BALANCE OF MASTICATORY MUSCLES IN SUBJECTS ACROSS DIFFERENT SKELETAL CLASSES

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ABSTRACT

Irregular antero-posterior relationship of the maxilla and mandible causes unstable occlusion and reduced mandibular movements during muscle contraction, which can cause changes in the masticatory muscle function.

Aim: The aim of the present study is to determine whether there is a difference in the asymmetry coefficient (ASIM) of the masticatory muscles (*m. temporalis anterior* and *m. masseter*) in patients classified as Class I, Class II and Class III according to Angle, by using the method of surface electromyography (EMG). An additional aim is to determine whether there are differences in the ASIM coefficient in female and male subjects.

Material and methods: The sample included 180 subjects, males and females. All subjects were divided into 3 groups of 60 subjects (30 males and 30 females) in skeletal classes I, II and III. An examination of muscle function was conducted by a non-invasive method of surface electromyography.

Results: The results of this study showed that there is no statistically significant difference in the ASIM index among groups of respondents (p=0,149).

Conclusion: The conclusion of the present study is that there is no statistically significant difference in the coefficient of asymmetry of the masticatory muscles (*m. temporalis anterior* and *m. masseter*) in patients across Class I, Class II and Class III according to Angle. The difference in the asymmetry coefficient between female and male subjects is also not statistically significant.

Key words: masticatory muscle, EMG, balance

Introduction

Malocclusions are very common irregularity in contemporary generations and are caused by the incorrect position of the teeth within the arch and the incorrect relationship of the dental arches in occlu-sion. [1-3] According to Edward Angle's classification, malocclusions are classified into three classes: Class I, Class II, and Class III. This classification is based on the mesio-distal relationship of the teeth, dental arches and jaws. [4] Understanding the function of masticatory muscles and their influence on craniofacial morphology is essential for orthodontics. [5]

The first attempt to study muscle activity in orthodontics was reported by Moyers back in 1949, when he suggested that different patterns of muscle activity were associated with different types of occlusions. He discovered that changes in the temporal muscle function are an etiological factor in the development of Class II malocclusions. When patients with Class II malocclusion were compared with patients with normal occlusion, an increased level of electromyographic (EMG) activity was found in the temporal muscle both in the rest position and in the intercuspal position. [6]

Irregular antero-posterior relationship of the maxilla and mandible causes unstable occlusion and reduced mandibular movements during muscle contraction which can cause changes in the masticatory muscle function. [7]

Asymmetry is defined as the absence or lack of symmetry or balance and different coordination between individual parts or organs on opposite sides of the body. [8]

Moderate asymmetry is a common finding in the human body. The morphology and function of the paired structures differ on each side. [9] The masticatory muscles activity in persons with proper dentition without pathology of the neuro-muscular system shows a deviation of 2-20% from perfect symmetry. [10-13]

This range of asymmetry is regarded as "physiological" asymmetry. [12]

However, masticatory muscle asymmetry can be associated with a number of pathological conditions. [14-18]

Electromyography (EMG) is the most objective and reliable technique for assessing muscle function and efficiency by detecting their electrical potentials [19]. Surface electromyography (with EMG) is used as a non-invasive method of examining muscle activity by using pairs of electrodes applied to the surface of the skin above the examined muscle. [20]

The introduction of standardized EMG protocols and indices that are used in order to assess the activity of paired masticatory muscles has enabled a number of much more reliable analyses [9]. Ferrario et al. [11 have developed a method for standardization of myoelectric potentials, which calculates the indices representing muscle activity and symmetry of pair muscle contraction in different functional tasks.

This method reduces variability within the sample and can be used to assess jaw muscles activity. [21]

Electromyography can determine the proper physiological activity of the masticatory muscles, but can also be used to perform a passive monitoring of changes in masticatory function and an assessment of the effects of some treatments. [22]

Previous studies have shown that patients with temporomandibular dysfunction (TMD) demonstrate a higher degree of masticatory muscle asymmetry compared with the subjects who have proper temporomandibular function. [13, 23, 24]

There are studies proving that the subjects with unilateral cross-bite have a higher masticatory muscle asymmetry index compared with the subjects who have proper occlusion. [18, 21

These studies have shown that there is a significant relationship between the function and symmetry of the masticatory muscles and the malocclusions in the transversal plane [25, 26], whereas, when it comes to the sagittal anomalies that are the topic of this study, opinions are divided and there is no clear position concerning the relationships of masticatory muscle function across all three skeletal classes. [16, 27]

The aim of the present study is to determine whether there is a difference in the asymmetry coefficient (ASIM) of the masticatory muscles

(*m.temporalis anterior* and *m.masseter*) in patients classified as Class I, Class II and Class III according to Angle, by using the method of surface electromyography (EMG). An additional aim is to determine whether there are differences in the ASIM coefficient in female and male subjects.

Material and methods

The research was conducted at the Faculty of Dentistry, the University of Sarajevo, in the Department of Orthodontics. The sample included 180 subjects. All subjects were divided into 3 groups of 60 subjects (30 males and 30 females) in skeletal classes I, II and III. The skeletal class was identified according to Angle's classification of malocclusions, on the basis of the relationship of the first permanent molars and permanent canines. An examination of muscle function was conducted by a non-invasive method of surface electromyography. During the first examination, patients were informed about the research, and about the reasons and purpose of the research. The research subjects were included in the study after they confirmed their participation consent in writing. The study was approved by the Ethics Committee of the Faculty of Dentistry with Clinics, the University of Sarajevo,

Inclusion criteria:

- Patients with various types of malocclusions of Class I, Class II and Class
- Orthodontically untreated
- With all permanent teeth developed (except third molars), full dentition
- Ages 15-35

Exclusion criteria:

- Patients with congenital and craniofacial deformities
- Patients with TM-dysfunctions, parafunctions
- Patients with transverse anomalies
- Patients with pathological processes within the maxilla or mandible
- Use of any medication that could affect muscle activity, such as antihistamines, sedatives, central nervous system depressants, and psychiatric medications

Electromyography procedure

The study was conducted with a wireless Theetan SpA electromyograph (Milan, Italy). The Theetan device recorded, amplified, digitized and filtered the analog EMG signal. The software program processed the raw electrical signals and generated a set of roots mean square values (RMS values). Thereafter, the RMS values were processed by using an algorithm to generate muscle activity and asymmetry indices.

During the experiment, the subjects were sitting in an upright position with the Frankfurt Plain parallel to the floor. Prior to the start of this recording, the patients were instructed verbally to avoid any stressful situation. One calibrated tester performed all EMG measurements.

The electrical activity was examined on a total of 4 muscles: the temporalis anterior (TA) and masseter muscles (MM) of the right and left side (i.e. the left and right side *musculus masseter* and the left and right side *musculus temporalis anterior)*. Bipolar pre-gelled surface EMG electrodes were placed along the line of muscle fiber direction. Prior to placing the electrodes, the skin was cleaned with an alcohol-based agent and imaging was performed 5-6 minutes later allowing the gel to adequately moisturize the skin surface. Male subjects had a shaved face and female subjects had their potential makeup removed from their faces. Disposable silver-silver chloride bipolar electrodes whose dimensions were 41 mm * 21 mm with a diameter of 10 mm and having an interelectrode distance of 21 ± 1 mm were used as recommended by SENIAM (European Coordinated Action Program in the EMG field for the European Union – designed *inter alia* for surface *EMG* in non-invasive assessment of muscles). The muscle fibers along which the electrodes were placed were

detected by palpation during maximal voluntary masticatory muscle contraction (MVC). For *musculus temporalis anterior* (TA) the electrodes were placed vertically along the anterior edge of the muscle (approximately over the coronary suture). For *musculus masseter* (MMs) they were also placed in parallel to the direction of muscle fibers with the upper pole of the electrode at the intersection between the *tragus-labial commissure* and the *exocanthion-gonion* lines.

At least two sEMG recordings were taken in each session:

The first imaging or calibration presents a maximal voluntary 5-second masticatory muscle contraction (MVC) performed on two 10 mm thick cotton dental rolls, placed between the posterior teeth in the area of the second premolars and the first molars. This image represents the calibration of the EMG device. Without prior calibration, the results would be affected by several factors such as cross-talk (analysis of nearby muscles), skin conductivity (variable depending on tissue composition) and skin condition (sweating), and electrode position. What was analyzed during the calibrations is not occlusion, but maximum muscle activity in ideal conditions without the influence of the tooth-jaw relationship.

The second recording also took 5 seconds and was performed during maximal voluntary contraction of the masticatory muscles, without insertion of any cotton dental rolls in the subject's central occlusion. Thus, during this measurement, the focus was on the strength of the masticatory muscles conditioned by occlusion, which is why these values were compared with the maximum muscle activity measured without the influence of occlusion, i.e. during calibration.

During both recordings, the software has automatically selected 3 seconds of the most stable EMG signal.

The symmetry of the masticatory muscles was determined on the basis of the asymmetry coefficient.

ASIM (asymmetry index). This index is calculated by comparing the activity of the right end pair of masseteric and temporal muscles with the left end pair of musculus masseter and musculus temporalis. ASIM is ranging from -100 percent and + 100 percent; where a value of 0 percent shows perfectly symmetrical activation of the two pairs of muscles. Negative values indicate a greater level of activity of the left end pair; while conversely, positive values indicate a greater level activity of the right end pair. Reference values are -10% ⩽ ASIM ⩽ +10%. (28)

Results

Results were processed by standard statistical methods, using SPSS computer program for Statistical Analysis (SPSS-Statistical Package for Social Sciences) version 21.0. The results were analyzed by ANOVA test, and student t-test for variables that met the requirements for application, respectively appropriate nonparametric tests (Kruskal-Wallis test and Mann-Whitney U test) for variables for which an irregular distribution was found. A value of $p<0.05$ was taken as statistically significant.

The ASIM value in group 1 was -2.15% (-7.92%-3.01%) in group 2 -2.45% (-7.77%-7.07%) while in group 3; 1.73% (-5.23%-12.37%). The determined difference in ASIM values between the examined groups did not differ significantly (p = 0.149) (**chart 1**)

Chart 1. ASIM value in the studied groups

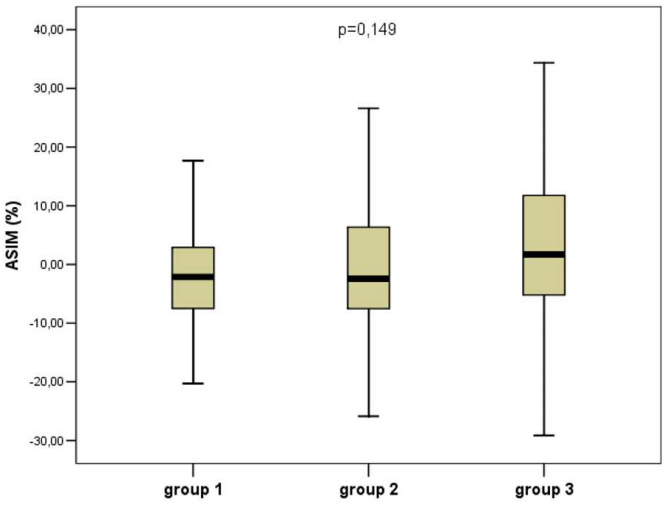
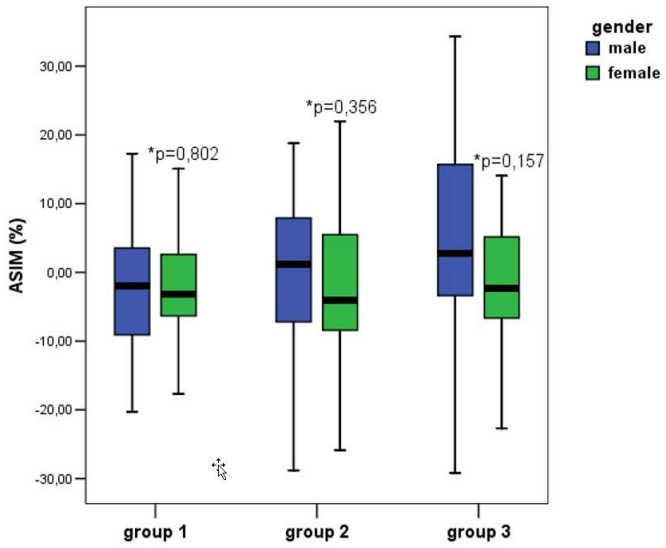


Chart 2. ASIM value in the studied groups in relation to gender



The value of ASIM in group 1 in male subjects was -1.93% (-9.11%-4.27%) and did not differ significantly from the value of ASIM in female subjects of the same group; -3.12% (-6.51%-2.70%) (p = 0.802). The value of ASIM in group 2 in male subjects was 1.19% (-7.20%-7.99%) and did not differ significantly from the value of ASIM in female subjects of the same group; -4.02% (-8.65%-6.27%) (p = 0.356). The value of ASIM in group 3 in male subjects was 2.79 (-3.37-16.25) and did not differ significantly from the value of ASIM in female subjects of the same group; -2.34% (-6.90%-5.81%) (p = 0.157) (**chart 2**).

Discussion

Balanced muscle function and movements of the mandible contribute to normal masticatory activities such as food intake, digestion, mastication, speech and swallowing. Mastication is a very complex and organized neuromuscular activity that involves bones, muscles, teeth and surrounding structures. [29]

An asymmetrical use of the masticatory muscles creates skull torques and, in combination with the occlusal loading, it can cause deformations not only on the maxilla and mandible but also on the distant bones of the skull. The proper functioning of the temporomandibular joint depends on these loadings and the balance of the masticatory muscles. [30]

The results of this study show that there is no statistically significant difference in the masticatory muscle asymmetry coefficient between the subjects in skeletal Class I, Class II and Class III. The ASIM value in the first group was -2.15% (-7.92% -3.01%), in the second group; -2.45% (-7.77% -7.07%) while in the third group it was; 1.73% (-5.23% -12.37%). Considering that in the first and second group the values of ASIM index are negative, we can conclude that a higher level of EMG activity was recorded in the left end pair of musculus masseter and musculus temporalis contrary to the third group where the value of ASIM coefficient is positive and indicates higher EMG activity in the right end pair of musculus masseter and musculus temporalis. The identified difference in ASIM values between the examined groups did not differ statistically significantly (p = 0.149).

There was also no significant statistical difference in relation to the sex of the research subjects. The ASIM value observed in Group 1 in male subjects was -1.93% (-9.11% -4.27%) and did not differ significantly from the ASIM value observed in female subjects of the same group; -3.12% (-6.51% -2.70%) (p = 0.802). The ASIM value observed in Group 2 in male subjects was 1.19% (-7.20% -7.99%) and did not differ significantly from the ASIM value observed in female subjects of the same group; -4.02% (-8.65% -6.27%) (p = 0.356). The ASIM value observed in Group 3 in male subjects was 2.79% (-3.37% -16.25%) and did not differ significantly from the ASIM value observed in female subjects of the same group; -2.34% (-6.90% -5.81%) (p = 0.157).

Similar results were confirmed in a study conducted by Ferrari et al., which concluded that there was no significant difference in the activity and symmetry of *musculus masseter, musculus temporalis* and *musculus sternocleidomastoideus* observed among research subjects in the first class according to Anleu and partly in the first class according to Angle. The only difference they

observed was that the results found in the subjects associated with the first class were more homogeneous, but still without a significant difference present between the groups. [11]

A study examining the activity index and masticatory muscle asymmetry index in women with and without TMD also obtained similar results and concluded that there was no difference in terms of masticatory muscle asymmetry index among the examined groups. [31]

In a study conducted by Wieczorak at al., she concluded that the symmetry of the EMG activity of the musculus masseter and musculus temporalis was not related to the symmetry of the occlusal contacts being the assumption made at the beginning of the study. They concluded that the symmetry of EMG activity in asymptomatic young adults was not related to the symmetry of occlusal contacts. [16]

A different conclusion was reached by a study conducted by Nalamliang et al., whose results show that there is an influence of occlusal contacts on the symmetry of masticatory muscles, as a result of which they concluded that, in healthy subjects with normal dentition, the lateral side with more occlusal contacts shows lower levels of temporal muscle activity and lower total muscle activity compared with these activities observed on the contralateral side. [27]

A study conducted by Wieczorek and Loster [32] found that a comparison between the subjects who were and those who were not orthodontically treated, shows that there was a higher asymmetry index in the group of orthodontically treated patients indicating the presence of greater muscle activity on the right side. A possible explanation for the predominance of the asymmetry index on the right side may lie in the fact that similar to what is characteristic for the overall population, the majority of research subjects were also right-handed. It would be interesting to investigate whether mastication is interrelated with the handedness or the individual preference of using hand, known as the dominant hand. [32] There was no significant difference between the different skeletal classes within the study group, which is also confirmed by some other studies. [16]

Contrary to these results, some researchers have proved that there is an asymmetry during the contraction of the masticatory muscles in healthy young individuals. [12]

Similarly, Suvinen and Kemppainen [33] and Scopel et al. [34] have reported in their studies that even in the resting position of the mandible, muscles were physiologically asymmetric, and that asymmetry and activity indices of 4% and 17%, respectively, should be considered normal. This study shows that most subjects had the dominance of the right temporalis muscle. [34]

The major purpose of our cross-sectional study is to identify the interrelationship between balanced occlusion and masticatory muscle function. The balance of masticatory muscles in sagittal irregularities is not significantly disturbed and it would be highly recommended in any case to evaluate this balance in greater detail in terms of transverse irregularities.

Conclusion

The conclusion of the present study is that there is no statistically significant difference in the coefficient of asymmetry of the masticatory muscles (*m. temporalis anterior* and *m. masseter*) in patients across Class I, Class II and Class III according to Angle. The difference in the asymmetry coefficient between female and male subjects is also not statistically significant.

Declaration of interest

The authors declare no conflict of interest.

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