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**NEW APPROACHES TO THE RELAXATION OF MASTICATORY  
AND NECK MUSCLES IN PATIENTS WITH MUSCULO-ARTICULAR DYSFUNCTION  
OF THE TEMPORO-MANDIBULAR JOINT**

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A new method for percutaneous electric neurostimulation of masticatory and neck muscles, based on the use of low-frequency bipolar pulsed current with a special pulse shape and parameters maximally close to the shape and parameters of the nerve fibers pulses, is suggested. The myorelaxation effect comparative analysis of the suggested method for percutaneous electric neurostimulation (PENS) by means of the developed device and the existing common PENS method with the use of the "Myomonitor J5" apparatus, which generates low-frequency unipolar pulsed current, is carried out. As a result of the obtained data processing by means of the variation statistics methods it has been proved that the use of the suggested myorelaxation method reliably provides 16-20% more effective relaxation of the masticatory and neck muscles with a longer clinical effect ( $p < 0.05$ ) than the existing widespread procedure with the use of the "Myomonitor J5" apparatus. Greater myorelaxation effect was also confirmed by electromyographic studies of masticatory and neck muscles.

**Key words:** temporo-mandibular joint, musculo-articular dysfunction, percutaneous electric neurostimulation.

*The present study is a fragment of the research project "Improvement of prosthetic techniques and materials quality in the treatment of dental patients", state registration No. 0115U000146.*

Problems of timely diagnosis and effective treatment of patients with musculo-articular dysfunction (MAD) of the temporo-mandibular joint (TMJ) are among the most urgent, important and complicated problems of modern dental orthopedics.

Despite the fact that these problems are constantly a prime focus of researchers around the world and a large number of publications are devoted to them, many issues remain understudied, debatable, and research findings obtained by different scholars are often ambiguous and even controversial. Until now, there is no commonly determined concept for treating patients with TMJ MAD.

Insufficient theoretical and clinical substantiation of many issues of diagnosis, differential diagnosis, treatment and rehabilitation of patients with TMJ MAD causes numerous difficulties in practical health care and errors in the diagnosis and treatment of this pathology, which makes patients to spend a long period of time (sometimes years) in useless, vain moving from one specialist to another without receiving adequate, effective help. The result of this is the disease transition into a chronic form, persistent irreversible disorders of the entire dento-facial system function, disability of patients. The fact that most patients with TMJ pathology do not receive timely and adequate medical care draws attention of many domestic and foreign researchers [6, 8, 11, 12].

Our own long-term clinical observations have shown that TMJ dysfunction is inextricably linked with the function disorder of masticatory muscles that are in a spasmodic, discoordinated, unbalanced state in the disease. The primary task of a dentist is to eliminate hypertonicity and spasm of masticatory muscles, to bring muscle to a normal physiological state, typical for a healthy person. Treatment of TMJ MAD today contains a package of measures, among which the leading place is occupied by the myorelaxation therapy and the therapy using occlusal bite splints, immobilizing dental splints [1, 5, 9, 10, 11]. Many scholars' research, as well as our own studies, suggest that the efficacy of treating TMJ MAD patients by means of occlusive therapeutic splints primarily depends on the accuracy of determining the correct ("true", the best) physiological central occlusion that is characteristic of healthy individuals without signs of TMJ MAD [6, 11, 15].

There are different methods for its determination, the essence of which is the relaxation of masticatory muscles that are in a discoordinated state. It can be said that the masticatory muscles relaxation is the first essential measure necessary to determine the "true" central occlusion, which ultimately influences the efficacy of TMJ MAD patients treatment.

As of today, many researchers consider the most efficient method for masticatory and the neck muscles relaxation and based on it determination of the best central occlusion and central jaw ratio to be the percutaneous electrical neural stimulation (PENS) method. This method was developed in the 1970s in the USA by Professor Bernard Jankelson, who not only suggested and substantiated this method, but also developed a special device, the "Myomonitor" apparatus. The basis of the B. Jankelson's neuromuscular concept is relaxation of the head and neck muscles, which should be a compulsory element in the diagnosis and treatment of occlusive disharmony [10, 11, 15].

Over the past years, the myomonitor by B. Jenkelson has undergone a number of improvements and at the present time, the “Myotronics Inc.” (USA) produces the fifth generation of the “Myomonitor J5” device. However, it should be noted that the author's personal clinical experience with the use of the modified method by B. Jenkelson and the “Myomonitor J5” device for treatment of TMJ MAD patients showed that this method is not free from certain shortcomings.

The main disadvantage of the method for reprogramming the masticatory and neck muscles functions, suggested for the TMJ MAD treatment, is due to the fact that the unipolar pulse current causes the muscles' motor response in a definite direction (depends on the direction of current flow through the tissue) in the zone, where electrodes are connected. After the myorelaxation procedure with such a current, there remains “memory” in the muscles, causing a systematic error in the optimal central occlusion establishment due to the modified muscle working vector, thus reducing the B. Jenkelson method's efficacy.

Therefore, there was a need to develop a new approach to the myorelaxation of masticatory and neck muscles in TMJ MAD patients, which would provide more efficient relaxation of these muscles, which is an urgent and important task for improving the treatment outcome in dental patients with TMJ MAD.

**The purpose** of the study was to develop and implement into the clinical practice a new method for masticatory and neck muscles relaxation, based on the percutaneous electric neurostimulation (PENS), to provide deeper and more efficient relaxation of these muscles compared to the existing PENS methods which would permit to improve the quality and to minimize the time of treatment for TMJ MAD patients.

**Materials and methods.** To achieve the purpose of the study, 72 patients were selected who sought medical attention by themselves with typical complaints or were referred by other doctors to the multifield dental clinic - the Republican Center for Dental Implantation (RCDI) in Kharkiv being suspected of having a TMJ disease in 2017-2018. As a result of a thorough clinical examination of the dento-facial system in patients according to the established procedure [7, 14], including the use of special examination methods (functional and radiation ones) in 60 patients (83%), the musculo-articular TMJ dysfunction was diagnosed. All patients have given the voluntary informed consent to participate in the study. The age of patients ranged from 18 to 68 years, men were 17 out of 60 (28%), and women - 43 (72%).

To study the efficacy of various methods for relaxing masticatory and neck muscles and to perform a comparative analysis of 60 patients, 2 groups of 30 persons were formed by the stratification randomization method, because this method of forming groups to the greatest extent ensures their homogeneity, which is decisive to ensure reliability of the results.

More than 70% of the patients in each group fall on young people (up to 45 years of age according to the WHO classification of 2017). The mean age of patients in the main group was  $38.8 \pm 1.1$  years, while that in the comparison group amounted to  $37.4 \pm 1.2$  years. The number of women in each group exceeded the number of men almost three times. As to the duration of the disease, in the main group there were 8 persons (27%) being treated up to 3 months, 6 patients (20%) - over 12 months, and in the comparison group there were 9 (30%) and 5 (17%) patients respectively.

In patients of the comparison group, the masticatory and neck muscles relaxation was carried out according to the common PENS procedure using the “Myomonitor J5” apparatus, which is detailed in a number of publications [11, 15]. The muscle relaxation procedure lasted 60 minutes. It is necessary to determine the physiological rest position of the mandible and to fix the optimal occlusion.

In the main group patients, the masticatory and neck muscles relaxation was performed according to the author's technique by affecting the muscles with the low-frequency bipolar impulse current with a special pulse shape maximally close to the shape of pulses in nerve fibers for 30 minutes (the utility model patent of Ukraine No. 59315 dated May 10, 2011 [2]). The source of the pulsed current was a special electronic device for muscle relaxation, developed by the author (the utility model patent of Ukraine No. 86404 dated 12.25.2013 [3]).

The statistical processing of the obtained quantitative indices was carried out using by means of the variation statistics methods using the Microsoft Excel 2007 software. To determine the homogeneity of the groups under study, the Pearson's (chi-square) criterion was applied. The mean values of the indices are represented as  $M \pm m$ , where  $M$  is the arithmetic mean,  $m$  - standard mean error. The statistical reliability assessment of the difference between the mean values of the indices in the main group and those in the comparison group was performed using the Student's t-criterion (being preliminary checked to be assured in the normal law of the random variable distribution). The difference was considered to be reliable at the level of statistical significance  $p < 0.05$ .

**Results of the study and their discussion.** As a result of a functional clinical examination of the dento-facial articular system in patients, it was revealed what particular clinical TMJ MAD symptoms occurred the most frequently among the patients in the both groups (Table 1).

Table 1

**Frequency of detecting the main TMJ MAD symptoms in patients of the both groups**

Symptom	Main group*		Comparison group*	
	n	%	n	%
Number of patients	30	100	30	100
Tenderness to palpation in TMJ	29	97	28	99
The presence of noise in the joints (clicks, crunch, crack, crepitation) in different phases of opening or closing the mouth	27	90	26	87
Tenderness to palpation in TMJ	23	77	25	83
Decreased height of the lower third of the face	26	87	24	80
Facial asymmetry	20	67	22	73
Lower jaw movements disorder (deflection, deviation)	24	80	23	77
Limited opening of the mouth, including the maximum opening of the mouth, mm				
20-27	2	7	2	7
28-32	11	36	10	33
33-37	9	30	8	27
38-40	2	7	3	10

Note: \* - the groups are homogeneous by the frequency of the main TMJ MAD symptoms detection in accordance with the Pearson chi-squared test at the significance level of  $p < 0.05$ .

Most of these major TMJ MAD symptoms are primarily due to hyperactivity, long-term spasm, discoordination of masticatory muscles, imbalance in the activity of masticatory muscles and TMJ. Myorelaxation therapy is aimed at eliminating these pathological conditions.

The content of the suggested new approach to myorelaxation of masticatory and neck muscles and the developed treatment procedure lie in the following.

At the beginning of the procedure, the places of the electrodes connection on the skin are determined, deprived of fat with a cotton swab soaked with 70% alcohol solution. These places are symmetrically located on the right and left on the cheeks in front of the ear antilobium below the cheekbone arch. The other two points of the electrodes connection are located on the back, in its upper part, in the area of the 7th cervical vertebra acantha (about 5 cm to the right and to the left of it) over the trapezius muscle. That is, 4 electrodes with the conductive gel are used. From the device, generating the pulsed current, 4 cables with clips for connection to the electrodes outgo. After switching on the device, the amplitude of pulses is set on the keyboard, focusing on the patient's sensation: from 0 to the occurrence of a slight acanthesthesia (marginal pain sensation). The session was carried out for 30 minutes in 2 stages of 15 minutes each, changing the mode of electrical potentials. The electric neurostimulation is performed by "packets" of individual pulses having a special shape (short front and exponential recession) with alternating polarity. During the sessions, the electric neurostimulation mode was selected individually for each patient, depending on the severity of the disease clinical manifestations, functional and morphological disorders of the TMJ and muscles, as well as on the patient's general condition by setting parameters within a certain range and operating the device using the developed software (tab. 2).

Table 2

**Recommended modes of masticatory and neck muscles relaxation according to the suggested method**

Parameters	Range of changing the impact parameters	Stage I	Stage II
Cumulative exposure – T, minutes	20-30	10-15	10-15
Duration of the pulse "packet" - $t_{imn}$ , sec.	1-10	8-10	1-1,5
Duration of the pulse "packets" interval - $t_{in}$ , sec.	1-12	1.5-2	1-1.5
Amperage – I, $\mu A$	2-15	2-10	12-15
Pulse rate in the "packet" - f, Hz	1-10	9-10	2-3

It is advisable to additionally detect trigger zones and to perform the masticatory muscles electric neurostimulation in two stages. At the first stage, the trigger zones massage is carried out in the mode shown in table 2. At the second stage, the general stimulation and relaxation of the entire damaged zone is carried out in the mode presented in the same table. Simultaneously, functional blocks in the spinal-locomotor segments of the cervical spine are eliminated.

At the end of the procedure, the masticatory muscles begin to contract, synchronously raising and lowering the lower jaw and setting it into its natural (physiological) position. This moment is optimal for fixing the true (right) central occlusion. After the masticatory and neck muscles relaxing, the lower face height was determined by the anatomical and physiological method and the correct physiological central occlusion was fixed with A-silicone material for matching the models in the articulator and manufacturing occlusal

dental bite splints. The myorelaxation effect of the PENS procedure can be objectively assessed by such an important index as the maximal mouth opening width which is limited in TMJ MAD patients due to the muscle spasm. Thus, the easiest way to detect the muscles relaxation degree, to remove hypertonicity and spasm using various muscle relaxation techniques, without electromyography, is to measure the maximum mouth opening width in patients with an electronic device (to ensure accuracy of measurements) after the procedure. This parameter was measured between the cutting edges of the front upper and lower incisors by the OSHLUN (USA) electronic dial caliper before the muscle relaxation procedure, 30 minutes after the procedure, 1 day, 5 days (the period for making occlusal dental bite splints) in patients of the both groups. The results of the measurements were statistically processed and compared with the norm. According to various scientific sources, the normal mouth opening width in healthy individuals is 40 to 50 mm.

To determine the reference value of the mouth opening width that can be taken as the norm in this study for comparison with the indices of the both groups, a control group was examined including 24 conventionally healthy persons aged 18 to 60 years, who had intact dental arches, orthognathic occlusion, did not complain of masticatory muscles and TMJ and had no signs of TMJ MAD. As a result of measuring the maximum mouth opening width by the same instrument according to the accepted method in this group of individuals, a mean value of 47.0±1.1 mm was obtained, which was accepted for the norm in the present study.

The results of the study are presented in table 3.

Table 3

**Mean values of the maximum mouth opening in patients width in patients of the main and the comparison group**

Control terms	Main group		Comparison group	
	Abs., mm	relative norm, %	Abs., mm	relative norm, %
Reference value	47.0±1.1	100	47.0±1.1	100
Before the myorelaxation procedure	32.1±2.4*	63.3	31.9±2.6	67.9
30 minutes after the procedure	45.3±1.2**	96.4	39.2±1.3	83.4
After 1 hour	48.3±0.5**	102.7	40.4±1.1	86.0
After 1 day	48.0±0.5**	102.1	40.1±1.2	85.3
After 5 days	46.8±0.4**	99.6	39.5±1.3	84.0

Note 1: \* - the difference between the mean values of the both groups indices before the myorelaxation procedure is statistically insignificant ( $p > 0.05$ ) in accordance with the Student's t-criterion.

Note 2: \*\* - the difference between the mean values of the both groups indices after the myorelaxation procedure is statistically reliable ( $p < 0.05$ ) in accordance with the Student's t-criterion.

According to the given data, using the suggested muscles relaxation technique by means of the developed device permits to achieve a more complete and deep relaxation of masticatory and neck muscles due to the muscle spasms elimination, which was confirmed by the 16-20 % larger (in different periods of time) mouth opening amplitude in patients of the main group compared to the second group after a myorelaxation session. A significant myorelaxation effect was confirmed by the electromyographic study performed in half the patients of the both groups and showed a reduction and significant alignment of the masticatory muscles tonicity, which had been elevated and asymmetric before the myorelaxation procedure.

To assess the efficacy of the suggested technique for masticatory and neck muscles relaxation, a comparative analysis of the suggested PENS method effect using the developed device and the above-mentioned common PENS method using the "Myomonitor J5" apparatus was performed (table 4).

Table 4

**Comparative characteristics of the myorelaxation therapy efficacy with application of the suggested and the traditional PENS methods**

Indices	Index value			
	suggested method with the developed device		B. Jankelson's method with "Myomonitor J5" apparatus	
	n	%	n	%
Total number of patients	30	100	30	100
Number of patients, whose pain sensations in masticatory muscles and TMJ have completely disappeared or significantly reduced	28	93	25	83
Number of patients who have significantly improved their psychoemotional state	27	90	24	80
Number of procedures for a course of treatment:				
- with the disease duration of up to 1 year	3-4		8-9	
- in the presence of "extend" masticatory and neck muscles contracture	5-6		10-12	
Single session duration, min.	30		60	
Number of patients, who complained of the discomfort during the procedure	none		5	16

The clinical trial results are one more confirmation and supplement to the scientific data obtained by other researchers regarding the high efficacy of the PENS method for the masticatory and neck muscles relaxation in TMJ MAD patients. Our study is also consistent with the data obtained by other researchers about the positive effect of the PENS procedures on normalization of the psycho-emotional state in patients, which is important, and in many cases is even of a leading importance in the TMJ MAD treatment [1, 4, 5, 8, 10, 13]. However, in most published studies it is noted that the course of PENS treatment procedures is not less than 10-12 procedures [1, 10, 13], and sometimes needs even 14-15 daily sessions. [4]. Moreover, the presented methods provide for the mandatory addition of other physiotherapeutic procedures: electro-, ultraphonophoresis, magneto- and laser therapy, etc. to the PENS procedures [3, 4, 10]. The suggested PENS method does not require them.

The main advantage of the suggested technique is that it permits accurate and objective determination of the true (correct, optimal) physiological central occlusion and central jaw ratio, which is decisive for the efficient treatment of TMJ MAD patients with occlusal dental bite splints.

The developed device is portable, simple in design and easy in control, and it is by several times cheaper than imported devices with similar functions.

Contra indications to the developed device application are the same as those for the similar devices. They are: the presence of a cardiac pacemaker in the patient, epilepsy, malignant neoplasms in the history, pregnancy, high blood pressure and other general contraindications for physiotherapeutic procedures.

### Conclusion

The performed studies prove that the suggested technique of masticatory and neck muscles relaxation using the developed device permits to provide deeper and more efficient relaxation of masticatory and neck muscles in comparison with traditional methods, in particular, with the common established method, using "Myomonitor J5" apparatus, which permits more efficient treatment of patients with muscular and articular TMJ dysfunction, and also significantly improves the quality of orthopedic and (or) orthodontic treatment of patients with various occlusion disorders.

The steady clinical effect obtained in the treatment of TMJ MAD patients, confirmed by more than 5 years of many patients dispensary monitoring, as well as a significant reduction in the time and cost of treatment and rehabilitation of patients, provides all grounds to recommend the suggested method for implementation in the clinical practice, which will have not only high medical effect, but also socio-economic efficiency.

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## Реферати

**НОВІ ПІДХОДИ ДО РЕЛАКСАЦІЇ  
ЖУВАЛЬНИХ М'ЯЗІВ І М'ЯЗІВ ШІЙ  
У ПАЦІЄНТІВ З М'ЯЗОВО-СУГЛОБОВОЮ  
ДИСФУНКЦІЄЮ СКРОНЕВО-  
НИЖНЬОЩЕЛЮПНОГО СУГЛОБА**

Боян А.М.

Запропоновано нову методику черезшкірної електронейростимуляції жувальних м'язів і м'язів ший, засновану на використанні низькочастотного біполярного імпульсного струму зі спеціальною формою і параметрами імпульсів, максимально наближених до форми і параметрів імпульсів в нервових волокнах. Проведено порівняльний аналіз міорелаксаційного ефекту застосування запропонованої методики черезшкірної електронейростимуляції (ЧЕНС) за допомогою розробленого пристрою та існуючої поширеної методики ЧЕНС з застосуванням апарату «Міомонітор J5», який генерує низькочастотний однополярний імпульсний струм. В результаті обробки одержаних даних методами варіаційної статистики доведено, що використання запропонованої методики міорелаксації достовірно забезпечує на 16-20% більш ефективне розслаблення жувальних м'язів і м'язів ший з більш тривалим клінічним ефектом ( $p < 0,05$ ), ніж існуюча поширена методика зі застосуванням апарату «Міомонітор J5». Більший міорелаксаційний ефект було підтверджено також електроміографічним дослідженням жувальних м'язів і м'язів ший.

**Ключові слова:** скронево-нижньощелепний суглоб, м'язово-суглобова дисфункція, черезшкірна електронейростимуляція.

Стаття надійшла 3.07.18 р.

**НОВЫЕ ПОДХОДЫ К РЕЛАКСАЦИИ  
ЖЕВАТЕЛЬНЫХ МЫШЦ И МЫШЦ ШЕЙ  
У ПАЦИЕНТОВ С МЫШЕЧНО-СУСТАВНОЙ  
ДИСФУНКЦИЕЙ ВИСОЧНО-  
НИЖНЕЧЕЛЮСТНОГО СУСТАВА**

Боян А.М.

Предложена новая методика чрезкожной электронейростимуляции жевательных мышц и мышц шеи, основанная на использовании низкочастотного биполярного импульсного тока со специальной формой и параметрами импульсов, максимально приближенных к форме и параметрам импульсов в нервных волокнах. Проведен сравнительный анализ миорелаксирующего эффекта применения методики чрезкожной электронейростимуляции ЧЕНС с помощью разработанного устройства и распространенной методики с применением аппарата «Миомонитор J5», который генерирует низкочастотный однополярный импульсный ток. В результате обработки полученных данных методами вариационной статистики доказано, что использование предложенной методики миорелаксации достоверно обеспечивает на 16-20% более эффективное расслабление жевательных мышц и мышц шеи с более длительным клиническим эффектом ( $p < 0,05$ ), чем существующая методика с применением аппарата «Миомонитор J5». Большой миорелаксирующий эффект был подтвержден также электромиографическим исследованием жевательных мышц и мышц шеи.

**Ключевые слова:** височно-нижнечелюстной сустав, мышечно-суставная дисфункция, чрезкожная электронейростимуляция.

Рецензент Аветіков Д.С.

DOI 10.26724/2079-8334-2019-2-68-25-29

UDC 616.613-002-036.1-036.4:616.12-073.432.19]-053.2

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**LEFT VENTRICULAR GEOMETRY IN CHILDREN WITH CHRONIC PYELONEPHRITIS  
AT EARLY STAGES OF THE CHRONIC KIDNEY DISEASE**

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The purpose of the study was to determine the features of the left ventricular geometry in children with chronic pyelonephritis at the initial stages of the CKD. The tendency towards a gradual increase of the left ventricular cavity with the chronic kidney disease progression has been established, so that in patients of group 3 the end-diastolic index and the end-systolic index were significantly different from the statutory indices. A statistically significant increase in the of myocardial mass index was recorded in patients of the 1 st ( $p = 0.02$ ), 2nd ( $p = 0.016$ ) and 3rd ( $p < 0.001$ ) groups. In general, left ventricular hypertrophy was determined in 15.4% of patients in the 1st group, 36.7% - in the 2nd group, 47% - in the 3 rd group. In children with chronic pyelonephritis from the early stage of chronic kidney disease, processes of left ventricular remodeling occur, which are characterized by the formation of predominantly eccentric hypertrophy.

**Key words:** children, chronic pyelonephritis, chronic kidney disease, hypertrophy of the left ventricle

*The study is a fragment of the research project "Development of methods for diagnosis and correction of the target organs hemodynamics disorders in somatic diseases accompanied by cardiovascular complications in children", state registration No. 0116U004963.*

Cardiovascular diseases (CVD) are the most important concomitant pathologies affecting the long-term survival of patients with the chronic kidney disease (CKD) [6]. As in adults, cardiovascular pathology leads to the majority of deaths in children with CKD, since these patients have a high prevalence of traditional and uremia-associated risk factors for cardiovascular diseases [9, 15]. In children and adolescents with CKD, cardiovascular complications usually have a subclinical course, starting their development at the early stages [12, 13]. Among cardiovascular pathologies in patients with CKD both in