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# THE CONDITION OF THE MASTICATORY MUSCLE GROUP IN THE TREATMENT OF PATIENTS WITH REDUCED OCCLUSION HEIGHT

# STAN GRUPY MIĘŚNI ŻUCIA PODCZAS LECZENIA PACJENTÓW Z OBNIŻONĄ WYSOKOŚCIĄ ZGRYZU

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C. Data analysis/statistics
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**Summary**

**Background.** Dysfunction of the masticatory muscle group occurs in all types of masticatory system pathology. This is sometimes associated with changes in the musculoskeletal system, which are manifested in hypertension and hypotonia of the masticatory group of muscles, that cause a decrease in occlusal height.

**Material and methods.** There were 123 patients enrolled, aged 35-54 years, who were made temporary fixed, fiberglass-reinforced plastic prostheses for the upper or lower jaw. There are several methods to improve the quality of orthopedic treatment with fixed bridges with reduced occlusal height, considering the condition of the masticatory muscles. One is the use of temporary fixed structures that provide a gradual increase in occlusal height, allow muscles to adapt to new conditions, and promote restructuring of "usual" myostatic reflexes.

**Results.** To examine the effect of fixed structures on the m. masseter and m. temporalis, a technology for the manufacture of advanced temporary bridges was developed. This allowed us to study the process of masticatory muscle group adaptation to fixed orthopedic structures kept on the abutment teeth of patients without fractures for 6 months. In addition, it was possible to prepare the dental and maxillofacial system for permanent orthopedic treatment.

**Conclusions.** Determination of the average total values of m. masseter and m. temporalis allowed us to establish the most effective intervention for patients with reduced occlusion height before, 1 month, and 6 months after temporary orthopedic treatment. There was a tendency for patients of all groups to approach the absolute symmetry.

**Keywords:** masticatory muscles, dental occlusion, electromyogram, masseter muscle, temporalis muscle

**Streszczenie**

**Wprowadzenie.** Dysfunkcja grupy mięśni żucia występuje we wszystkich rodzajach patologii układu żucia. Jest to niekiedy związane ze zmianami w układzie mięśniowo-szkieletowym, które objawiają się hipertensją i hipotonią grupy mięśni żucia, które powodują obniżenie wysokości zgryzu.

**Materiał i metody.** W badaniu wzięło udział 123 pacjentów w wieku 35-54 lat, u których wykonano tymczasowe stałe protezy z tworzywa sztucznego wzmocnionego włóknem szklanym dla górnej lub dolnej szczęki. Istnieje kilka metod poprawy jakości leczenia ortopedycznego za pomocą mostów stałych o zredukowanej wysokości zgryzu, uwzględniających stan mięśni żucia. Jedną z nich jest zastosowanie tymczasowych konstrukcji stałych, które zapewniają stopniowe zwiększanie wysokości zgryzu, pozwalają mięśniom na adaptację do nowych warunków oraz sprzyjają przebudowie „zwykłych" odruchów miostatycznych.

**Wyniki.** W celu zbadania wpływu stałych struktur na mięśnie żwaczy i mięśnie skroniowe, opracowano technologię wytwarzania zaawansowanych mostów tymczasowych. To pozwoliło na zbadanie procesu adaptacji grupy mięśni żucia do stałych struktur ortopedycznych pozostawionych na zębach filarowych u pacjentów bez pęknięć przez okres 6 miesięcy. Ponadto stało się możliwe przygotowanie układu stomatologicznego i szczękowo-twarzowego do stałego leczenia ortopedycznego.

**Wnioski.** Wyznaczenie średnich wartości całkowitych mięśni żwaczy i mięśni skroniowych pozwoliło na ustalenie najkorzystniejszego zabiegu dla pacjentów z obniżoną wysokością zgryzu przed leczeniem, 1 miesiąc i 6 miesięcy po tymczasowym leczeniu ortopedycznym. U pacjentów wszystkich grup zaobserwowano tendencję do zbliżania się do symetrii bezwzględnej.

**Słowa kluczowe:** mięśnie żucia, zgryz, elektromiogram, mięsień żwacz, mięsień skroniowy

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## Introduction

The number of patients in need of orthopedic treatment, which relates to a decrease in occlusal height, has increased in recent years. The prevalence of such a symptom complex is up to 40% among the Ukrainian population [1]. Decreased bite height is often accompanied by changes in the musculoskeletal system, which can be manifested as hypertension and hypotonia of the masticatory muscle group [2]. In addition, when drawing up an orthopedic treatment plan, patients often do not consider the condition of the muscles, which leads to complications that occur after continuous orthopedic treatment. These are characterized by chipping of the facing material, and pathological changes to the temporo-mandibular joint, masticatory muscle group, and local blood circulation [3]. The decrease in occlusal height, which occurs when the vertical size decreases and the inter-occlusal distance increases, is important [4]. With the loss of each tooth, the inter-occlusal distance decreases unevenly, which is further influenced by several factors, including age, the presence and location of the remaining teeth, and the presence of removable orthopedic structures in the patient's oral cavity [5]. Masticatory dysfunction occurs in all types of pathology of the masticatory system simultaneously with changes in structure [6]. The aesthetic aspect and the electrical excitability of the pulp are however violated, which ultimately creates downstream problems, including an increased risk of developing complications [7,8]. The actual number of patients with reduced occlusion height is difficult to determine, because the problem of decreasing occlusion height is relevant around the world [9-16]. At the same time, the issue of diagnosing the condition of the masticatory muscle group, which accompanies the decrease in bite height, as well as their interaction, reactions and interdependence in the treatment process is insufficiently studied.

Bubnov [17] proposed the ultrasonic identification of trigger points to diagnose muscle contractility and detect trigger points in myofascial pain syndrome. Some patterns that must be considered when opening the bite, namely, the optimal opening of the bite cannot exceed 3-4 mm, which is equal to the state of physiological rest, and causes almost no changes in muscle tone [18]. Most forms of occlusion height reduction are local and can be treated passively. Zokol et al. [19] proposed to gradually increase the bite height by 3 mm, and include in the treatment process physical therapy, the purpose of which is both static and dynamic muscle elongation.

The modern dental industry offers many materials for the restoration of individual teeth, and occlusion in general. However, they require a thorough scientific comparison. Therefore, the aim of this study is to increase the effectiveness of preparation for orthopedic treatment in a patient with partial tooth loss and a reduced bite height, based on data from a multi-parameter electromyographic study.

## Material and methods

This study enrolled 123 patients aged 35-54 years. The patients were divided into three groups. Group 1 (n=32) included participants with a reduced bite height of 0-2 mm, who were fitted with temporary plastic, fiberglass-reinforced prostheses for the upper or lower jaw, depending on the initial clinical indication. Group 2 (n=31) included patients with a reduction in occlusal height of 3-4 mm in the frontal area, who were fitted with temporary plastic, fiberglass-reinforced plastic prostheses for the upper or lower jaw, depending on the initial clinical indication. Patients in group 3 (n=30) had a reduction in bite height of 5 mm and were fitted with two temporary plastic, fiberglass-reinforced prostheses for the upper and lower jaws (Figure 1).

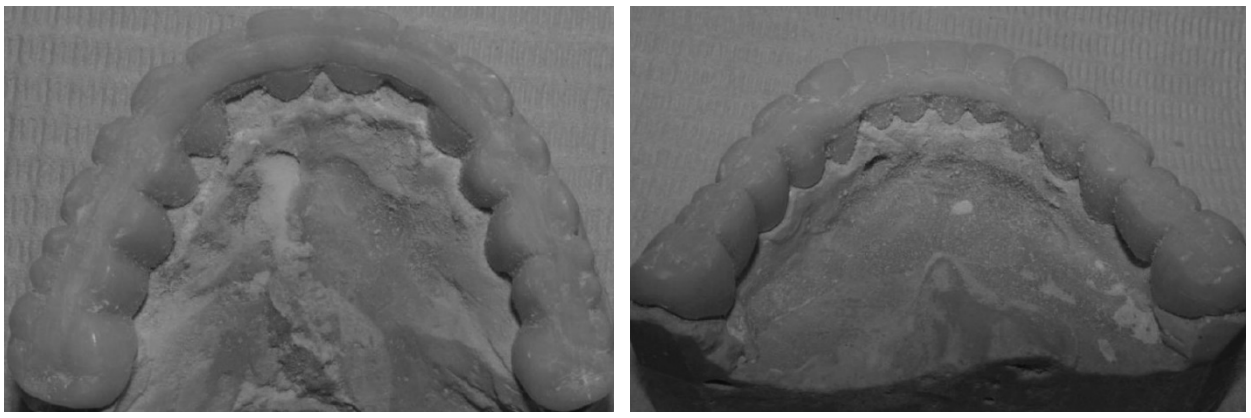


**Figure 1.** Ready unpolished prostheses on the model

The control group included 30 healthy individuals with intact dentitions belonging, having orthognathic occlusion, without concomitant pathologies and complaints of symptoms characteristic of the temporomandibular joint diseases.

As a basis for determining the degree of reduction in the height of the bite, the method of anthropometric determination of standard sizes of tooth crowns described by Radlinsky was chosen [20]. In masticatory muscle, palpation was used to inform differential diagnosis, and was performed according to the method described by Skorykova [21].

The program used to examine the bioelectrical activity of masticatory muscles was carried out at the "Neuro-EMG-Micro" electromyographic complex, which was designed to study the human nervous and muscular systems by recording and analyzing their electrical signals.

A special computer program "DiagnosticDocExtractor" was developed for the automated calculation of masticatory sample data, as well as calculation of the Ferrari index and the average total value of electromyograms.

In order to study the effect of fixed structures on the masticatory muscle group, including the superficially located m. masseter and m. temporalis, a technology for the manufacture of advanced temporary bridges was developed. This allowed us to study the process of adaptation of the masticatory muscle group to fixed orthopedic structures and kept on the abutment teeth of patients without breakage for 6 months [22-23].

After preliminary modeling of the bridge frame, it was prepared according to the rules of preparation of abutment teeth for adhesive bridge prosthesis by double reinforcement technology using fiberglass beams and tapes. Thus, two-support platforms with a step-like transition between them, a depth of no more than 2 mm on the masticatory and proximal surfaces, a width of no more than 1.5-2 mm, the main platform ended at the contact point so as not to break the point contact of the dentition. To ensure that the material did not touch the gingival papilla, an additional area on the masticatory surface was formed in the projection of the enamel-dentin border of the unprepared tooth to half of the masticatory surface of the tooth in the case of premolars and molars. In the case of a dentition defect in the frontal part, fiberglass tape or beam reinforcement from the oral surface was used. This was due to the difficulty of fixation, or the need for excessive preparation of abutment teeth in the case of double reinforcement technology.

Fiberglass elements were selected on the principle of basic physical indicators of strength and elasticity, which were as close as possible to similar indicators of plastic. They were fitted and placed in the prepared places of the prosthesis frame, after which the final modeling of the bridge prosthesis was performed. The makeshift bridge was polymerized in a dental pneumo-polymer for 30 min at a temperature of 125 ºC and a pressure of 6 Bar. The prosthesis was then processed, fitted and fixed in the patient's mouth according to generally accepted rules. The study of the dynamics of changes in the m. masseter and m. temporalis muscles in preparation for permanent orthopedic treatment of patients was performed through a multi-parametric electromyographic study before treatment, 1 week after treatment, as well as 1, 3, and 6 months after fixation in the patient's oral cavity of temporary orthopedic design.

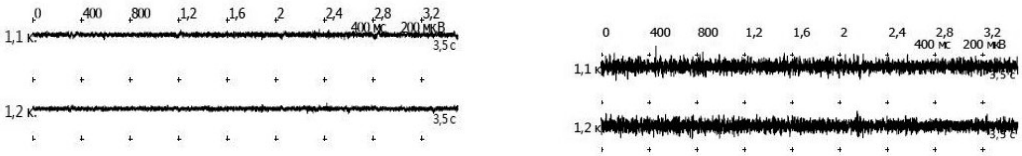
Initially, a qualitative assessment of electromyograms was performed, after which a visual preliminary assessment of electromyograms was performed. The process of changing myostatic reflexes of the masticatory muscle group was characterized by gradual change of electromyograms in the process of observation to similar forms of electromyograms in the control group.

The study was approved by the Ethics Committee of the Faculty of Dentistry of Ivano-Frankivsk National Medical University, Ukraine. The comprehensive clinical examination of patients was performed at the clinic of the Department of Dentistry of the Research and Training Institute of Postgraduate Education of Ivano-Frankivsk National Medical University. All procedures relevant to research involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee, and with the 1964 Helsinki declaration and its later amendments, or comparable ethical standards. Informed consent was obtained from all the study participants. All the subjects who completed the institutional survey gave consent for anonymized data to be used for publication purposes.

All statistical calculations were performed using the program Statistica 6.0.

**Results**

The qualitative characteristics of electromyograms before temporary orthopedic treatment of all patients, especially those included in groups 2 and 3, were characterized by a violation in structure and filling. In particular, all patients in group 3 had a significant decrease in the amplitude of bioelectric activity of the masticatory muscles, except for the sample that reflected the state of relative physiological rest of the jaws, where there was an increase in the amplitude of bioelectrical activity (Figures 2 and 3).



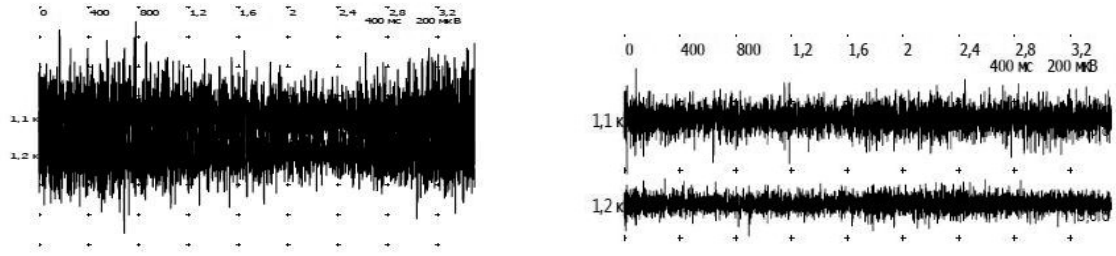

A) B)

**Figure 2.** Comparative characteristics of m. masseter interference electromyograms in the state of relative physiological rest of the control group (A) and patients in group 3 (B)


A) B)

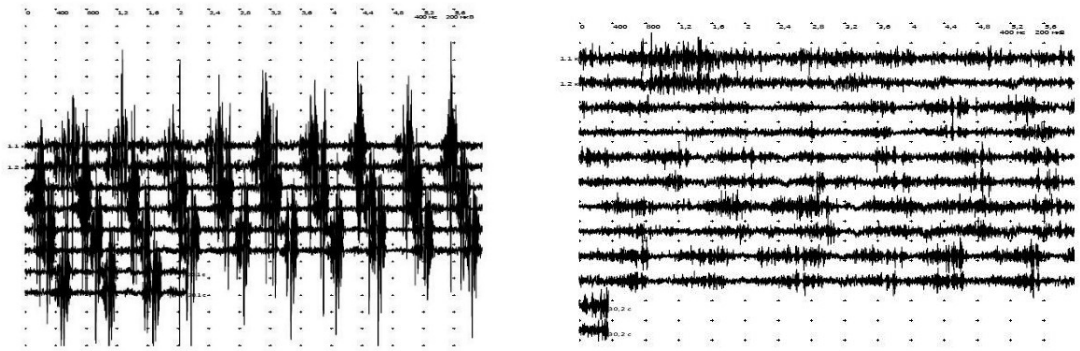
**Figure 3.** Comparative characteristics of m. masseter interference electromyograms at maximum mouth opening of the control group (A) and patients in group 3 (B)

At the maximum compression of the jaws, there were violations or absence of the structure of the electromyogram in the form of a "continuous cylinder", which was due to the development of neuromuscular fatigue and tension. This explained the shape of the electromyograms on a type of "spindle". In the state of relative physiological rest, and at the test of maximum opening of the mouth due to the activation of compensatory capabilities, the highest rates were shown for patients in group 2, which ranged from 59.02±5.19 μV ($p$<0.001) for the right m. masseter in the state relative physiological rest, to 187.94±14.58 μV ($p$>0.05) for the left m. masseter at the test of maximum compression of the jaws. At the test of maximum compression of the jaws, there was a significant decrease in maximum amplitudes (μV) of patients in group 3, which ranged from 283.98±21.80 μV ($p$<0.001) for the right m. masseter to 388.46±38,91 μV ($p$<0.001) for the right m. temporalis (Figures 4 and 5).




A) B)

**Figure 4.** Comparative characteristics of m. masseter interference electromyograms at maximum compression of the jaws of the control group (A) and patients in group 3 (B)



A) B)

**Figure 5.** Comparative characteristics of m. masseter interference electromyograms when performing chewing test of the control group (A) and patients in group 3 (B)

The data of the average total work of m. masseter and m. temporalis clearly demonstrated the mutual compensation of these muscle pairs. In all cases, except for the sample of maximum mouth opening, where the highest rate before treatment was observed in group 2: 166.03±11.12 μV ($p$>0.05), there was a decrease in maximum amplitudes depending on the severity of the pathological condition. Also, before treatment, there was significant variability in the reduction of muscle symmetry, which ranged from 68.56±3.66% ($p$<0.01) (m. temporalis in group 3) to 85.22±2.00, 10% ($p$>0.05) (in group 1). Some parameters of the turno-amplitude analysis by Willison show the severity of the process. In particular, patients of all groups had a violation of the masticatory muscles (Figure 6).

**Figure 6.** A patient in group 3 who presented with decreased muscle symmetry before treatment

When monitoring patients, it is necessary to monitor the dynamics of changes in superficial electromyograms over 6 months when performing a maximal compression test of the jaws. This demonstrated the possibility of defective recovery of masticatory muscle function, while demonstrating the effectiveness of temporary structures and the need for comparative data from each patient, as well as readiness for permanent orthopedic treatment. Thus, patients in group 1 showed positive dynamics after 1 month, for both the right m. masseter: 1085.19±102.84 μV ($p$>0.05) and the left m. masseter: 1075.32±93.18 μV ($p$>0.05), as evidenced by the stabilization of the process after 6 months – for the right m. masseter: 1219.54±61.37 μV ($p$>0.05), for the left m. masseter: 1195.85±62.44 μV ($p$>0.05). The patients in groups 2 and 3 showed only approximation of data to patients in the control group with a pronounced positive trend after 3 months: group 2: 701,34±36.26 μV

($p$<0.01), group 3: 527.32±32.66 μV ($p$<0.001); for the left m. temporalis: group 1: 1048.51±39.73 μV ($p$>0.05), group 2: 735.35±37.63 μV ($p$<0.01), group 3: 505.18±30.45 μV ($p$<0.001). At the same time, the functional purpose of m. temporalis contributed to the complete recovery 1 month after treatment: 990.95±58.37 μV ($p$>0.05), for the left m. temporalis: 1026,11±55.62 μV ($p$>0.05), group 2: 563.57±46.94 μV ($p$<0.001), group 3: 406.50±34.03 μV ($p$<0.001).

After 6 months of temporary orthopedic treatment, the presence of concentration of points in the second, fourth, fifth and seventh fields of the tour-amplitude analysis of patients of groups 1 and 2 in more than half of cases indicates a full restoration of m. masseter and m. temporalis function. The absence of the left location of the concentration of points 6 months after treatment of all groups indicated the normalization of myostatic reflexes of the masticatory muscle group. The compensatory capabilities of the masticatory muscle group showed significant variability in the location of the concentration of points in patients with a reduced bite height of 3-4 mm, with a tendency to normalize 6 months after temporary orthopedic treatment (Figure 7).

**Figure 7.** Group 3 patient with decreased muscle symmetry 6 months after treatment

In terms of m. masseter dynamics, the changes in group 2 were as follows: before treatment, the continuous position was characteristic of three patients: 9.68±5.31% ($p$>0.05), after treatment for four patients: 12.90±6.02% ($p$>0.05); single location of points: before treatment it was characteristic for 20 patients: 64.52±8.59% ($p$>0.05), after 3 and 6 months for 25 patients: 80.65±7.10% ($p$>0.05). The location of individual points before treatment was observed in four patients: 12.90±6.02% ($p$>0.05), after 3 and 6 months in two patients: 6.45±4.41% ($p$>0.05).

In terms of m. temporalis, the continuous position was characteristic of 12 patients: 38.71±8.75% ($p$>0.05), 13 patients: 41.94±8.86% ($p$>0.05); the dynamics of the location was as follows: before treatment in 3 patients: 9.68±5.31% ($p$<0.001) and after 6 months in 14 patients: 45.16±8.94% ($p$>0.05). The dynamics of the location of individual points was as follows: before treatment, this location was observed in 16 patients: 51.61±8.98% ($p$<0.01) and after 6 months in 5 patients: 12.90±6.02% ($p$>0.05). The study of the behavior of m. masseter and m. temporalis during the act of chewing showed that a full recovery of the total work of m. masseter and m. temporalis with a decrease in bite height by 3 mm or more is almost impossible due to a number of factors. However, the positive trend showed the maximum allowable recovery depending on the age and degree of development of the pathological process. At the same time, in group 1, there was a significant increase in the total amplitude (μV) as early as 1 week after treatment: before treatment: 776.33±39.52 μV ($p$<0.01) and 901.11±33.70 μV ($p$>0.05). Despite further fluctuations, in 1 month after treatment there were following results: 1030.78±59.5 μV ($p$>0.05), after 3 months: 995.58±28.34 μV ($p$>0.05) and after 6 months: 1046.53±30.42 μV ($p$>0.05). Statistical indicators suggested that these fluctuations are a variant of the norm and are not a sign of inadequate treatment. At the same time, in groups 2 and 3, for these indicators there was a pronounced positive effect of treatment after 3 and 6 months. In group 2, this was expressed as follows: before treatment: 550.47±36.19

μV ($p$<0.001), after 3 months: 767.30±23.46 μV ($p$<0.001), after 6 months: 860.39±24.97 μV ($p$<0.01). In group 3: before treatment: 333.12±17.31 μV ($p$<0.001), after 3 months: 485.98±18.05 μV ($p$<0.001), after 6 months: 595.73±15.76 μV ($p$<0.001) (Table 1).

**Table 1.** The effect of treatment on masticatory muscles (m. masseter and m. temporalis) function during a chewing test measured using surface electromyograms (μV)

| Term of treatment | Groups | | | | | | | | *p*-value | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group 1 (n=32) | | Group 2 (n=31) | | Group 3 (n=30) | | Control group (n=30) | | | | |
| | Indicator | M±m | Indicator | M±m | Indicator | M±m | Indicator | M±m | pk-1 | pk-2 | pk-3 |
| Before treatment | 776.33 | 39.52 | 550.47 | 36.19 | 333.12 | 17.31 | 1098.4 | 99.69 | <0.01 | <0.001 | <0.001 |
| 7 days after treatment | 901.11 | 33.7 | 554.13 | 36.82 | 331.8 | 15.7 | 1098.4 | 99.69 | >0.05 | <0.001 | <0.001 |
| 1 month after treatment | 1030.8 | 59.53 | 597.4 | 31.03 | 394.15 | 16.25 | 1098.4 | 99.69 | >0.05 | <0.001 | <0.001 |
| 3 months after treatment | 995.58 | 28.34 | 767.3 | 23.64 | 485.98 | 18.05 | 1098.4 | 99.69 | >0.05 | <0.001 | <0.001 |
| 6 months after treatment | 1046.5 | 30.42 | 860.39 | 24.97 | 595.73 | 15.76 | 1098.4 | 99.69 | >0.05 | <0.01 | <0.001 |

Notes: M±m – the arithmetic average and its error.

Despite the differences in their function and adaptive capabilities, the m. masseter and m. temporalis act with one another, and show a generalized picture of behavioral reactions and changes in myostatic reflexes typical of the masticatory muscle group. Determination of the mean total values of m. masseter and m. temporalis confirmed the conclusions given above, and allowed us to establish the most informative terms of observation of patients with reduced occlusion height. i.e., before treatment, 1 month, and 6 months after temporary orthopedic treatment. In percentage terms, there was a tendency to approach the indicators of patients of all groups to absolute symmetry. This was most clearly manifested 6 months after temporary orthopedic treatment in determining all indices, especially in the index of compensatory interaction of m. masseter and m. temporalis TC, which was in group 1: 96.90±0.43% ($p$<0.01), in group 2: 93.47±1.18% ($p$>0.05) and in group 3: 91.11±1.21% ($p$>0.05). The period of 6 months demonstrates the time of adjustment of myostatic reflexes and the effectiveness of full restoration of the dentition.

## Discussion

Based on our results, it is reasonable to conclude that the process of adaptation to the orthopedic structure of patients with a reduced bite height of not more than 2 mm lasts up to 1 month, and has little effect on the masticatory muscle group. Therefore, in the absence of pronounced hypertension, temporary orthopedic treatment is unpractical. Patients with a decrease in occlusal height of 3-4 mm need the most individualized treatment approach, since the pathological condition and peak compensatory mechanisms of the masticatory muscle group are imposed. Temporary orthopedic structures for such patients are recommended after a comprehensive examination of the dental system. Patients with a decrease in bite height of 5 mm or more require the use of a temporary orthopedic structure. Patients in this group often have masticatory muscle atrophy, so the degree of improvement after treatment should be calculated individually. Positive dynamics of results was achieved after the manufacture of prostheses by the proposed improved method. This was evidenced by a decrease in maximum amplitudes (μV) in a state of relative physiological rest and by a change in the position of the concentration points of the turn-amplitude analysis in positions close to those of the control group. Based on the conducted multiparameter study of m. masseter and m. temporalis with the help of superficial electromyograms in a state of relative physiological rest and when performing functional and masticatory tests, the effectiveness of preparation of the dental system for permanent orthopedic treatment with fixed structures is obvious.

## Conclusions

The problem of reducing the bite height, the prevalence of which is up to 40% among the Ukrainian population [1], its diagnosis, orthopedic treatment and rehabilitation of the dental and maxillofacial system remain an important problem in dentistry. Despite numerous methods of diagnosis and preparation of the dental and maxillofacial system for permanent orthopedic treatment, the possibilities, timing and specifics of changes in myostatic reflexes in the process of preparing the patient for orthopedic treatment remain little studied. Therefore, the search for new effective methods for diagnosing the condition of the masticatory muscle group and the dental system in general, an effective method of preparing patients for orthopedic treatment with permanent orthopedic structures and formulating indications for the preparation of the dental system based on the muscle group remain relevant in orthopedic dentistry.

The degree of changes in the maximum amplitudes of m. masseter and m. temporalis depends on the severity of the pathological process, and is manifested by a reduction in function and mastication. The use of fixed temporary acrylic bridges for the preparation of the dental and maxillofacial system for permanent orthopedic treatment allows their successful use in the clinic of orthopedic dentistry. The process of adaptation of the masticatory muscles to raising the bite height and restoring the tuberculous fissure contacts of jaws is difficult and long.

A similar treatment process was used for patients included groups 2 and 3; however, due to the degree of violations of the latter group, the adaptation processes of patients of group 1 took longer. The most noticeable qualitative changes were observed in groups 2 and 3, 6 months after the fixation of temporary orthopedic structures. The shape of their electromyograms was as close as possible to patients with intact masticatory apparatus. The form of electromyograms in the masticatory sample was represented by a fragmented structure of records, and flashes of activity seemed to be formed without areas of biopotential loss or excessive single flashes of activity.

Thus, the qualitative parameters of the electromyogram indicate the regularity of changes in the biopotentials of m. masseter and m. temporalis, depending on the degree of pathological process and the pronounced normalization of the masticatory muscles and dental system in general. This was the case regardless of the degree of reduction in occlusal height, but accordingly to the ratio "term of normalization – the severity of the pathological process".

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