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The comparative analysis of masticatory muscles electromyographic activity in patients with orthodontic disorders and those with orthognatic bite

Summary. The analysis of bioelectric activity of masticatory muscles, as well as such characteristics as their symmetry and synergy is recommended to determine the degree of functional disorders of these muscles. The objective: to conduct a comparative analysis of electromyographic activity of masticatory muscles in patients with orthodontic disorders and those with orthognatic bite. The materials and methods: a total superficial electromyography of m. Masseter and the front part of the m. Temporalis in 87 people with the presence of orthodontic pathology and 22 persons with orthognatic bite at compression on teeth and cotton rolls. The results: it is determined the reduction of the average amplitude parameter of the same name muscles and ratio indexes of the average amplitude of the muscles of the right and left side at compression on rolls compared to the compression on teeth in both observed groups. Statistically significant differences form. Masseter were not found when comparing the coefficient of the same name muscles coordination between the groups, as opposed to the following measures for m. Temporalis ($p < 0,05$). Conclusion: The condition of occlusion appears on the EMG results, which have been confirmed by us in this study. At orthodontic pathology the EMG results should be evaluated together with the results of other studies (the diagnostics of TMD, clinical functional analysis, TMJ study). It is necessary to conduct further research in this area in order to highlight and explain some causes of the appearance of masticatory muscles asymmetry, its connection with orthodontic pathology, its impact on the course of the disease and the results of orthodontic treatment.

Key words: orthodontic pathology, orthognatic bite, superficial electromyography, masticatory muscles, symmetry, synergy.

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Порівняльний аналіз електроміографічної активності жувальних м'язів у осіб з ортодонтичною патологією та осіб з ортогнатичним прикусом

Резюме. Аналіз показників біоелектричної активності жувальних м'язів, а також таких характеристик, як їх симетричність та синергізм рекомендують для визначення ступеня функціональних порушень зазначених м'язів. Метою дослідження було провести порівняльний аналіз електроміографічної активності жувальних м'язів у осіб з ортодонтичною патологією та осіб з ортогнатичним прикусом. Проведено поверхневу сумарну електроміографію m. Masseter та передньої частини m. Temporalis 87 особам з наявністю ортодонтичної патології та 22 особам з ортогнатичним прикусом при стисканні на зубах та на ватних валиках. Визначено зменшення середнього показника амплітуди однойменних м'язів та індексів співвідношень середніх показників амплітуди м'язів правої і лівої сторін при стисканні на валиках порівняно зі стисканням на зубах в обох групах спостереження. При порівнянні коефіцієнта координації однойменних м'язів між групами статистично значимих відмінностей для m. Masseter не виявлено, на противагу таким показникам для m. Temporalis ($p < 0,05$). Стан оклюзії відображається на результатах ЕМГ, що ми підтвердили в даному дослідженні. При наявності ортодонтичної патології результати ЕМГ потрібно оцінювати в комплексі з результатами інших досліджень (діагностика дисфункцій СНЩС, клінічний функціональний аналіз, дослідження стану СНЩС). Необхідно проводити подальші дослідження в даному напрямку з метою виділення і пояснення окремих причин виникнення асиметрії жувальних м'язів, її зв'язку з наявністю ортодонтичної патології та впливу на перебіг та результати ортодонтичного лікування.

Ключові слова: ортодонтична патологія, ортогнатичний прикус, поверхнева електроміографія, жувальні м'язи, симетрія, синергія.

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Сравнительный анализ электромиографической активности жевательных мышц у лиц с ортодонтической патологией и лиц с ортогнатическим прикусом

Резюме. Анализ показателей биоэлектрической активности жевательных мышц, а также таких характеристик, как их симметричность и синергизм рекомендуют для определения степени функциональных нарушений указанных мышц. Целью исследования было провести сравнительный анализ электромиографической активности жевательных мышц у лиц с ортодонтической патологией и лиц с ортогнатическим прикусом. Проведено поверхностную суммарную электромиографию m. Masseter и передней части m. Temporalis у 87 лиц с наличием ортодонтической патологии и у 22 лиц с ортогнатическим прикусом при сжатии на зубах и на ватных валиках. Определено уменьшение среднего показателя амплитуды одноимённых мышц и индексов соотношения средних показателей амплитуды мышц правой и левой сторон при сжатии на валиках в сравнении со сжатием на зубах в обеих группах наблюдения. При сравнении коэффициента координации одноимённых мышц между группами статистически значимых отличий для m. Masseter не выявлено, в отличие от тех же показателей для m. Temporalis ($p < 0,05$). Состояние окклюзии отражается на результатах ЭМГ, что было подтверждено нами в данном исследовании. При наличии ортодонтической патологии результаты ЭМГ нужно оценивать в комплексе с результатами других исследований (диагностика дисфункций ВНЧС, клинический функциональный анализ, исследование состояния ВНЧС). Необходимо проводить дальнейшие исследования в этом направлении с целью выделения и выяснения отдельных причин возникновения асимметрии жевательных мышц, её связи с наличием ортодонтической патологии и влияния на течение и результаты ортодонтического лечения.

Ключевые слова: ортодонтическая патология, ортогнатический прикус, поверхностная электромиография, жевательные мышцы, симметрия, синергия.

Introduction. Occlusion pathology is associated with disorders of the temporomandibular joint (TMJ) and changes of the masticatory muscles functionality [2, 8]. During the study when creating experimental occlusal interferences asymmetrical jaw muscles-elevators contraction occurred, but there were no symptoms of temporomandibular disorder (TMD) [8]. Based on these data, it was concluded that asymmetric activation of the masticatory muscles, found in the pathology of occlusion, deformation and adentia and in dysfunctional states of TMJ is a compensatory mechanism for achieving the stability of the lower jaw during chewing [9, 11].

To characterize the functional state of masticatory muscles according to the results of electromyography (EMG) it was proposed functional tests, the main of which was the rest position and maximum willful compression (MWC). In many studies [4, 9, 13] it was proved that the rate of the MWC depends on the number of occlusal contacts

and their location on teeth, bite height and the presence of pathology bite.

For processing and analysis of electromyograms a number of methodical techniques, that allow establishing their quantitative and qualitative characteristics in normal and pathological conditions were developed. For this purpose symmetry, synergy and the ratio of activity and rest phases of the chewing muscles are determined in EMG. Such techniques are recommended for determining the degree of functional disorders of neuromuscular condition compared with occlusive characteristics. To improve the effectiveness of the analysis of EMG indicators relative values and indices are used to compensate for inconsistencies of the characteristics of certain devices and conditions of conducting EMG studies [3, 6, 10]. Unfortunately, these methods are not currently widespread used and don't receive proper attention. EMG data are recommended for planning treatment, its realization and preventing complications of

pathology bite, and hence a detailed study of these indicators is important in dentistry.

The objective of the study. Comparative analysis of masticatory muscles electromyographic activity in patients with orthodontic disorders and those with orthognathic bite.

Materials and methods. For the study it was selected 87 individuals (41 male and 46 female) with the presence of orthodontic pathology among the students of Dental Faculty of I. Horbachevsky Ternopil State Medical University. The average age of the patients was $19.3 + 1.1$ years. The criteria for inclusion were the patient's consent for the survey, the lack of medium and large defects of dentition, without signs of acute temporo-mandibular disorder. The study excluded people with medium and large defects of dentition, severe tooth-jaw deformities, as well as tooth decay and its complications, generalized periodontitis in the acute stage. To control during this study it was selected a group of 22 people with orthognathic bite, with no signs of muscle-joint dysfunction and periodontal disease (average age – $19.2 + 0.9$ years). These individuals were examined by the standard scheme of history case with clinical functional analysis. We conducted electromyographic study using electromyograph BioEMG III of BioPack complex according to the manufacturer's recommendations (Bio RESEARCH Assoc. Inc., USA). The analysis of bioelectric activity of masticatory muscles (front m. Temporalis, superficial part of the m. Masseter) at rest position and at MWC for 5 seconds was conducted. We determined the symmetry, the average amplitude and synergy of the various groups of masticatory muscles when performing this function. The study was repeated using cotton rolls placed on molars. Comparative analysis of the teeth compression results and those using rolls in lateral areas of the jaws was performed for each series and it was determined the balance of symmetric masticatory muscles on the left and on the right at a coordination rate of bioelectrical activity (BEA) by Aav., which provides correlation miscalculation of the same name muscles [3, 6]. The level of chewing muscles asymmetry was also determined according to the method [10], where the difference between the higher and lower index of similar amplitude of the same name muscles was divided by the maximum amplitude and multiplied by 100%. Survey results were analyzed using statistical package NCSS 2007 software (V. 07.1.20, Utah, USA).

The results and discussion. The comparative analysis of age characteristics of people of both working and control group by Student's t-test did

not determine statistically significant differences between the groups ($p > 0,05$). The analysis of study results according to the algorithm of total superficial EMG showed significant differences between the rates of temporal and masticatory muscles, which once again confirmed the impact of a number of general and local factors, including the patient's condition and technical characteristics of the electromyograph, on the results of the study [3, 4, 10].

During the qualitative analysis of total superficial EMG it was found that bursts of spontaneous activity at rest position were observed in 38.2 % of the working group, while the control group included 4.2 % of the patients. The activity of masticatory muscles in rest position in the patients of the control group was within the established norm (less than 2 % of the index MWC) [10]. In 7 patients (8.1 %) of the working group overall level of activity slightly exceeded the allowed norm and was defined as 2.16–3.03 mcV. Several people in both groups at MWC with cotton rolls and without them demonstrated the predominance of m. Temporalis over m. Masseter: 4 people in the experimental group (4.6 %) and 1 person in the control group (4.5 %). The parameters of m. Masseter amplitude prevail in most patients examined according to the results of MWC. BEA index m. Masseter at maximum willful compression in central occlusion is an individual indicator and data presented in various literary sources differ significantly. According to the statement [7], the increasing of the activity of m. Masseter indicates chronic bruxism or lowering the bite height. Reducing the height of the bite, which is observed in particular in orthodontic pathology II class by Angle, is often accompanied by a BEA decrease of chewing muscles. Their asymmetry at closing may occur due to disharmony of occlusal ratios of left and right side dentition. M. Masseter and m. Temporalis react differently to changes in occlusal correlations that may affect the stability of the mandible at compression [9].

The comparison of EMG studies according to the amplitude parameters of the same name muscles at compression in the control group identified its reduction at compression on rollers at an average of 1/3 compared to the compression on teeth, but without statistically significant differences in the t-test ($p > 0.05$). Indicators m. Masseter were significantly different in each person, average parameters were determined with great errors and deviations, indicated by the figures of Maximum (Max) and minimum (Min) (Table 1).

In the working group the results of EMG studies according to the amplitude parameters of the same name muscles at compression were as follows. It was revealed the decrease of an average activity at compression on rollers to an average of 1/3 relatively to compression on teeth, but there were no statistically significant differences in the t-test ($p > 0.05$). Average parameters were determined with great errors and deviations, with significant differences of values «Max» and «MIN» (Table 2).

While analyzing the amplitude of MWC of masticatory muscles some peculiarities were discovered. In the control group 1 person (4.5 %)

demonstrated an increased activity at compression on cotton rolls compared to compression with no rolls (83.1 mcV and 58.8 mcV, respectively) m. Masseter on the left. While other examined patients in this group showed the decrease of the amplitude at biting on cotton rolls compared to the compression with no rolls. Processing the data received in the working group it was found the increase of amplitude in the right m. Masseter at compression on rolls (44 patients or 50.6 %), while the value of this increase amounted to 1.5 to 22.7 mcV. In the left m. Masseter 26 individuals (29.9 %) showed changes from 1.9 to 35.6 mcV.

Table 1. Comparative analysis of the average amplitude of muscles lifts the lower jaw in the control group (n=22), $p > 0.05$

Muscles	mtype of loading	Indicators of amplitude BEA of masticatory muscles, mcV	
			Max–Min
m. Masseter (right)	Without cotton rolls	51.18±6.37	116.72–21.53
	With cotton rolls	35.07±5.48	79.26–18.44
m. Masseter (left)	Without cotton rolls	79.43±15.68	238.54–24.71
	With cotton rolls	44.19±9.03	126.19–3.85
m. Temporalis (right)	Without cotton rolls	42.16±7.05	90.72–18.37
	With cotton rolls	29.65±3.15	66.28–10.38
m. Temporalis (left)	Without cotton rolls	41.21±7.37	113.59–21.74
	With cotton rolls	29.51±4.62	83.25–7.61

Table 2. Comparative analysis of the average amplitude of muscles lifts the lower jaw in the working group (n=87), $p > 0.05$

Muscles	Type of loading	Indicators of amplitude BEA of masticatory muscles, mcV	
			Max–Min
m. Masseter (right)	Without cotton rolls	58.37±5.25	127.43–2.58
	With cotton rolls	51.75±5.18	177.14–8.62
m. Masseter (left)	Without cotton rolls	74.23±7.52	216.02–8.58
	With cotton rolls	54.63±8.49	194.81–9.64
m. Temporalis (right)	without cotton rolls	32.76±2.37	69.57–8.28
	With cotton rolls	27.61±3.05	63.92–5.41
m. Temporalis (left)	Without cotton rolls	35.37±2.48	63.35–8.39
	With cotton rolls	28.31±2.18	59.64–6.33

In m. Masseter on the right similar changes were found in 15 (17.2 %) patients and the magnitude of such changes ranged from 2,6 mcV to 23.1 mcV, in m. Temporalis on the left - in 26 people (29.9 %) at a value of 2.4 mcV to 32.5 mcV. In general, changes towards increasing of the compression amplitude were typical for patients with reduced height of bite (distal occlusion or second class by Angle). According to some authors [1, 4] this symptom is

considered to be the factor that provokes TMD.

The comparison of the highest or average activity in percentage is mostly used to assess the symmetry violation. The presence of asymmetry in the masticatory muscles functioning is a warning sign. It is believed that it precedes the occurrence of TMD. That is why we conducted the analysis of symmetry of chewing muscles BEA at the MWC on teeth and using cotton rolls. The study identified

a slight reduction of average indexes ratio of the muscles on the left and right sides at compression on rolls compared with compression on teeth, but without statistical authenticity ($p>0.05$). The index of coordination BEA m. Masseter and m. Temporalis(Aav.) was calculated. According to the data of literary sources for this parameter results no less than $87.0\pm 0.9\%$ is considered to be physiological [6]. As a result of our research in most cases of Aav. we obtained more than 100% ($124\pm 12\%$ $117\pm 15\%$ $122\pm 17\%$), indicating a significant prevalence of EMG amplitude parameters on the left. Statistically significant differences between the coordination indexes at teeth compression and compression on rolls was not found ($p>0.05$) (Table 3).

According to the recommendations [10] we determined asymmetry coefficient of ratios m. Masseter on the left and right sides. In the control group, the rate at compression on the teeth was

$26.1\pm 3\%$, using cotton rolls – $26.8\pm 6\%$. For m. Temporalis this figure in this group was $31.8\pm 5\%$ at compression on teeth and $35.2\pm 6\%$ at compression on rolls.

No significant statistical differences when comparing the indexes of the asymmetry ratios for m. Masseter and m. Temporalis at compression on teeth and the one on rolls were found. This resulting average coefficient of asymmetry for m. Masseter was significantly lower (t-criterion, $p>0.05$).

Within a working group calculated index of asymmetry for m. Masseter at compression on teeth was $27.6\pm 6\%$, the one on rolls – $28.2\pm 1\%$. The same figure for m. Temporalis was $15.8\pm 4\%$ and $+ 21.4\%$ respectively. Statistically significant differences were found when comparing the indices for m. Masseter and between indexes of m. Masseter and m. Temporalis at compression on teeth and on rolls.

Table 3. A comparative analysis of the average rate of muscle coordination

		control group (n=22)	working group (n=87)	t	p
m. Masseter	Without cotton rolls	1.35 ± 0.16	1.48 ± 0.17	0.72	$p>0.05$
	With cotton rolls	1.28 ± 0.18	0.96 ± 0.08	1.61	$p>0.05$
m. Temporalis	Without cotton rolls	1.52 ± 0.12	1.61 ± 0.13	0.51	$p>0.05$
	With cotton rolls	1.05 ± 0.17	0.59 ± 0.11	1.28	$p>0.05$

By analyzing the ratio of asymmetry for m. Masseter and m. Temporalis at compression on teeth we found a significant difference (t2-Student's criterion = 2.84, $p_2<0.05$). When analyzing correlations of asymmetry indices for m. Masseter and m. Temporalis at compression on rollers marginal difference (t3 = 1.87 at t-critical = 2.012, $p_3\geq 0,05$) was found. We found no statistically significant differences between the degree of asymmetry for m. Masseter at compression on teeth and rolls when comparing the parameters in the control and working group. At the same time, statistically significant differences between the working and control group were found while comparing the asymmetry for m. Temporalis (t1, p_1 – Table 4).

According to studies [10], the asymmetry at the level of 10–15 % is already significant for m. Masseter. This phenomenon was observed in both groups approximately equally and demonstrated with asynchrony in the MWC early phase.

In most studies in Ukraine, much attention is paid to the prevalence of asymmetry of masticatory muscles at closing and chewing in patients with TMD [2, 5, 6], while the presence of orthodontic

pathology is not taken into account. Although it is proved that the presence of interferences when chewing is a factor that contributes to bruxism, TMD, gums and periodontal lesions. Herewith a widespread viewpoint as to the application of cotton rolls for re-programming of chewing muscles, proper positioning of the mandible and eliminating the negative impact of premature contacts at closing on the state of the chewing muscles. In the study, these data have not been confirmed by us. It is proved that for functional harmony of masticatory apparatus muscles work in synergies and with agreed antagonism according to existing programs and this is a consequence of adaptation and compensation processes. It is also proved that orthodontic pathology affects the amplitude and symmetry parameters when performing a functional test of MWC. When periodontal diseases occur the activity indices are falling, but with an increased abrasion they can decrease and increase, under certain conditions [1, 4]. Thus, the data we obtained in both groups correctly characterize the samples of occlusal condition and are to a lesser extent related to the states of TMJ dysfunctions.

Table 4. A comparative analysis of similar muscle asymmetry coefficient

		Control group (n=22)	Working group (n=87)	t ₁	p ₁
m. Masseter	Without cotton rolls	25.4±4	27.3±2	0.37	p>0.05
	With cotton rolls	25.1±3	27.8±3	0.52	p>0.05
m. Temporalis	Without cotton rolls	34.3±5	17.3±3	2.58	p<0.05
	With cotton rolls	38.6±3	22.8±2	2.98	p<0.05

Conclusion. The condition of occlusion appears on the EMG results, which have been confirmed by us in this study.

At orthodontic pathology the EMG results should be evaluated together with the results of other studies (the diagnostics of TMD, clinical functional analysis, TMJ study). It is necessary to conduct further research in this area in order to highlight and explain some causes of the appearance of masticatory muscles asymmetry, its connection with orthodontic pathology, its impact on the course of the disease and the results of orthodontic treatment. It should be also noted, that the analysis of the maxillofacial muscles-synergists significantly enhances the evaluation of the results.

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It is necessary to conduct further studies to determine changes of amplitude and asymmetry parameters when performing functional tests during electromyography, because jaw closing is a complex process, and it can be influenced by the existing occlusal contacts. It should be clearly understood that a number of factors as occlusal, joint and neuromuscular ones can affect the final result of orthodontic treatment and therefore the received findings should be interpreted with caution.

It is necessary to investigate in greater detail the tests when placing jaws on cotton rollers to determine the indications for their use. The matter of asymmetry occurrence and connection of the given parameter with the presence and severity of orthodontic pathology requires further study.

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