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ELECTROMYOGRAPHIC EVALUATION OF JAW MUSCLES IN PATIENTS WITH DISTAL OCCLUSION

Electromyography is the most objective and reliable technique for evaluating muscle function and efficiency by detecting their electrical potentials, assessing the extent and duration of muscle activity. The main aim of surface electromyography is to detect the signals from many muscle fibers in the area of the detecting surface electrodes. Studies by many foreign and domestic researchers have identified the impact of sagittal malocclusion on the function of the masticatory muscles.

The aim of our study was to establish the relationship between the distal occlusion and the activity of the masticatory muscles in orthodontic patients.

Methods: 15 orthodontic patients aged (15.33±0.86) years with a distal occlusion were examined. The results of clinical and functional examinations during and after orthodontic treatment were analysed.

An electromyographic study of the masticatory and temporomandibular muscles in the examined patients was performed. Patients were examined in accordance with the main requirements of the Helsinki Declaration for Biomedical Research (Seoul, 2008).

Scientific novelty. The electromyographic activity of the biopotentials of the masseter and masseter muscles in stable and advanced position of the mandible in 15 patients with a distal occlusion was compared. A significant difference was found between stable and asdvanced position of mandibular in decreasing of the following parameters: in the maximum chewing amplitude of the left anterior temporalis muscle, the maximum chewing amplitude of the right anterior temporalis muscle, n the maximum chewing amplitude of the left masseter muscle, and the maximum chewing amplitude of the right masseter muscle.

Conclusion. The electromyographic study of the masticatory and temporomandibular muscles in patients with a distal occlusion, functional changes in the activity of the masticatory muscles at rest and in the advanced position of the mandible were revealed.

Key words: electromyographic activity, distal occlusion, masticatory muscles, temporal muscles.

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ЕЛЕКТРОМІОГРАФІЧНА ОЦІНКА ЖУВАЛЬНИХ М'ЯЗІВ У ПАЦІЄНТІВ З ДИСТАЛЬНИМ ПРИКУСОМ

Електроміографія є найбільш об'єктивним і надійним методом оцінки функції та працездатності м'язів шляхом визначення їх електричних потенціалів, оцінки ступеня та тривалості м'язової активності.

Основною метою поверхневої електроміографії є виявлення сигналів від багатьох м’язових волокон у ділянці детектуючих поверхневих електродів**.** Дослідження багатьох зарубіжних і вітчизняних науковців визначили вплив сагітальних аномалій прикусу на функцію жувальних м’язів.

Метою нашого дослідження було встановлення взаємозв’язку між дистальним прикусом та активністю жувальних м’язів у ортодонтичних пацієнтів.

Методи дослідження. Проведено клінічне обстеження 15 ортодонтичних пацієнтів віком 15,33±0,86 років з дистальним прикусом. Проаналізовано результати клінічного і функціонального обстеження на початку та після завершення ортодонтичного лікування.

Проведено електроміографічне дослідження жувальних та вискових м’язів у обстежених пацієнтів. Обстеження пацієнтів проводили з дотриманням основних вимог Гельсінкської Декларації щодо біомедичних досліджень (Сеул, 2008).

Наукова новизна. Проведено порівняння електроміографічної активності біопотенціалів вискового і жувального м’язів при стабільному і вимушеному (протрузії) положенні нижньої щелепи у 15 пацієнтів з дистальним прикусом. Виявлено достовірну різницю між показниками при стабільному та вимушеному положенні нижньої щелепи за такими параметрами: зниження максимальної амплітуди жування лівого переднього вискового м’язу в 1,5 раза, зменшення максимальної амплітуди жування правого переднього вискового м’язу в 1,8 раза, зниження максимальної амплітуди жування лівого жувального м’язу і зниження максимальної амплітуди жування правого жувального м’язу майже в 3 рази.

Висновок. Під час електроміографічного дослідження жувальних і вискових м’язів у пацієнтів з дистальним прикусом виявлено функціональні зміни в активності жувальних м’язів у стані спокою і у вимушеному положенні нижньої щелепи.

Ключові слова: електроміографічна активність, дистальний прикус, жувальні м’язи, скроневі м’язи.

Introduction. Electromyography is the most objective and reliable technique for evaluating muscle function and efficiency by detecting their electrical potentials, assessing the extent and duration of muscle activity. The main aim of surface electromyography is to detect the signals from many muscle fibers in the area of the detecting surface electrodes. These signals consist of a weighted summation of the spatial and temporal activity of many motor units. Hence, the analysis of the recordings is restricted to an assessment of general muscle activity, the cooperation of different muscles, and the variability of their activity over time. The main clinical uses of sEMG (surface electromyography) include the diagnostics and therapy of TMJ disorders, an assessment of the muscles function [9; 14]. Its known that the first step in correction of distal occlusion is evaluation of the patient’s potential growth. The best period of treatment is a time before a peak of growth of a child. Growth is the most important factor in planning treatment of distal occlusion, since the most significant changes during correction of this pathology are connected with the growth rather than the teeth movement. Orthodontists try to avoid the teeth extraction in growing patients, as they believe that it leads to worsening of face profile, esthetics, and does not allow to achieve optimal relationships of jaw and occlusion [11]. Orthodontic treatment of distal occlusion is important for protection of palate from trauma by mandibular incisors in a case of large sagittal gap; prophylaxis of dysfunction of temporomandibular joint; psychological rehabilitation of children during speech formation.

Many studies have also determined the influence of the sagittal malocclusions on the function of the masticatory muscles. Authors [7] affirm that in Angle’s Class I individuals who have adequate occlusal stability and intermaxillary balance the main function of the temporalis muscle is to maintain this stability. In contrast, in retrognathic individuals, maximal voluntary contraction (MVC) occurs predominantly in the posterior portion of the temporalis muscle probably to produce an antagonistic action to that of the pterygoid muscle and thereby ensure the stability of the mandible.

Research of scientist confirmed the dominance of temporal muscle activity due to lack of activity of masticatory muscles in patients with distal occlusion complicated by dental crowding [1].

The aim of the study by Moreno et al. [4] was to determine the influence of sagittal malocclusion on the electrical activity of the masticatory muscles. The results obtained indicated that patients with Angle class II showed higher activity than other classes for the temporalis muscles in deglutition and chewing; subjects with class III achieved the highest activity for the temporalis and masseter muscles during MVC.

Because of the inextricable association between function and morphology, one of the possibilities for orthodontic treatment is functional therapy. The objective of this kind of treatment is to enhance the equilibrium of the muscles and correctly balance the forces inducing the growth and the development of cranio-facial skeletal features [3,10]. This justifies EMG recordings of the masticatory muscles before, during, and after orthodontic therapies in order to monitor or assess their effectiveness.

The main example of a functional removable appliance is the activator, invented by Andresen. Erdem et al. [3] evaluated the activities of the masticatory muscles in children with class II division 1 malocclusion treated with this appliance and compared to untreated control patients at the start of the therapy and 12 months later, to check the effectiveness of this functional appliance. The activity of the temporalis and masseter muscles during clenching, chewing, and swallowing increased in both groups, particularly in the treatment group. The activity of the orbicularis oris during whistling increased significantly only in the treatment group.

Surface EMG recordings performed in a study by Saccucci et al. [10] confirmed that the functional device employed (Occlus-o- GuideOrtho-Tain Inc., Toa Alta, Puerto Rico) also achieved the aim of this orthodontic functional therapy. The study sample consisted of thirteen 9-year-old children with class II, deep bite, and labial incompetence, and 15 children of the same age with normal occlusion. The electrical potentials of the orbicularis oris (OO) were investigated before therapy, as well as after 3 and 6 months of treatment during many functional tests. The treatment group showed significantly lower values in the muscle tone of the lower orbicularis oris and during protrusion of the mandible comparing to the control group. In the treated group there was a significant increase in the muscle tone of the lower orbicularis oris at rest after 3 months of therapy.

The EMG studies were also helpful in defining the requirements for the application time of the functional appliances. To estimate this, the activities of the muscles at different times of day and night were compared. The results of the study by Tabe et al. [13] confirmed the low effectiveness of functional therapy during the night. The activity of the masseter, temporalis, and digastric muscles with the appliance in the mouth significantly decreased at night compared to daytime. The authors recommended use of functional appliances mostly during the day in combination with voluntary biting to achieve adaptation by the masticatory muscles, due to the high electrical activity during MVC and the higher activity of the muscles during the day than the night. Similar conclusions were presented by Hiyama et al. [4]. They analyzed the nocturnal activity of the masseter and suprahyoid muscles during therapy with a functional appliance such as the bionator. There were no significant changes in the maximal EMG activities of the muscles recorded during the first 3 hours without the appliance inserted and after 3 hours with the bionator in the mouth. This supports findings of the previous study, that it is not advisable to use functional appliances during sleep to obtain the desired treatment effects. EMG studies were also used to monitor therapy with fixed functional appliances, such as the Herbst appliance [5; 3] or its modification, the Forsus Fatigue Resistant Device (FFRD) [12].

Studies by Leung and Hägg [5] performed an analysis of the activity of the masseter and the temporalis muscles during treatment with the Herbst appliance, and determined the optimal time for such a therapy was 6 months. Similar changes in the activity of the same masticatory muscles during gradual advancement of the mandible with the Herbst appliance were described by Du and Hägg [3]. The electrical activity increased, especially in the masseter muscles. Moreover, the stability of the treatment's effects was assessed by monitoring muscle activities in the follow-up period after treatment. Further studies by Sood et al. [12] that described the muscle response during treatment with the Forsus Fatigue Resistant Device demonstrated that the appropriate neuromuscular adaptations occurred at the end of the 6th month of the therapy provided by this kind of fixed appliance. After 1 month of treatment there was a decrease in masticatory muscle activity during the swallowing of saliva and maximal voluntary clenching as a result of the instability of the occlusion due to the protrusion of the mandible.

Analysis of the studies presented above confirm influence of malocclussion on the electrical activity of the masticatory muscles. Therefore, surface EMG extends the number of tools that are useful in the clinical diagnosis of sagittal malocclusions, especial in patients with distal occlusion.

The purpose of the study is to investigate the association between distal occlusion and EMG activity of masticatory muscles in orthodontic patients.

Material and methods. There were examined 15 patients (average age -15,33±0,86 years) with skeletal distal occlusion caused by mandibular retrognatism (10 patients with Class II1 and 5 patients with Class II2) at Orthodontics Department of Danylo Halytskiy Lviv National Medical University. All patients with this type of malocclusion had increasing the value of angle ANB (>4°), due to the decrease the value of angle SNB (<80°). Main clinical characteristics of skeletal distal occlusion caused by mandibular retrognatism were: convexity of the facial profile with distal position of the lower lip and chin, protrusion of the upper lip, distal relationship of dental arches and jaw bases, protrusion of the upper incisors and retrusion of the lower incisors with increasing value of overjet, inserting of the lower lip between upper and lower incisors, passing of the upper and lower incisors during eruption and their supraposition, traumatic deep bite, short mandibular corpus and lower dental arch, narrow and elongated upper dental arch, expressed mentolabial sulcus, shortened the lower third of the face and retroinclination of the lower jaw. The results of clinical and functional examination, analysis of facial aesthetics, casts and lateral cephalogramms were studied before, during and at the end of the treatment.

The electromyographic complex "Neuromyograph Synapsis", manufactured by the scientific and medical factory "Statokin", was used to measure the biopotentials of the masticatory muscles. The activity of the masticatory muscles was evaluated simultaneously from both sides. Before the electrodes were fixated, the areas of the greatest muscle tension, were palpated.

EMG Procedure. To obtain a good quality EMG signal, impedance of the skin was reduced by removing the hair completely from the location where the electrodes were to be placed. In order to eliminate any wetness or sweat on the skin, the skin was cleaned with alcohol. Abrasive gel was used to reduce the dry layer of the skin. The surface EMG electrodes were positioned along the longitudinal midline of the muscle. The distance between the center of the electrodes and detecting surfaces was 1 cm. The longitudinal axis of the electrodes was parallel to the length of the muscle fibers during investigation.

In the study, electromyographic recordings of the biopotentials of the masseter and temporalis muscle were performed during general chewing and during advanced position of the mandible.

As the result of testing in the software it was carried out the calculation of the various parameters and filling in the tables based on them. The following parameters are displayed within these tables: LTA (left temporal anterior), RTA (right temporal anterior), LM (left masseter), RM (right masseter), A (max) - maximal amplitude of chewing (μV), A(aver) – average amplitude of chewing(μV), S – average means of chewing square (μV^*_{ms}).

The results of the surface EMG were presented as a graphical representation and a digital characteristic of the contractility of the temporomandibular muscles, which fully characterizes the bioelectrical activity.

Examination of patients was carried out taking into account the main provisions of the Helsinki Declaration on Biomedical Research (Seoul, 2008) Informed consent of the patient to the examination was obtained.

Statistics 10.0 environment was used for statistical data processing. Calculation of arithmetic means and their errors and probability of difference between means by means of t-test for unpaired samples. Differences in performance were considered statistically significant at $p<0.05$. Correlation dependences were measured using the Kendall-Tau correlation coefficient in the absence of a normal distribution.

Results of the study and their discussion. Comparison of muscles activities in patients with distal occlusion revealed a significant difference between stable and advised position of mandibula for following parametrs: the maximal amplitude of chewing of the left temporalis anterior muscles is in 1.5 times lower (52,34±6,72 µV vs 83,12±7,48µV, $p<0.01$) and almost in 1.8 times lower than maximal amplitude of chewing of the right temporalis anterior muscles (43,12±4,48µV vs 78,54±6,07µV, $p<0.001$); maximal amplitude of the left masseters is almost in 4 times lower (61,28±12,07µV vs 214,57±15,06µV, $p<0.001$), and almost in 3 times lower than the maximal amplitude of the right masseters (79,43±11,01 µV vs231,96±18,56, $p<0.001$). (Table 1).

Case report.

A male patient of 14 years reported with the compliance of on aesthetic defect. During extraoral examination it were revealed: retrognathic mandible and orthognathic maxilla, showing skeletal Class II profile with posterior divergence. Intraoral examination revealed proclined upper incisors with spacing in upper anterior teeth. The maxilla-mandibular relationship showed angles Class II malocclusion. Both overjet and overbite were increased. The overjet was increased overjet (around 5,5 mm) and overbite (of 4,5 mm).The upper and lower incisors are proclined and protruded, having skeletal class II due to the retruded mandible, vertical growth pattern, deep upper sulcus depth and lip strain. Figure 1–2 shows extra and intra oral photo, plaster casts of the examined patient with distal occlusion (Class II1).

Fig. 1. Patient 14 years old. Diadnosis: distal occlusion, Class II1 (from the frontal view)

Table 1

EMG during general chewing cycle in patients with distal occlusion

Patients during stable position of the mandible				Patients during advanced position of the mandible				
Muscle Areas	Valid N	Mean	Standart-Error	Muscle areas	Valid N	Mean	Standart-Error	P
LTA A(max)	15	52,34	6,72	LTA A(max)	15	83,12	7,48	0,01
RTA (max)	15	43,12	4,48	RTA A(max)	15	78,54	6,07	0,001
LM A(max)	15	61,28	12,07	LM A(max)	15	214,57	15,06	0,001
RM A(max)	15	79,43	11,01	RM A(max)	15	231,96	18,56	0,001

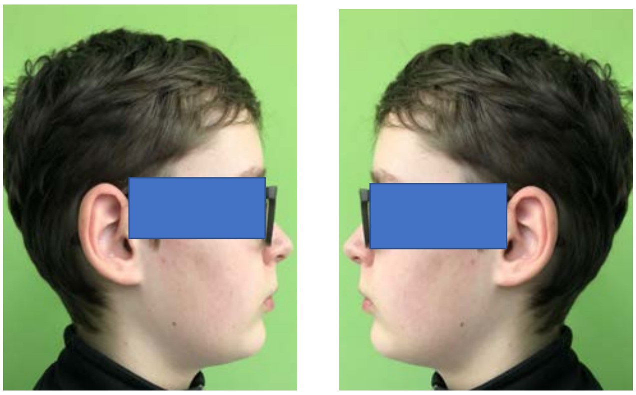

Fig. 2. Patient 14 years old. Diadnosis: distal occlusion, Class II1 (from the profile view)

Fig. 3. Patient 14 years old. Diadnosis: distal occlusion, Class II1, diastema, vestibular position of the teeth 13, 23 (intaoral photo from the frontal view)

Fig. 4. Patient 14 years old. Diadnosis: distal occlusion, Class II1, diastema, vestibular position of the teeth 13, 23 (intaoral photo from the buccal view)

Fig. 5. Patient 14 years old. Diadnosis: distal occlusion, Class II1, diastema, vestibular position of the teeth 13, 23 (plaster casts from the frontal, buccal and occlusal view)

The fragments of sEMG cycles of examined patient (Fig. 5-7) presents dates duaring general chewing at stable and advanced positions of the mandibular. Comparing of parametrs of stable and advanced position of mandibular revealed increasing in 1,5 times of the chewing maximal amplitude of the lateral temporalis anterior muscle and significant increasing in 4,6 times of the chewing maximal amplitude of the lateral masetter muscle while increasing of the chewing maximal amplitude of the right temporalis anterior and right masseter was insignificant.

Diagnosis: distal occlusion.

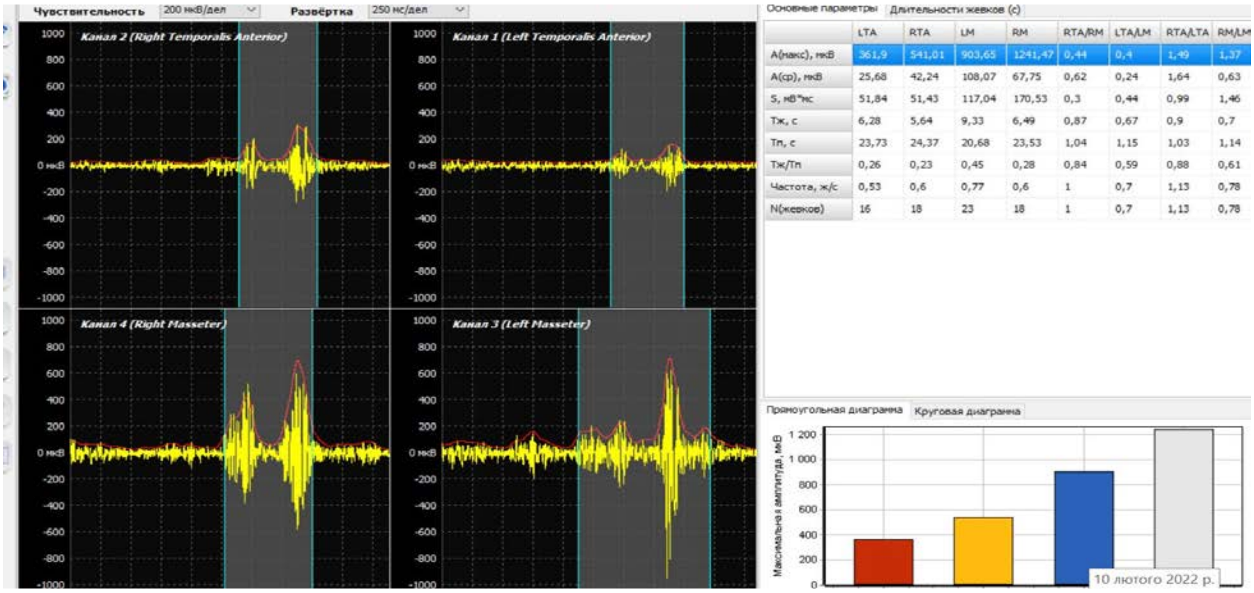

Fig. 6. Fragment of EMG during the general chewing cycle of the 14-year-old patient

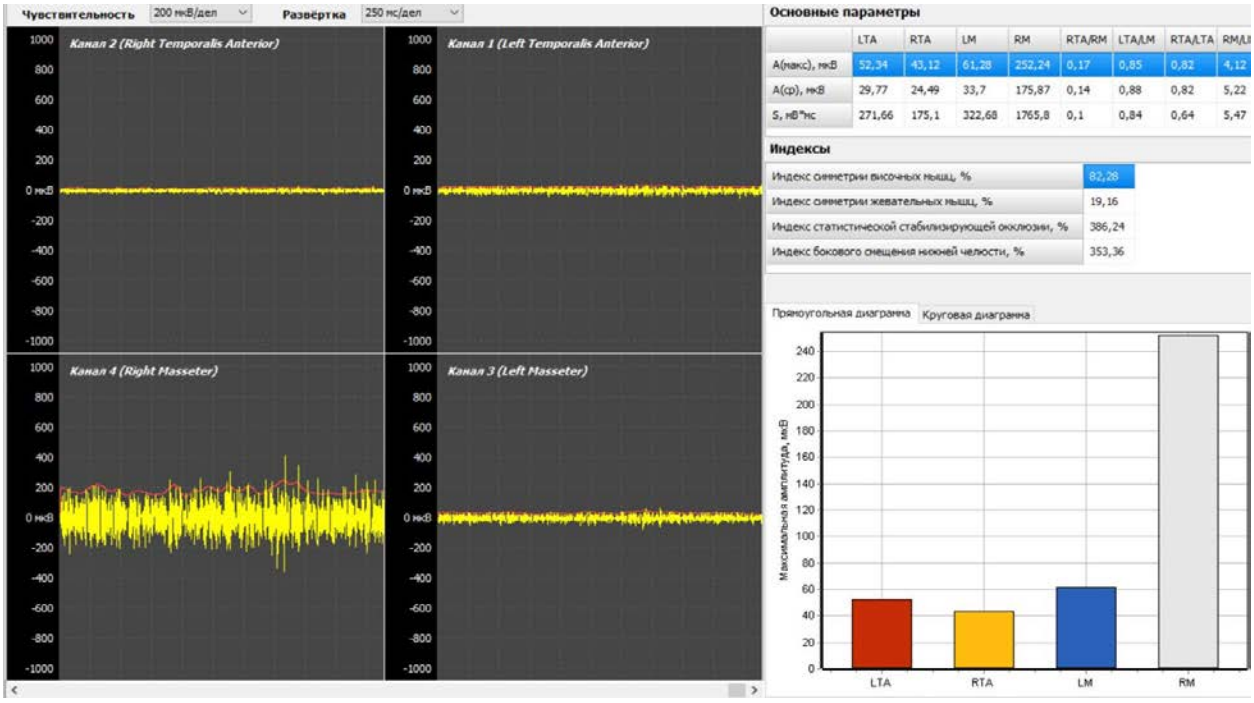

Fig. 7. Fragment of EMG during during stable position of the mandible of the 14-years-old patient. Diagnosis: distal occlusion

Conclusion. Investigation of sEMG of the patients with distal occlusion expressed functional changes in the activity of the masticatory muscles, which consisted in violation of the clarity of records, a significant decrease in the activity of the average amplitude of their biopotentials, an increase in the period of bioelectric activity and a decrease in rest.

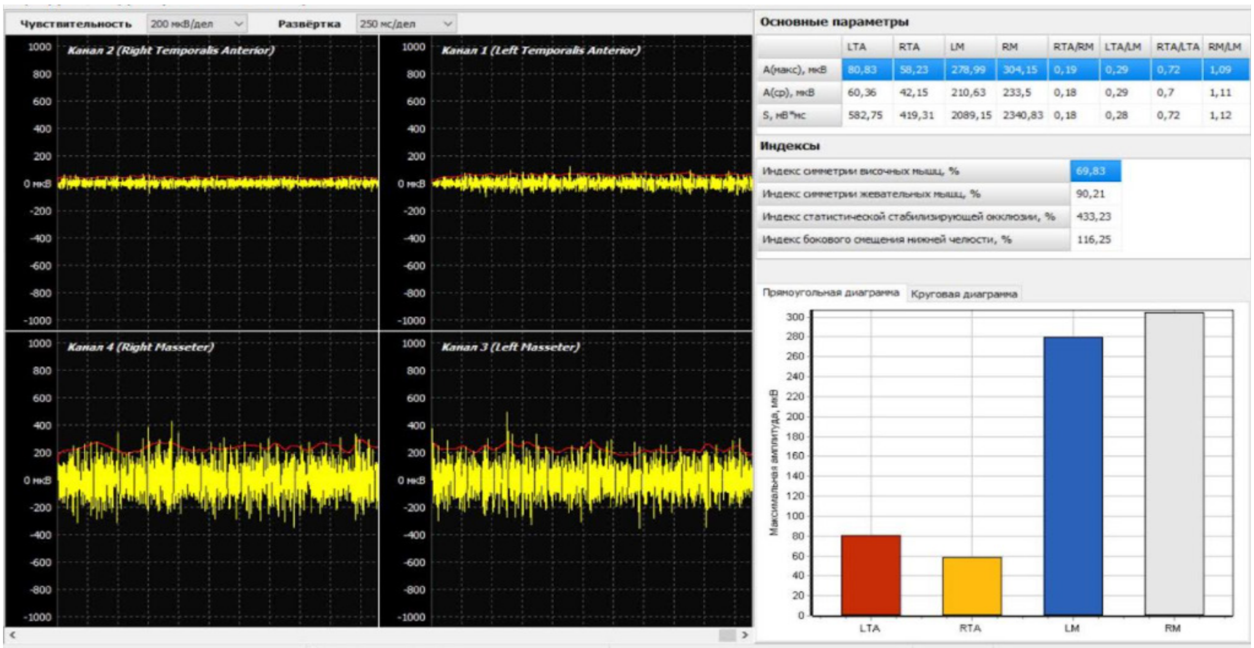

Fig. 8. Fragment of EMG during advanced position of the mandible of the 14-year-old patient. Diagnosis: distal occlusion

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