 https://doi.org/10.5114/for.2021.107531

Forum Ortod 2021; 17 (2): 114-21

Cechy związane z aktywnością EMG mięśni żwaczy u pacjentów z jednostronnym zgryzem krzyżowym tylnym: badanie przekrojowe

Features related to EMG-activity of masticatory muscles in patients with unilateral posterior crossbite: a cross-sectional study

Lyubov Smaglyuk[1] A E F (ORCID ID: 0000-0002-7030-8313)
Anastasiia Liakhovska[1] B C D (ORCID ID: 0000-0002-7268-9551)
Nelia Kulish[1] A B (ORCID ID: 0000-0002-9375-0083)

Wkład autorów: A Plan badań B Zbieranie danych C Analiza statystyczna D Interpretacja danych E Redagowanie pracy F Wyszukiwanie piśmiennictwa

Authors' Contribution: A Study design B Data Collection C Statistical Analysis D Data Interpretation E Manuscript Preparation F Literature Search

[1] Zakład Ortodoncji, Ukraińska Akademia Medyczno-Stomatologiczna, Ukraina
Orthodontics Department, Ukrainian Medical Stomatological Academy, Ukraine

Streszczenie

Częstość występowania zgryzu krzyżowego bocznego na świecie wynosi od 5% do 14%. Etiologia zgryzu krzyżowego bocznego może obejmować połączenie elementów czynnościowych zębowych, kostnych i nerwowo-mięśniowych. Technologię EMG wykorzystano do identyfikacji różnych wzorców mięśniowych i porównania danych diagnostycznych u poszczególnych osób. **Cel.** Celem badania było zbadanie cech aktywności EMG mięśni żwaczy u osób dorosłych z jednostronnym zgryzem krzyżowym bocznym. **Materiał i metody.** W badaniu oceniano aktywność EMG mięśni żwaczy u 26 osób w wieku 20–28 lat z jednostronnym zgryzem krzyżowym bocznym. Średni wiek wynosił 23,4 ± 2,1 lata.

Abstract

The worldwide prevalence of posterior crossbite was in a range from 5% to 14 %. The etiology of posterior crossbite can include combination of dental, skeletal, and neuromuscular functional components. EMG has been used to identify different muscle patterns and compare diagnostic data in individuals. **Aim.** The aim of the study was to investigate features of EMG-activity of masticatory muscles in adults with unilateral posterior crossbite. **Material and methods.** The study evaluated EMG-activity of masticatory muscles of 26 subjects of 20-28 years aged with unilateral posterior crossbite. The average age was 23.4 ± 2.1 years. 12 (46.2%) were men, 14 (53.8%) were women. The

Adres do korespondencji/*Correspondence address:*
Anastasiia Liakhovska
Orthodontics Deoartment, Ukrainian Medical Stomatological Academy
23 Shevchenko str., 36008 Poltava, Ukraine
email: anvitatali@gmail.com

12 (46,2%) stanowili mężczyźni, a 14 (53,8%) kobiety. Grupa kontrolna do porównania składała się z 30 osób dobranych pod względem płci bez wad zgryzu. **Wyniki.** W jednostronnych testach zwarcia zębów aktywność EMG mięśni skroniowych przednich i żwaczy była wyższa po stronie zgryzu krzyżowego, niezależnie od tego, czy była to strona pracująca czy równoważąca. W teście zwarcia zębów po stronie prawej mięsień skroniowy przedni był bardziej aktywny po stronie równoważącej w grupie badanej w porównaniu z grupą kontrolną. W teście zwarcia zębów po stronie lewej mięsień żwacz po stronie równoważącej (prawej) był bardziej aktywny u osób w grupie badanej. W teście maksymalnego dobrowolnego zwarcia stwierdzono wyższą aktywność EMG mięśni skroniowych przednich i żwaczy po stronie zgryzu krzyżowego. **Wnioski.** Pacjenci ze zgryzem krzyżowym charakteryzują się asymetryczną aktywnością EMG mięśni po prawej i lewej stronie z powodu zwiększonej aktywności EMG mięśni żwaczy po stronie zgryzu krzyżowego. **(Smaglyuk L, Liakhovska A, Kulish N. Cechy związane z aktywnością EMG mięśni żwaczy u pacjentów z jednostronnym zgryzem krzyżowym tylnym: badanie przekrojowe. Forum Ortod 2021; 17 (2): 114-21).**

Nadesłano: 19.11.2020
Przyjęto do druku: 18.05.2021
https://doi.org/10.5114/for.2021.107531

Słowa kluczowe: mięśnie żwacze, wada zgryzu, aktywność EMG, zgryz krzyżowy

control group for comparison consisted of 30 sex-matched individuals without malocclusion. **Results.** In one-side teeth clenching tests EMG-activity of anterior temporal and masseter muscle was higher on crossbite side, whether it was working or balancing side. In the right-side teeth clenching test anterior temporalis muscle was more active on the balancing side in the study group comparing with the control group. In the left-side teeth clenching test masseter muscle on the balancing side (right) was more active in the subjects of the study group. In the maximum voluntary clenching test higher EMG-activity of the anterior temporal and masseter muscle was found on the crossbite side. **Conclusions.** Patients with crossbite are characterized by asymmetric EMG-activity of muscles on the right and left sides due to increased EMG-activity of the masticatory muscles on the crossbite side. **(Smaglyuk L, Liakhovska A, Kulish N. Features related to EMG-activity of masticatory muscles in patients with unilateral posterior crossbite: a cross-sectional study. Orthod Forum 2021; 17 (2) 114-21).**

Received: 19.11.2020
Accepted: 18.05.2021
https://doi.org/10.5114/for.2021.107531

Key words: masticatory muscles, malocclusion, EMG-activity, cross bite

Introduction

The worldwide prevalence of posterior crossbite was in a range from 5% to 14 %, without differences in gender (1, 2). Some studies indicate that crossbite reduced its prevalence from 14% to 7%. This could be explained (particularly in the developed countries) by the epidemiological impact of orthodontic treatments carried out during primary and mixed dentitions up to adolescence (2, 3, 4). The etiology of posterior crossbite can include any combination of dental, skeletal, and neuromuscular functional components, but the most frequent cause is reduction in width of the maxillary dental arch. Such a reduction can be induced by bad habits or obstruction of the upper airways caused by adenoid tissues or nasal allergies (5). Some studies in children and adolescents have shown that posterior crossbite has been associated with asymmetrical function of the masticatory muscles, signs and symptoms of temporomandibular disorders (TMD), such as pain, headache, and muscle tenderness, which may relate to the masticatory muscle performance (6). Subsequent adaptation of the neuromusculature to the acquired mandibular position can cause asymmetric mandibular growth and as a result facial disharmony (5). The asymmetrical function in posterior crossbite patients was reported to be associated to different development of the right and left sides of the mandible over time, asymmetric contraction of the masticatory muscles (5, 7, 8, 9), reduced thickness of the ipsilateral masseter muscle (10), and a different chewing pattern associated to an increase in the reverse chewing cycle (11). However, others reported different findings with a consequent inconsistency retrieved from the literature (12). The objective evidence based wide applicable method of muscle functional diagnostic is EMG. EMG has been used to identify different muscle patterns and compare diagnostic data in different individuals (13).

Aim

Therefore, the aim of our study was to investigate features related to EMG-activity of masticatory muscles in adult patients with unilateral posterior crossbite.

Material and methods

Two groups of individuals were studying: (1) study group: 26 subjects of 20-28 years aged with unilateral posterior crossbite, (2) control group: 30 age- and sex-matched individuals

with normal occlusion. The average age of subjects in study group was 23.4 ± 2.1 years. 12 (46.2%) were men, 14 (53.8%) were women. All subjects were found unilateral cross bite without mandibular shift and a forced bite, 10 (38.5%) of them – right crossbite, 16 (61.5%) – left crossbite. In control group 13 (43.3%) subjects were men, 17 (56.7%) were women. The average age of individuals was 24.8 ± 1.8 years. Exclusion criteria of the study for subjects of two groups were: previous orthodontic treatment, general diseases, traumas and clefts in maxillofacial region.

Surface EMG of anterior temporal, masseter muscles of both sides (left and right) was performed to all subjects of both groups using the electromyograph Synapsis. The recordings were undertaken two times by two investigators (authors of the article), who had been trained and received a certificate confirming the ability to work with the electromyograph Synapsis. EMG-activity was determined as the average of the two measurements. 4-channel electromyograph Synapsis (Neurotech company, Russia) included in a wide working band (from 0.5 Hz to 15 kHz), sampling frequency for each channel up to 40 kHz, low noise level not exceeding 6 μV, resistance to signal guidance, amplitude range of measured signals 0.1 μV-200μV. The myograph is powered via the USB interface of a computer. During the EMG examination, the subjects, seated in an upright position with the head in natural posture, with legs standing on foot on a firm support (floor), hands quietly lie on the hips. Arms and legs were not be crossed (14). Before the EMG test, the subjects were explained the purpose and features of EMG, to warn about the absence of pain sensations.

To record muscle bioelectrical activity, unipolar electrodes were used, which are connected to the electromyograph by 4 separate wires with separate inputs. Before applying the electrodes, the skin was cleaned and degreased with 70% solution of ethyl alcohol, which reduced the interelectrode resistance. Electrodes placement was very essential. Disposable silver chloride surface electrodes (diameter 10 mm, Neirosoft, Russia) were positioned on the muscular bellies parallel to muscular fibers. These points were identified by palpation in the area with the greatest muscle tension during teeth clenching. To determine the point of placement of the electrode on the masseter muscle, palpation was performed in the area above 3 cm in anterosuperior direction of the lower jaw angle parallel to the lower third of the imaginary line connecting the lower jaw angle and the outer angle of the eye of the same side of the face. For the frontal part of the temporal muscle, palpation was performed along the anterior edge of the muscle parallel to the frontotemporal suture (12, 15, 16, 17, 18).

EMG-activity was recorded in 3 tests, lasted 30s for each one: maximum voluntary clenching, clenching of the standard cotton roll on the left side (left-side clenching), clenching of the standard cotton roll on the right side (right-side clenching). Maximum voluntary clenching was performed in intercuspal position. EMG data were processed using Neurotech's Synapsis software. EMG-activity for each muscle was estimated by maximum amplitude of the muscle contractions (μV).

The procedures received approval from the Bioethics Committee of the Ukrainian Medical Stomatological Academy (Poltava, Ukraine). All patients signed a statement of informed consent.

EMG-activity between sides (right and left/normal and crossbite) were statistically analyzed using Student's paired t-test (level of significance $p1<0,05$). Differences in the indicators of EMG-activity between the study (with crossbite) and control (with normal occlusion) groups ere evaluated using analyses of Fisher's criterion X2. The hypotheses were verified at the level of significance $p<0,05$.

Results

The average values of EMG-activity of the masticatory muscles of the subjects of two groups in tests of clenching teeth on the left and right sides are shown in Table 1 and Table 2.

Table 1 and Table 2 show the averages and standard deviations of EMG-activity of masticatory muscles (maximum amplitude, average amplitude) for both groups. On comparing the left and right sides in subjects of the control group with normal occlusion, there was significant statistical difference for EMG-activity of the masticatory muscles. Thus, EMG-activity was statistically higher on the working side (in left-side clenching test working side is left, in right-side clenching test working side is right) than on the balancing side. Such EMG-activity of masticatory muscles in control group in test of one-side clenching with cotton rolls could be considered as physiological and compatible with normal function. In subjects of the study group with unilateral posterior crossbite there was a significant statistical difference for EMG-activity of the anterior temporalis muscles and statistical difference was not found for masseter muscles in the left-side clenching test. The left (working side) anterior temporal muscle demonstrated a higher EMG activity than the muscle on the balancing side. In the right-side clenching test there was not a significant difference in EMG-activity of anterior temporalis and masseter muscles on the working and balancing sides in the study group.

On comparing EMG-activity of masticatory muscles in two groups there was not significant statistical difference except of masseter muscle on the balancing (right) side in a left-side clenching test and anterior temporalis muscle on the balancing (left) side in a right-side clenching test. The EMG-activity of right masseter and left temporalis muscles was higher in the subjects of study group than in the control one.

The examples of EMG of subjects of the control and study groups are presented in Figure 1, 2, 3, 4, 5, 6.

Table 1. EMG-activity of masticatory muscles in patients with normal occlusion and unilateral posterior crossbite in left-side clenching test.

Group	Max. Amplitude, μV			
	m.temporalis dextra	m.temporalis sinistra	m.masseter dextra	m.masseter sinistra
Study	738,54±48,43*	1004,45±61,23	897,45±43,12	978,38±46,78
Control	608,16±54,53*	934,28±55,59	685,16±46,77*	965,68±43,40
p	>0,05	>0,05	<0,05	>0,05

*p1<0,05

Table 2. EMG-activity of masticatory muscles in patients with normal occlusion and unilateral posterior crossbite in right-side clenching test.

Group	Max. Amplitude, μV			
	m.temporalis dextra	m.temporalis sinistra	m.masseter dextra	m.masseter sinistra
Study	876.42±28.76	841.92±27.25	937.88±30.17	922.26±29.87
Control	933,28±31,47*	679,28±37,65	1022,72±31,48*	732,72±31,48
p	>0,05	<0,05	>0,05	<0,05

*p1<0,05

Table 3. EMG-activity of masticatory muscles in patients with normal occlusion and unilateral posterior crossbite in maximum bilateral clenching test.

Group	Max. Amplitude, μV			
	m.temporalis dextra	m.temporalis sinistra	m.masseter dextra	m.masseter sinistra
Study	1017.01±31.43	986.42±29.29	860.55±29.65	886.52±28.6
right crossbite (n=10)	1132.54±34.21	885.38±27.52	935.33±31.88	818.55±22.64
left crossbite (n=16)	901.47±28.65	1087.45±31.06	785.76±27.42	954.48±34.55
Control	967.32±31.57	962.24±45.67	1072.44±30.03	1052.84±30.77
p	>0.05	>0.05	>0.05	>0.05

*p1<0,05

EMG-activity of masticatory muscles of two groups in maximum voluntary clenching test is represented in Table 3.

In control group there was symmetrical EMG-activity of masseter and anterior temporalis muscles on right and left side, and found no significant difference in indicators of the tested muscles. In subjects with normal occlusion masseter muscles demonstrated a slighty higher EMG-activity than the anterior temporalis muscles (p>0.05). Subjects with a posterior crossbite had a masticatory pattern different from subjects of the control group. Although in our study we found no differences in EMG-activity between control and study group in maximum clenching test, in subjects of study group there was higher EMG-activity of the anterior temporalis muscles than the masseter muscles. To demonstrate asymmetrical muscle work, we analyzed separately EMG-activity of masticatory muscles in subjects of right and left crossbite in this test. The anterior temporal and masseter muscle EMG-activity differed between the left and right sides, and higher muscle activity was found on the crossbite side.

The examples of EMG of subjects of the control and study groups in the maximum voluntary clenching are presented in Figure 7, 8, 9.

Discussion

Despite of the insignificant, compared to other malocclusion, prevalence of the posterior unilateral crossbite, it is important that its frequency and the presence of functional problems associated with this pathology, increase. Therefore, the study of the masticatory muscles work is an important issue. This is confirmed by the studies of many authors. However, there are conflicting data in the literature regarding the features of EMG-activity of the masticatory

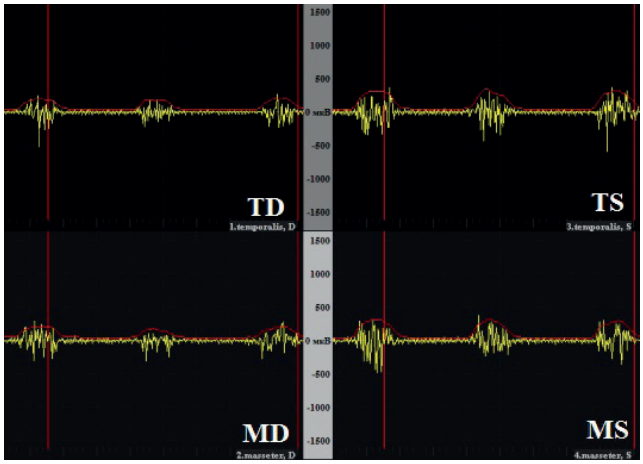

Figure 1. The fragment of the electromyogram of the 25 year-old male patient V. of the control group in the left-side teeth clenching test. EMG-activity of the anterior temporal and masseter muscles is higher on the working side (left, TS, MS) compared to the balancing side (right, TD, MD). The activity of the temporal and masseter muscles on the same side did not differ significantly.

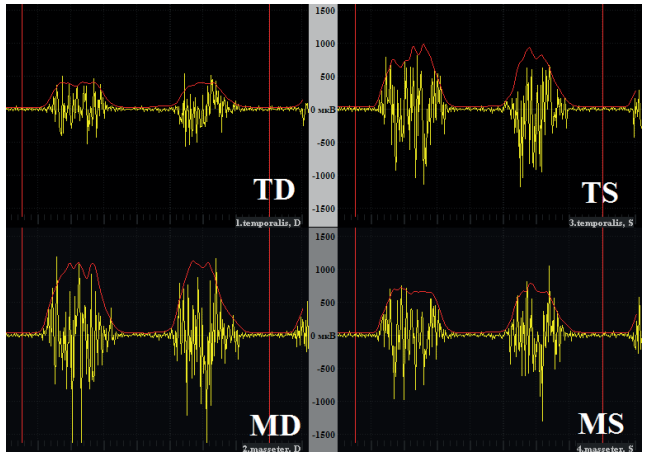

Figure 2. The fragment of the electromyogram of the 23 year-old male patient T. of the study group with right crossbite in the left-side teeth clenching test. Increased EMG-activity of masseter muscle on the balancing side (right, MD) compared to the working side (left, MS). EMG-activity of the anterior temporal muscle (TS) is higher than EMG-activity of the masseter muscle (MS) on the working side (left).

muscles. Most authors emphasized the presence of asymmetric activity, although some authors point out the lack of differences compared with subjects with normal occlusion (5, 6, 12, 19). In our study, we examined EMG-activity of the masticatory muscles in individuals matched in age and sex who had normal occlusion without occlusal pathologies in transversal plane to establish the characteristics of normal muscle activity. These individuals formed a control group that was selected for comparison. In the literature there are data on a large variety of deviations in normal EMG-activity of masticatory muscles (13, 14). Some authors point to the physiological asymmetric work of the muscles of the body on the left and right sides, and as a consequence of asymmetry in the work of the masticatory muscles (5). The authors found that the right anterior temporal muscle demonstrated a higher EMG-activity than the left anterior temporal muscle in the normocclusive group, suggesting that muscular asymmetry could be considered physiological and compatible with normal function (20).

We paid attention to the quantitative value of the maximum activity of contractions and symmetry on the left and right sides. Thus, we found the symmetrical work of the masseter and anterior temporal muscles in maximum voluntary clenching test. This means that in control group EMG-activity did not differ by more than 15% on the left and right sides. The average values had no statistically significant differences ($p>0.05$). The EMG-activity of the masseter muscle was higher than the temporal in 83.3% of cases, but without statistically significant difference. In the test of one-side clenching we determined muscular asymmetry, which is a physiological functional characteristic in this case. So EMG-activity was higher on the working side, compared to the balancing side. This difference was statistically confirmed and concerned the temporal ($p<0.05$) and masseter ($p<0.05$) muscles. There are differences in the results of studies on features of muscle activity at rest position in subjects with posterior unilateral crossbite (6). Alarcon et al found no significant differences in any of the anterior temporal, masseter muscles in the normocclusive and right posterior crossbite subjects at rest position (6). Kecik et al showed that the anterior temporal and masseter muscle activity at rest position differed significantly between the crossbite and control groups, and higher muscle activity was found on the crossbite side (21).

In tests for active muscle work, most studies have found associations between crossbite and parameters related to the masticatory muscle performance, such as asymmetric electromyographic (EMG) activity (20). Alarcon et al. reported the crossbite side to be less active than in normocclusive subjects, and did not find any difference between the crossbite side and non-crossbite side (13). Instead, Andrade et al. found that the masseter of the crossbite side was more active than that of the non-crossbite side in the unilateral posterior crossbite group during maximal clenching (5). Conversely, Piancino et al. reported a reduced masseter activity on the crossbite side and unaltered or increased on the non-crossbite side (19). In our study we found features of masticatory pattern in subjects with posterior unilateral crossbite. In one-side teeth clenching tests EMG-activity of anterior temporal and masseter muscle was

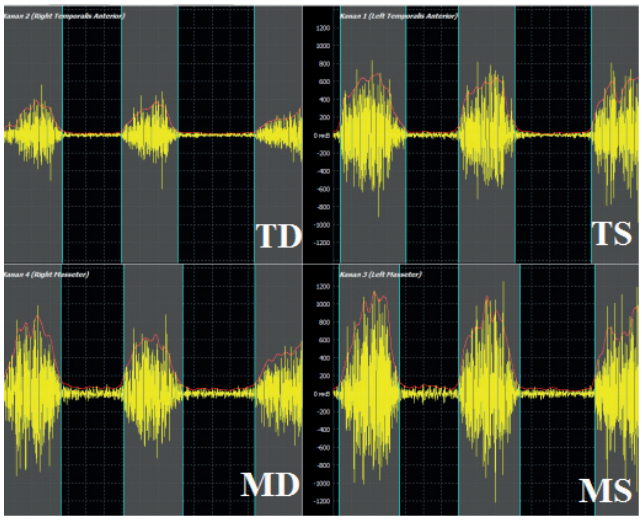

Figure 3. The fragment of the electromyogram of 23 year-old patient B. of the study group with left crossbite in left-side teeth clenching test. Increased EMG-activity of masticatory muscles on the working side (left, TS, MS).

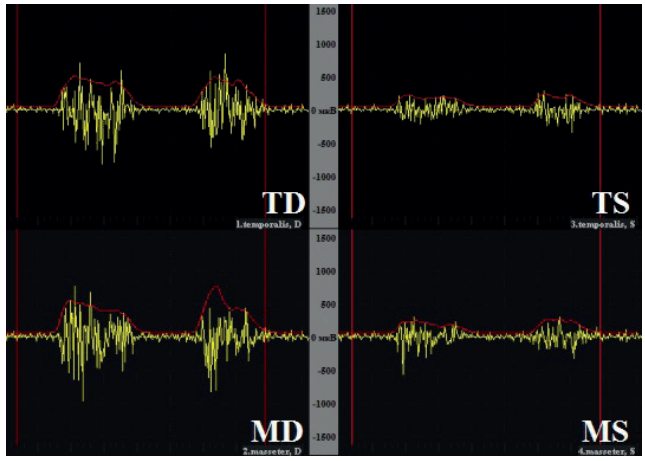

Figure 4. The fragment of the electromyogram of the 22 year-old male patient D., control group in the right--side teeth clenching test. EMG-activity of the anterior temporal and masseter muscles is higher on the working side (right, TD, MD) compared to the balancing side (left, TS, MS).

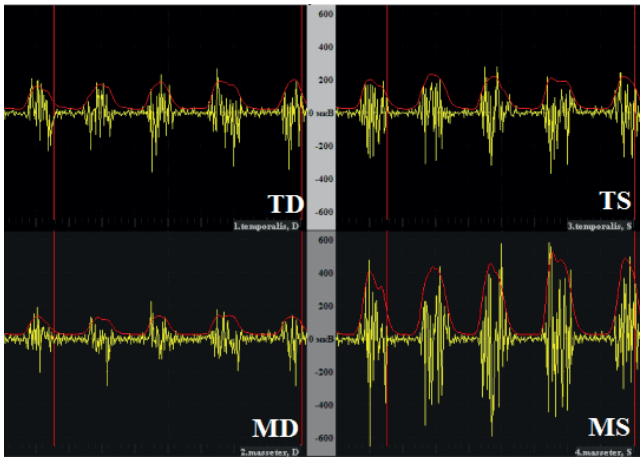

Figure 5. The fragment of the electromyogram of the 28 year-old female patient Yu., of the study group with left crossbite in the right-side teeth clenching test. Increased EMG-activity of masticatory muscles on the balancing side (left, TS, MS) compared to the working side (right, TD, MD).

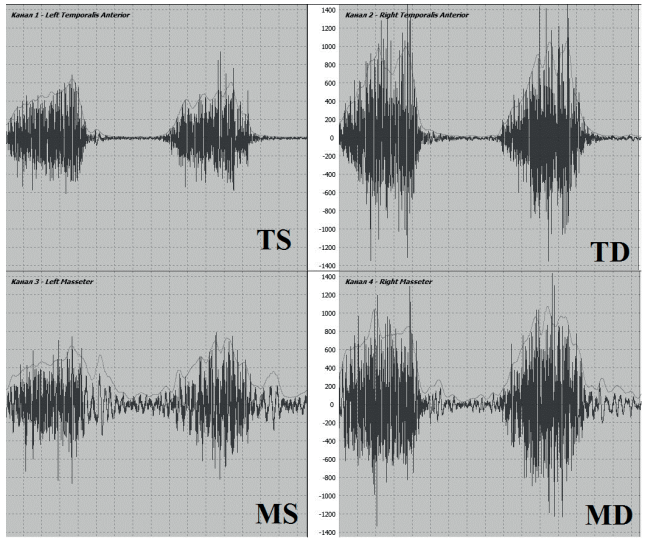

Figure 6. The fragment of the electromyogram of the 25 year-old male patient K. of the study group with right crossbite in the right-side teeth clenching test. Increased EMG-activity of masticatory muscles on the working side (right, TD, MD).

higher on crossbite side, whether it was working or balancing side. This feature explains that there was not significant difference in EMG-activity of the masticatory muscles on the left and right sides in right-side teeth clenching test and of masseter muscles in left-side teeth clenching test. The left (working side) anterior temporal muscle demonstrated a higher EMG-activity than the muscle on the balancing side in the test of teeth clenching on the left side. In the right-side teeth clenching test anterior temporal muscle was more active on the balancing side in the study group comparing with the control group. In the left-side teeth clenching test the masseter muscle on the balancing side (right) was more active in the subjects of the study group. It may also be a confirmation of the increased EMG-activity on the side of crossbite. Another feature in the study group was that the masseter muscle to be less active then the temporal

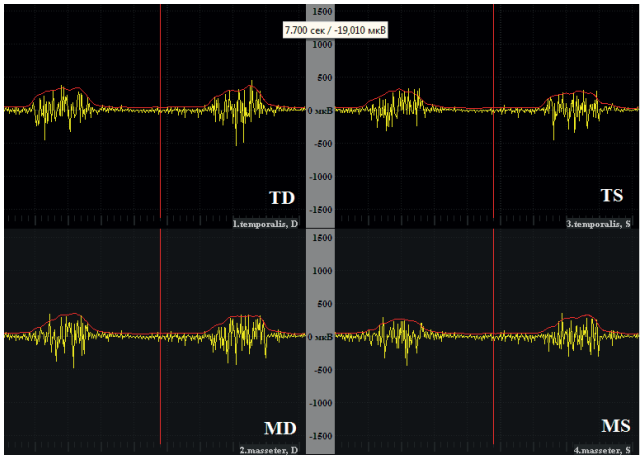

Figure 7. The fragment of the electromyogram of the 26 year-old male patient K. control group in the maximum voluntary clenching test. Symmetrical and equal activity of the temporal and masseter muscles on the left and right sides.

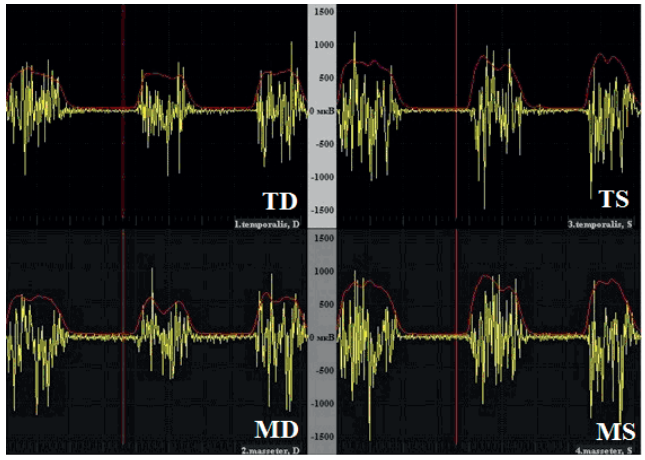

Figure 8. The fragment of the electromyogram of 26 year-old patient B. of the study group with left crossbite in maximum voluntary clenching test. Significantly increased EMG-activity of the masseter and temporal muscles on side with crossbite (left, TS, MS).

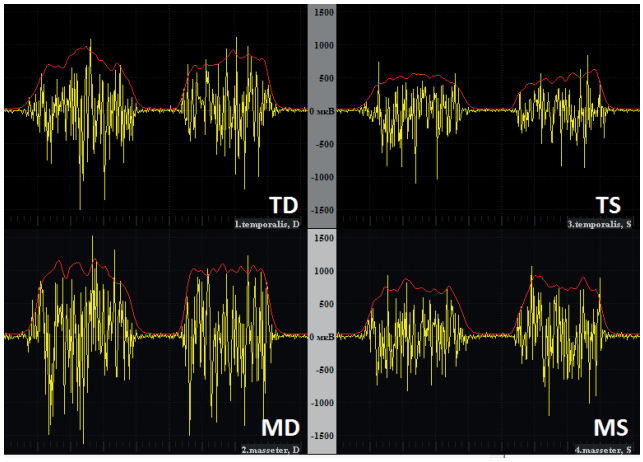

Figure 9. The fragment of the electromyogram of 26 year-old patient B. of the study group with right crossbite in maximum voluntary clenching test. Significantly increased EMG-activity of the masseter and temporal muscles on side with crossbite (right, TD, MD).

muscles, which is confirmed in some studies and contradicts others (5, 19). The asymmetric activity of the masticatory muscles is also proved by the difference with the control group in EMG-activity of the muscles in the maximum voluntary clenching test. EMG-activity of the anterior temporal and masseter muscle differed between the left and right sides, and higher muscle activity was found on the crossbite side

In our opinion, the asymmetric activity of the masticatory muscles is associated with the difference in the occlusal contacts on the side with normal occlusion and the crossbite side. The masticatory muscles develop the greatest maximum amplitude at the time of clenching teeth in maximum intercuspal position. Due to the fact that subjects have different occlusial contacts, the muscles on the side of crossbite, try to reach higher occlusal stability, develop maximum amplitude that exceeds the values on the opposite side (7, 22). Although there are different data in studies. Association between posterior crossbite and EMG-activity is found by skeletal asymmetry, connected with linear and volumetric mandibular asymmetry on crossbite and non-crossbite sides (5, 20) or by possibly consequence of functional mandibular shift in order to reach an occlusal stability (5, 13, 20, 23, 24). Subjects of the study group did have a forced bite or functional mandibular shift.

Conclusions

Orofacial region, particulary, its components: craniomandibular (TMJ), neuromuscular systems and occlusion, perform important functions for human life, and are one of the indicators of general somatic human health. Electromyography is a modern, objective, minimally invasive highly informative method of functional diagnostics of muscles of the orofacial region, registration of activity of their motor units.

The major parameters for evaluating used of the data after electromyography: the amplitude, the ratio of symmetrical muscle activity. Normal pattern of the masticatory muscles is characterized by symmetrical EMG-activity on the left and right sides.

Patients with crossbite are characterized by increased EMG-activity of the masticatory muscles on the side of crossbite, asymmetric work of muscles on the right and left sides.

Obtained data proves the importance of dynamic individual screening of the functional state and rebuilding of the muscles of the cranio-mandibular system.

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