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Examination of the bioelectrical activity of the masticatory muscles during Angle's Class II division 2 therapy with an activator

Ispitivanje bioeleketrične aktivnosti mastikatornih mišića kod strmog zagrižaja tokom terapije aktivatorom

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Abstract

Background/Aim. The muscles of the orofacial region have great influence on the development of dentition and occlusion formation. It is known that improper function of these muscles is one of the major etiological factors in malocclusion. A correlation between function disorders of orofacial muscle and occlusion disorders has been confirmed, as well as a correlation between the bioelectric activity of the masticatory muscles, recorded by electromyography, and bite force upon maximal voluntary contraction of these muscles. The aim of the study was to analyze the bioelectriacal activity of temporal and masseter muscles. **Methods.** The sample consisted of 100 subjects of both sexes, divided into the control group (n = 30) with neutral and complete dental arches, and the study group (n = 70) of patients with distal occlusion. Electromyographic measurement of bioelectric potentials in all the subjects was conducted for the examined muscles in the physiologic rest position, central mandible occlusion, and during maximal voluntary contraction of muscles and saliva swallowing, in Angle Class I and II/2 occlusal relationships, prior to treatment, after one year of the orthodontic treatment and after the treatment with an activator. **Results.** Comparing the values of thebioelectrical activity in the control and the study group before the treatment, a decreased muscle activity was established in all the three positions in the study group. After the first year of orthodontic treatment the results showed an elevation in the bioelectrical activity in both muscles. After treatment with an activator, the bioelectrical activity in both muscles in the study group was higher than before the treatment, as it is confirmed by a positive highly significant coefficient of correlation. **Conclusion.** In all the three measured positions of the mandible with Angle Class II/2 malocclusion, bioelectrical activity was lowest at baseline and increased during the first year of treatment, and at the end of the treatment it partially reduced close to the approximate values in normal occlusion. Research on electromyographic activity of masticatory muscles is useful in everyday clinical practice, especially in present distinctive skeletal discrepancy before, during and after orthodontic treatment, if on the bases of the results we can evaluate the treatment, but also determine the start and duration of the retention period and retention device type.

Key words:
electromyography; masticatory muscles; malocclusion, angle class I; malocclusion, angle class II; activator appliances; treatment outcome.

Apstrakt

Uvod/Cilj. Mišići orofacijalne regije imaju veliki uticaj na razvoj zubnih nizova i formiranje okluzije. Poznato je da je nepravilna funkcija mišića jedan od značajnih etioloških faktora u nastanku malokluzija. Takođe, potvrđena je uzajamna povezanost poremećaja funkcije orofacijalnih mišića i poremećaja okluzije, kao i korelacija između bioelektrične aktivnosti mastikatornih mišića, registrovane elektromiografskom metodom, i ispoljene sile zagrižaja pri maksimalnoj voljnoj kontrakciji ovih mišića. Cilj studije bio je analiza bioelektrične aktivnosti temporalnog i maseteričnog mišića. **Metode.** Uzorak je činilo 100 osoba oba pola, podeljenih u kontrolnu grupu (n = 30) sa neutrookluzijom i potpunim zubnim nizom, i ispitivanu grupu (n = 70) sa distookluzijom. Kod svih ispitanika sprovedeno je elektromiografsko merenje bioelektričnog potencijala za ispitivane mišiće u položaju fiziološkog mirovanja, centralne okluzije mandibule, i pri maksimalnoj voljnoj kontrakciji mišića i gutanju pljuvačke, kod klase I i II/2 okluzalnih odnosa po Anglu, i to pre lečenja, nakon jedne godine ortodontskog lečenja i po završetku lečenja sa aktivatorom. **Rezultati.** Poređenjem vrednosti biolektričnog potenicijala pre lečenja utvrđena je smanjena aktivnost u sva tri položaja praćenih mišića u ispitivanoj grupi u odnosu na kontrolnu. Nakon prve godine ortodontskog tretmana utvrđeno je povišenje bioelektrične

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aktivnosti oba mišića. Po završetku tretmana aktivatorom, bioelektrična aktivnost oba mišića u ispitivanoj grupi bila je viša u odnosu na vrednosti pre tretmana, što dokazuje pozitivan, veoma značajan koeficijent korelacije. **Zaključak.** U sve tri merene pozicije, pri različitim položajima mandibule kod strmog zagrižaja, bioelektrična aktivnost je bila najmanja na početku terapije i povećavala se tokom prve godine lečenja, da bi se na kraju terapije delimično smanjila na vrednosti približne vrednostima normalne okluzije. Istraživanja elektromiografske aktivnosti mastikatornih mišića imaju smisla u svakodnevnoj kliničkoj praksi, kod izrazitih skeletnih diskrepanci pre, u toku i nakon ortodontske terapije, ukoliko na osnovu njih možemo vrednovati rezultate lečenja, ali i odrediti početak i dužinu trajanja retencionog perioda i vrstu retencionog aparata.

Ključne reči:
elektromiografija; mišići, mastikatorni; malokluzija, klase I; malokluzija, klase II; ortodontski aparati; lečenje, ishod.

Introduction

Normal occlusion (*eugnathia*) presents a morphologically and functionally balanced bite. Disruption of this balance leads to the formation of malocclusion, with expected change in force and electromyographic (EMG) activity of the muscles of the orofacial region [1, 2].

The role of the basic functions of the orofacial region in the etiology of malocclusion is relatively unknown, because it is observed that the normal occlusion is often accompanied by markedly disturbed functions of the orofacial musculature. On the other hand, according to the Moss and Chalmers [3] theory, the skeleton is formed in response to the soft tissue. Therefore, it is very important to estimate the functional part in the etiology of certain malocclusion. EMG recording of orofacial muscle activity is important in scientific research, but even more in clinical practice [2, 4]. Craniofacial region is a part of the organism which consists of organs that perform many different functions by motor muscle activity. Jaws and teeth in the rest position are under the constant influence of external and internal muscles of the orofacial region [5]. The muscles of the orofacial region together with other factors (shape and position of the tooth bud, craniofacial skeleton form, etc.) play an important role in teeth setting, dental arch shape modifications and other dentoalveolar structures, establishing jaw relationships, etc. [6]. Morphology of these muscles at the same time depends on the type of diet, sex, age, and state of development of teeth and jaws [7]. Angle has emphasized that muscles have great influence on the development of dentition and occlusion formation. It is well-known that improper function of muscles is one of the major etiological factors in malocclusion [8]. A correlation between function disorders of orofacial muscle and occlusion disorders has also been confirmed. Furthermore, a correlation between the bioelectric activity of the masticatory muscles, recorded by EMG, and bite force upon maximal voluntary contraction of these muscles has been established [9].

The improper function of muscles is one of the major etiological factors in malocclusion. Malocclusions present a common pathological condition of masticatory system. They are characterized by an irregular contact between the maxillary and mandibular teeth that prevent the necessary effectiveness of jaw movement [10]. Malocclusion is usually defined as a consequence of orofacial system growth disorder, trauma, poor oral habits, genetic factors and disorders of masticatory forces balance. Of orthodontics importance are mandible elevating muscles: m. masseter, *m. temporalis, m. pterygoideus medialis*, and mandible depressants such as *m. pterygoideus lateralis* and *m. genioglossus*, which play an important role in facial morphology and tongue function. Also important are the facial muscles such as *m. mentalis* and m. *orbicularis oris* [4, 11].

A specific orofacial anomaly is classified by Angle's sagittal occlusion irregularities as a second class malocclusion (Class II). This malocclusion is also known as degbis [12]. In people with temporal degbis unfavorable type of chewing prevails with a significantly reduced abrasion of posterior teeth. Regarding the function of the orofacial musculature, there is an increased temporal muscle function with masseteric muscle limitation, which is related to the type of chewing [13].

The orofacial muscles region consists of muscles of the head, face and jaws. They differ in origin, structure and physiological properties, and are accordingly divided into: masticatory muscles, facial muscles and muscles of the cranial vault [14].

The group of the masticatory muscles is built of 4 pairs of muscles: temporal, masseteric, outer and inner pterygoid. *M. temporalis* is a broad, flat, fan-shaped muscle that fills temporal pit. Contraction of its anterior and middle fibers elevates the mandible and closes the mouth. Contraction of isolated anterior fibers involves in propulsion, and isolated contraction of posterior muscle fibers in lower jaw retropulsion. Unilateral muscle contractions perform mandible lateral pulsion. Temporal muscle is especially sensitive to occlusal interference and is responsible for the position of the jaw in the vertical direction. Muscle inervation originates from the deep temporal nerves (*temporales profundi*), lateral branches of the mandibular nerve [15]. M. masseter is a short, strong, and thick rectangular muscle, which extends from the zygomatic bone arch, lower to the mandible angle, covering the mandible laterally. *M. masseter* strongly elevates the lower jaw and closes the mouth. Isolated contraction of superficial muscle fibers involves in propulsion, while isolated deep muscle fibres contraction is involved in retropulsion of lower jaw. Unilateral muscle contractions perform mandible lateral pulsion. By its strong action it is involved in food crushing [16]. The muscle innervation originates from masseteric nerve, a lateral branch of the mandibular nerve.

The aim of the study was to analyze the bioelectrical activity (BA) of m. masseter superficialis and *m. temporalis anterior* in different jaw positions both in Angle Class I and

Class II/2 occlusal relations, periodically – before treatment, after one year of orthodontic treatment and after orthodontic treatment with activator.

Methods

The sample consisted of 100 subjects of both sexes, who were treated at the Dental Clinic of Vojvodina, Novi Sad, divided into the control and the study groups. The control group (30 subjects, aged 8–12 years) were subjects with neutroocclusion and complete dental arches. The study group (70 subjects, aged 8–12 years) consisted of patients with distal occlusion and retrusion of upper incisors (Angle's Class II/2), with complete dental arches, randomly selected from the current Dental Clinic casuistry, with previously signed consent.

In both groups EMG analysis was performed for *m. temporalis anterior* and m. masseter superficialis in the physiologic rest position (PR), mandibular central occlusion (CO), during maximal voluntary contraction of muscles and saliva swallowing (MVC), in normal occlusion (Angle Class I malocclusion) and distal occlusion (Angle Class II/2 malocclusion), before the treatment, after one year of treatment and after orthodontic treatment with the activator. Measurement was done at the constant temperature of 25°C, using the Medelec Synergy® device. For recording action potentials of the orofacial muscles we used facial intramuscular coaxial electrodes, set according to the Greenfield scheme. Before the testing two lines were determined: horizontal (representing the Frankfurt horizontal line) and vertical (passing through the frontal edge of the external acoustic hole). Then we determined the muscles positions according to their lines: m. masseter 3 cm forward relative to the vertical line and 6 cm below the horizontal line; *m. temporalis* 3.6 cm in front of the vertical line and 5.6 cm above the horizontal line. EMG was performed symmetrically on the left and the right side, for both muscles for 20 seconds. Upon registration EMG activity, EMG device filters are set to 100 Hz–2 KHz. For evaluation of EMG activity in relaxation (physiological rest) registered activity was 10 μV oscilloscope amplification, and the mandibular central occlusion and maximum voluntary muscle contraction was 250–500 μV, depending on subject's EMG activity. To incorporate the summary of muscle bioelectric activity integrator is used, and the mean value of three consecutive measurements were analyzed. Survey results were analyzed visually with an oscilloscope and graphical paper representation, in milivolt (mV), as mean cumulative action potential voltage amplitude.

We used orthodontic records of: history, clinical findings, functional analysis, study models, cephalometric orthopantomographic and profile shots; before, one year after the treatment and after the treatment was complited. To all the study group subjects, lower lip activator pelota and upper incisors proclination padel spring were set. Construction bite brought the lower jaw forward toward class I jaw relationships, with vertical opening of 2–3 mm beyond vertical resting dimension.

The registered values of the orofacial muscles action potential changes in determined positions were compared. We analyzed the correlation between orofacial muscle EMG activity and occlusal relationships. BA data of the muscles were analyzed quantitatively describing the results, classified according to the parameters set out in the study protocol, and presented in tables and figures.

Statistical analysis consisted of standard statistical methods, while the significance of the results was determined by Student's t-test ($p < 0.05$). For the analysis of the significance of Pearson's correlation factor (r), the scale values for r were used: ± 0.2 – ± 0.01 – no significance, ± 0.4 – ± 0.2 – weak significance, ± 0.7 – ± 0.4 – significant, ± 0.7 – ± 1.0 – very significant correlation.

Results

All the subjects included in this study were divided into the normal occlusion – Angle Class I (the control group) (n = 30) and the distocclusion group – Angle Class II (the study group) (n = 70). In both groups subjects were 8–12 years old (average age in the control group – 11.23 ± 1.56 years, and in the study group 11.68 ± 1.21 years). The age difference was statistically insignificant ($p > 0.05$).

During the research BA was measured for the selected masticatory muscles in three positions: PR, CO, and MVC.

At the beginig BA was recorded for both groups. According to the results, there was no significant difference in the left temporal muscle between the two groups, while in the right temporal muscle the significance was noted in all three positions ($p < 0.05$) (Table 1). BA analysis of m. mas-

Table 1

Bioelectrical acitivity of *m. temporalis* in the subjects with normal bite (Class I) and distocclusion (Class II)

M. temporalis (measured position)	Bioelectrical activity (μV)					
	Class I (n = 30)		Class II (n = 70)		*r*	*p*
	x̄ ± SD	CV (%)	x̄ ± SD	CV (%)		
Left						
PR	8.06 ± 1.94	24.09	6.8 ± 0.62	9.1	-0.4	> 0.05
CO	64.94 ± 19.74	30.4	52.4 ± 13.97	26.66	-0.25	> 0.05
MVC	653.15 ± 109.13	16.71	535.56 ± 137.73	25.72	-0.39	> 0.05
Right						
PR	7.70 ± 1.79	23.28	7.06 ± 2.63	37.28	-0.35	< 0.05
CO	70.38 ± 32.86	46.7	57.81 ± 26.0	44.98	-0.36	< 0.05
MVC	635.26 ± 252.6	39.76	559.63 ± 125.92	22.5	-0.39	< 0.05

PR – physiologic rest position; CO – central occlusion; MVC – maximal voluntary contraction; CV – coefficient of variation; *r* – Pearson's correlation factor.

seter showed statistical significance ($p < 0.05$) in both left and right muscle in all positions, except CO (Table 2).

Table 2

Bioelectrical acitivity of m. masseter in the subjects with normal bite (Class I) and distocclusion (Class II)

M. masseter (measured position)	Bioelectrical activity (μV)					
	Class I (n = 30)		Class II (n = 70)		*r*	*p*
	$\bar{x}$ ± SD	CV (%)	$\bar{x}$ ± SD	CV (%)		
Left						
PR	5.77 ± 2.73	47.36	4.9 ± 1.75	35.78	-0.22	< 0.05
CO	81.69 ± 10.63	13.01	44.97 ± 6.17	13.73	-0.37	> 0.05
MVC	604.21 ± 234.63	38.83	510.12	154.50	30.29	-0.26
Right						
PR	6.1 ± 2.21	36.16	5.57 ± 3.08	55.3	-0.31	< 0.05
CO	79.66 ± 28.36	35.6	63.74 ± 19.77	31.02	-0.22	> 0.05
MVC	626.12 ± 191.72	30.62	565.66 ± 179.39	31.71	-0.34	< 0.05

PR – physiologic rest position; CO – central occlusion; MVC – maximal voluntary contraction; CV – coefficient of variation; *r* – Pearson's correlation factor.

BA was measured in the study group subjects after the first year of the activator therapy. In both temporal and masseteric muscles there was a statistically significant difference between BA ($p < 0.05$) in all the three positions (Tables 3 and 4). A significant positive correlation (r) was established in all measuring positions for temporal muscle, while in the masseteric muscle it was positive and very significant in CO and MVC position for the left, and PR and MVC positions for the right muscle.

Table 3

Bioelectrical acitivity of *m. temporalis* in the subjects with distocclusion (Class II), before and after a year of the therapy

M. temporalis (measured position)	Bioelectrical activity (μV)					
	before therapy		after year of the therapy		*r*	*p*
	$\bar{x}$ ± SD	CV (%)	$\bar{x}$ ± SD	CV (%)		
Left						
PR	6.8 ± 0.62	9.1	7.46 ± 2.79	37.32	0.85	< 0.05
CO	52.40 ± 13.97	26.66	63.6 ± 16.95	26.66	0.71	< 0.05
MVC	535.56 ± 137.73	25.72	593.97 ± 147.83	24.89	0.83	< 0.05
Right						
PR	7.06 ± 2.63	37.28	7.58 ± 4.39	57.92	0.79	< 0.05
CO	57.81 ± 26.0	44.98	64.22 ± 28.89	44.98	0.8	< 0.05
MVC	559.63 ± 125.92	22.5	601.97 ± 205.21	34.09	0.83	< 0.05

PR – physiologic rest position; CO – central occlusion; MVC – maximal voluntary contraction; CV – coefficient of variation; *r* – Pearson's correlation factor.

Table 4

Bioelectrical acitivity of m. masseter in the subjects with distocclusion (Class II), before and after a year of therapy

M. masseter (measured position)	Bioelectrical activity (μV)					
	before therapy		after year of the therapy		*r*	*p*
	$\bar{x}$ ± SD	CV (%)	$\bar{x}$ ± SD	CV (%)		
Left						
PR	4.9 ± 1.75	35.78	5.37 ± 1.92	35.78	0.66	< 0.05
CO	44.97 ± 6.17	13.73	54.9 ± 12.83	23.36	0.81	< 0.05
MVC	510.12 ± 154.50	30.29	549.12 ± 166.31	30.29	0.7	< 0.05
Right						
PR	5.57 ± 3.08	55.3	5.81 ± 3.21	55.30	0.75	< 0.05
CO	57.88 ± 19.77	31.02	65.47 ± 20.31	31.02	0.66	< 0.05
MVC	565.66 ± 179.39	31.71	588.0 ± 186.47	31.71	0.78	< 0.05

PR – physiologic rest position; CO – central occlusion; MVC – maximal voluntary contraction; CV – coefficient of variation; *r* – Pearson's correlation factor.

At the end of research we compared BA in all the positions for both muscles before and at the end of the therapy treatment. In the temporal muscle a statistically significant difference was noted in all positions of the left and the right muscle, except for the right muscle in MVC position (535.56 μV *vs* 663.2 μV, $p > 0.05$), but the correlation was positive and very significant in all the positions, except CO in the right muscle ($r = 0.6$), where it was significant (Figure 1).

In the masseteric muscle a statistically significant difference was present only in PR and MVC positions for both left and right muscle ($p < 0.05$), while a correlation was positive and of a very high significance for all the positions in the left and the right masseteric muscle ($r > 0.7$) (Figure 2).

Discussion

This electromyographic activity (EA) study on chewing muscles at Angle Class II/2 confirmed the basic starting point that improper orofacial muscle function has an impact

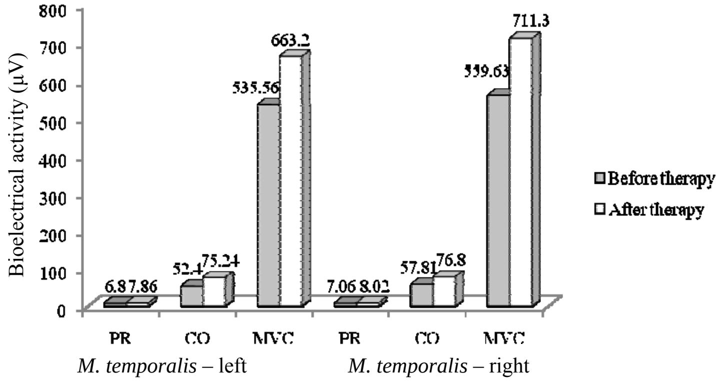

Fig. 1 –Bioelectrical acitivity of *m. temporalis* in the subjects with distocclusion (Class II), before and at the end of the therapy (PR – physiologic rest position; CO – control occlusion; MVC – maximal voluntary contraction).

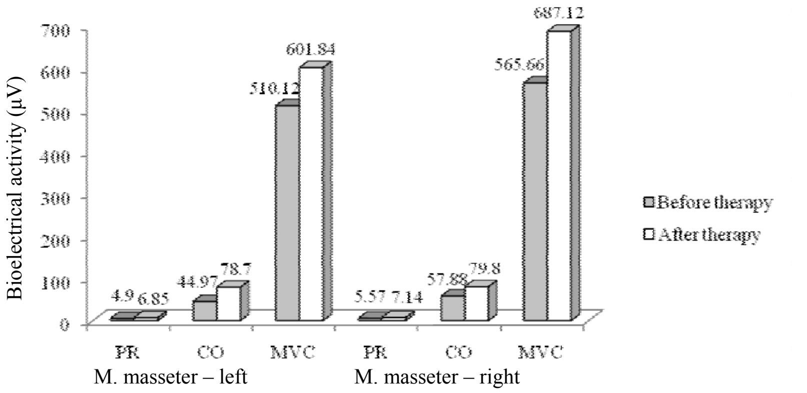

Fig. 2 – Bioelectrical acitivity of m. masseter in the subjects with distocclusion (Class II), before and at the end of the therapy (PR – physiologic rest position; CO – control occlusion; MVC – maximal voluntary contraction).

on occlusion and that reeducation of modified function is important in the treatment, affecting treatment results stability.

The results show that in the control group with normal occlusion, Angle Class I malocclusion had a higher mean bioelectrical potential (BP) of *m. temporalis* compared to the m. masseter in the physiologic rest position of the mandible (15.76 μV *vs* 11.87 μV) and at maximum voluntary muscle contraction (1288.41 μV *vs* 1230.33 μV). Deviations are defined only in central occlusion, where m. masseter showed higher BP compared to *m. temporalis* (161.35 μV vs. 135.32 μV), while during maximal voluntary contraction m. masseter showed BP close to temporal muscle activity, but did not reach it. These results are consistent with results of studies by other authors and the cause may be the temporal chewing type which dominates in this group. However, the results of the study by Shi and An [17] indicate a higher activity in the masseteric muscle in normal occlusion compared to distocclusion. These variations can be explained as a consequence of stress and psychological factors, which are reported in findings of Ingervall and Bitsanis [18], and are followed by the increase in impulses coming into the muscle from the central nervous system in children, during the first registration of BA of muscles.

Ma et al. [19] noted that independantly on the occlusion temporal muscles were more active in the postural position of the mandible, and the masseter in central occlusion during maximal voluntary contraction of masticatory muscles.

Comparing the results of Castroflorio et al. [20] with the results of this study, we can conclude that all of the registered values of masticatory muscles action potentials in our study, are proportionally higher, which is directly related to the increased EMG calibration of our device.

The subjects with Angle Class II/2 malocclusion showed a greater BA of *m. temporalis* compared to m. masseter in all the measured positions, which can be the consequence of the dominant type of chewing in this group.

Comparative analysis of the BA of the masticatory muscles in physiological rest, central occlusion of the mandible and at maximal voluntary muscle contraction in normal and distal occlusion, showed that all the registered nominal values of action potential increased with a statistical significance in central occlusion of the mandible, in the control group compared with the experimental group of subjects ($p < 0.05$). These results may be the consequence of the decrease in muscle tone of the disturbed occlusal relationship, and as the result of reducion in the number of active muscle fibers and impulses coming from the central nervous system, and the consequential reduction in activated motor units, or a combination of both. Our results are compatible with this results of other authors [3, 21, 22]. Antonarakis et al. [23] point out that unlike the Class I malocclusion, where the muscle function is normal, except in cases of open bite, in Angle Class II malocclusion there is abnormal muscle activity [23]. Lowe et al. [21] suggests that there is a dependent relationship between skeletal morphology (size of the mandibular angle and the degree of parallelism in jaw bases) and EMG amplitude of the anterior temporal and masseter muscles during maximal voluntary contraction [21]. According to Tuncer et al. [24], damaged muscle activity at Angle Class II/2 can be attributed to different dentofacial morphology and unstable conditions of occlusal contact.

The EA of the masticatory muscles in Angle Class II/2 malocclusion significantly increased during the first year of the treatment with the activator compared to the start of the therapy. Increasing potential action is approximately equal for both observed muscles. At the end of the therapy both muscles activity decreased approaching the values of the action potentials of muscles in normal occlusion, but stil not reaching it. The bioelectric potential values of masticatory muscles at the end of the treatment were significantly higher compared to their values before the treatment ($p < 0.05$). These results are compatible with the results of Ingervall and Bitsanis [18] and Stavridi and Ahlgren [25].

Uner et al. [26] have showed the effects of activators on the masticatory muscles in distal occlusion and found an increased activity in the masseter muscle in the physiologic rest position of the mandible at the beginning of treatment, and the reduction of the activity at the end of treatment, while in the control group there was no change in the recorded EMG actions of the muscles examined.

Ingervall and Bitsanis [18] have observed the function of the masticatory muscles in the first six months and in the first year after the initiation of the activator therapy in patients with distal occlusion, and concluded that the increased muscle activity of the temporal muscle, after starting the treatment, gradually decreased as the result of adaptation to the new position of the mandible. Activity of masseteric and temporal muscle during maximal voluntary contraction and chewing was influenced by the incisal instability, and the changes in the activity of these muscles were slight.

Stavridi and Ahlgren [25] have reported an increase of EA in the masseter muscle during swallowing in patients with distal occlusion treated with an activator.

Pancherz et al. [27] concluded, by measuring the action potentials of masseter and temporal muscles in patients with distal occlusion, that the reduced activity of these muscles after treatment with activator and Herbst appliance, gradually increased, approaching the values obtained with normal occlusion, which is compatible with the results of our study.

The BA of the masticatory muscles certainly has an impact on clinical status of malocclusions, but also on performance of their functions and coordination during the various mandible movements.

Conclusion

The bioelectrical activity of the masticatory muscles in the position of physiologic mandible rest and in maximal voluntary muscle contraction, in Angle Class I malocclusion, was higher in *m. temporalis*, while in the central occlusion position m. masseter showed a higher activity. In Angle Class II/2 malocclusion occlusal relationships, prior to be therapy, the bioelectric activity was higher in *m. temporalis*. Bioelectrical activity of both muscles in all the three measured positions was nominally higher in Class I occlusal relationships when compared to Angle Class II/2 malocclusion. In all the three different mandible positions with Angle Class II/2 malocclusion, bioelectrical activity was lowest at the beginnig of the therapy, and increased during the first year of treatment, and by the end of the treatment it was partially reduced to the value of normal occlusion. Masticatory muscles electromyographic activity research is useful in everyday clinical practice, especially in the present distinctive skeletal discrepancy before, during and after the orthodontic treatment, if on the bases of the results we can evaluate the treatment, but also determine the start and the duration of a retention period and retention device type.

Conflict of Interest

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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