896-904. doi: 10.1111/joor.12002.

12. Gracht I, Derks A, Haselhuhn K, et al. EMG correlations of edentulous patients with implant overdentures and fixed dental prostheses compared to conventional complete dentures and dentates: a systematic review and meta-analysis. Clin Oral Implants Res. 2017; 28(7):765-773. doi: 10.1111/clr.12874.

13. Grigoriadis A. Adaptability of mastication in people with implant-supported bridges. J. Clin. Periodontol. 2011; 38(1):395-404.

14. Korhonen R.K. Can mechanical myotonometry or electromyography be used for the prediction of intramuscular pressure. Physiol. Meas. 2005; 5:951-963. doi: 10.1088/0967-3334/26/6/006

15. Lobbezoo F. Topical review: modulation of trigeminal sensory input in humans: mechanisms and clinical implications. J. Orofac. Pain. 2002; 16(1):9-21.

16. Milovanovich P, Durich M. Innervation of bone: why it should not be neglected. // Medicinski Podmladak. 2018; 3:25-32.

17. Trulsson M, Partridge NC. From brain to bridge: masticatory function and dental implants. J. Oral. Rehabil. 2012; 2(39):858-877. doi: 10.1111/j.1365-2842.2012.02340.x.

18. Raggatt L.J. Cellular and Molecular Mechanisms of Bone Remodeling. Journal of Biological Chemistry. 2010; 285:103-108. doi: 10.1074/jbc.R109.041087.