ELECTROMYOGRAPHY OF THE MASSETER MUSCLE - A SYSTEMATIC REVIEW

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Abstract: The chewing muscles are at the base of the stomatognatic system. Due to their ability to perform contractions, it is possible to bring the lower jaw in motion and to chew. During this process there is an electronic potential of each of the muscles which can be investigated by electromyography. Knowing the values and parameters of this study about musculus masseter, as a major chewing muscle, it would be an advantage in establishing the function of the chewing system and the diagnosis of various diseases. The purpose of this review is to analyze and summarize the scientific data on electromyography (EMG) of m. masseter in norm and craniomandibular disfunctions. An electronic search was made in the following databases PubMed, Google, Lilac from June to July 2017, according to keywords. From the published literary sources, the titles and information which do not correspond to the topic of this review are excluded, which resulted in a final selection of 30 scientific papers. The analysis of the data shows the possibilities of applying electromyography in the study of m. masseter in both conditions – norm and pathology. There are different techniques and conditions in performing this study. Some of the authors offer the use of a surface EMG, examining the muscle in static states such as maximum intercuspation, incisal occlusion, muscle contraction at 50% of maximum clenching force, etc. Other sources suggest an investigation of the m. masseter during dynamic conditions such as chewing, laterotrusion, protusion / retrusion, etc. In the cases which analyze the muscle activity during chewing, there is a lack of consensus in regard to the used food for the purpose of the study. Also of interest are the studies with needle EMG, due to which a difference in the activity of the superficial and deep parts of a normal musculus masseter is proven. There is information about using a portable EMG during sleep in a patient-friendly environment, which is particularly useful for diagnosing nocturnal bruxism and bruxomania. Despite the variety of techniques, EMG is seen as one of the most precise methods in the study of chewing muscles and the diagnosis of craniomandibular disorders.
Keywords: electromyography, musculus masseter, craniomandibular disorders, bruxism

1. INTRODUCTION

A reliable method for testing and recording the electronic potential generated by skeletal muscle cells is electromyography (EMG).

Normally resting muscular tissue is electrically inactive. During voluntary contraction of the muscle there is a potential of action. With the increase of the rate contraction, more muscle fibers generate a potential for action, which is detected by the presence of varying values and different amplitudes of the electromyogram. The deviation from the norm varies according to the type of disorder; the age of the patient; the method of application of the electromyography (needle or surface); patient readiness for compliance and others. Electronic muscle activity during rest, elevated or decreased values of action potency and amplitudes are detected [1].

Chewing muscles are part of the skeletal muscles and are particularly important for basic life processes such as eating, dental articulation and speech. It is believed [2] that knowledge and interpretation of the electromyographic parameters of the study of musculus masseter would be in help of dentists to diagnose and monitor craniomandibular disorders and analyze the results of the treatment.

2. AIM

The purpose of this literature review is to present and analyze the current literature information about electromyography of musculus masseter in norm and craniomandibular disorders.

3. MATERIALS AND METHODS

An electronic search was conducted in the following databases: PubMed, Google, Lilac (from June 2017 to July 2017) by keywords: "Electromyography", "Musculus Masseter", "Craniomandibular Disorders", "Bruxism". 846

literary sources have been found.Those whose titles were not related to the topic of the review were excluded, which resulted in a final selection of 30 scientific papers. The data is analyzed, summarized and presented in the main part of this review.

4. RESULTS AND DISCUSSION

Investigation of musculus masseter in static conditions in healthy people

The activity of chewing muscles and in particular m. masseter in healthy individuals is still a subject of many studies. In 1999, Gallo L.M. et al. [2] study m. masseter in healthy individuals during sleep in a natural environment, using electromyography and specially made portable recording devices. The obtained data is analyzed according to the number, duration and amplitude of the contraction period. The amplitude of the signal is expressed as a percentage of the amplitude recorded during the maximum voluntary contractions (% MVC). According to this study, the mean value of the number of contraction episodes of the muscle overnight was 71.9 ± 28.7, corresponding to 10.5 ± 3.8 for one hour and the average mean amplitude was 26.2 ± 6.4% MCV. Thisinformationleads to the conclusion that healthy objects show intermittent periods of activity of m. masseter, which are considered short-term and low-intensity.

Visser, McCarroll and Oosting [2] also investigate the EMG activity of m. masseter in healthy individuals but under different conditions. A bipolar surface EMG on the left and right m. masseter is used. At the beginning, each patient was asked to clench teeth as hard as possible for about 3 s and the resulting value is being considered as maximum EMG activity. Studies were then performed at 10% and 50% of the maximal activity of m. masseter with contractions lasting about 5 seconds. When reaching a constant level of clenching, a record of about 3 seconds is made and an average value for each muscle is reported. In conclusion, the results indicate that there is no significant difference in the activity of m. masseter at different ages, but there is a higher muscle activity in males than in females with clenching of 10%. There was no significant difference in EMG values in the side with more or less tooth contacts.

In a comparative study of m. masseter in 29 healthy patients with ultrasound and bipolar surface electromyography Bakke et al. [4] establish a straightforward relationship between muscle thickness and the amplitude of electronic activity.

Interesting facts are presented by Manns, Miralles and Palazzi [5]. They investigate the relationship between the EMG activity of m. masseter, bite strength and muscle stretching. 8 healthy subjects were tested with surface EMG and a gnathodynamometer to determine the chewing strength during isometric muscle contractions measured from 7 mm to maximum jaw opening. Different series of recordings were made and the first is with a constant bite of 10-20 kg. In this situation, the EMG values are higher at a bite opening of 7 mm, decreasing at 15-20 mm and increasing again when the maximum opening is approaching. In the second series of records, the bite strength is measured at a constant EMG value, and the results show that the force increases at a specific range of opening of the jaw (15-20mm) and decreases at maximum jaw opening. In conclusion, it was found that for each object there is an optimal muscle stretch at maximum efficiency of m. masseter, achieving maximum bite strength with least EMG activity.

Often different authors offer different techniques and conditions of application of the electromyography, which also results in a difference in the obtained results. This is noticed by Frame, Rothwell, and Duxbury [6] which undertake a study which aim is to determine the reproducibility of the electromyogram of m. masseter under standard conditions and to assess the possible causes of the differences reported in different studies within one day. No statistically significant difference was founded in the records received in one day, but it was found in the records of the different days. These variations are identified by the authors as a lack of precision in re-positioning of the electrodes rather than a difference in muscle activity.

Investigation of musculus masseter in different dynamic conditions in healthy people

Except in a state of rest and contraction, m. masseter can also be investigated during chewing function by surface electromyography. After reviewing Niscimento et al. [7] found that the methods of conducting, as well as the food used, vary considerably from one author to another. For example, Payron, Lassauzay and Woda [8] investigate the EMG activity of m. masseter during the chewing of 4 different hardness gelatin products, and the results show a progressive increase in muscle activity with increased firmness of the food. Other authors [9] offer muscle analysis during chewing different amount of nuts, and the obtained data indicate a difference in activity at a different volume of food. Kimoto et al. [10] analyzed m. masseter during chewing. They establish a higher EMG activity on the working side compared to the balancing and Rahal and Gomez [11] establish a difference of 20μV on average between the left and right m. masseter during chewing of grapes. In a study of m. masseter during gum chewing by EMG Ferarrio and Sforza [12] calculate chewing frequency for each side and subject and find significantly higher

values in men than in women. All this points to the many variations of conducting an EMG study of m. masseter during chewing and the lack of consensus on the use of specific food.

Investigation of the different parts of musculus masseter in norm

The activity of the masseter muscles is not homogeneous in their different parts and this is approved by a number of studies with needle EMG. Blanksma [13] investigated the possibility for regional differences in muscle activity during dynamic states. He uses three bipolar thin-walled electrodes put in m. masseter. Recordings are made at maximum occlusion and during chewing a gum. The results of the study show that the activity of m. masseter in the deep and superficial parts is different under different circumstances. During chewing - the activity is higher on the working side than the balancing. This proves that different areas of muscle are activated differently depending on the working action. In support of this data is also the study by Van Eijden [14], which examines the different sides (front, middle and back) of the superficial and deep parts of m. masseter of healthy individuals. Recordings are made in static conditions (central and incisal occlusion), in various jaw movements (protrusion / retrusion, left / right laterodeviation, opening and closing) and during chewing with 6 thin-walled bipolar electrodes. Higher activity of the deep part of the muscle was found while chewing and opening/closing thejaw and lower activity of this part of the muscle in incisal occlusion. During chewing, the higher activity passes from the surface to the deep part for the working side and right-about - from the deep to the surface part for the balancing side. During laterodeviation, the highest activity begins in the deep part when the jaw moves, for example, to the right (or left) and gradually passes to the surface when the jaw moves back to the left (or the right). In summary, a time difference and activity rate of the different parts of m.masseter is observed.

Investigation of musculus masseter in craniomandibular disorders

Craniomandibular disorders (CMD) include pain and tension in the chewing muscles, temporomandibular joint, difficulty in opening the mouth, etc. Often these disorders are associated with bruxism, bruxomania and hyperactivity of the chewing muscles. The use of EMG in such cases is a source of additional information and is an advantage in understanding the dysfunction of the masticatory system [15].

Visser et al. [2] conducted a comparative study of healthy and diagnosed with CMD patients. They find that the affected patients show a lower EMG activity of m. masseter compared to the control group. In support of this is Perry's discovery [16] that chewing muscles show a low discharge rate in the presence of severe disorders. To determine EMG diagnostic criteria for CMD, Kotani et al. [17] determine the slope of the voltage / tension curves and compare it with those of healthy patients. Thus he finds that most curves are significantly steeper in the affected patients. They also see those with a normal slope, which are supposed to be due to muscle fatigue. Later, they found that the amplitudes of the electromyogram of CMD patients made during bruxomania were significantly lower than those observed in healthy subjects.

The study of the night EMG activity of m. masseter is particularly important in regard to night clenching and grinding is considered an etiological factor in mandibular disorders. In a comparative study of the activity of m. masseter in healthy patients and in those suffering from nocturnal bruxism Reding et al. [18] establish a positive relationship between emerging rhythmic constrictions of the resting muscle and the diagnosis of "bruxism". Fuchs [19] also explores the activity of m. masseter during sleep and found higher values in CMD patients, and Clark, Beemsterboer and Rugh [20] found a positive relationship between EMG values and the severity of symptoms.

Kroon and Naeije [21] examined patients with CMD and mostly unilateral pain in m. masseter using a surface EMG. The recordings are made with 30 second contractions at 50% of the maximum clenching force. Electromyographic signals of the muscles with pain are significantly weaker. Painful muscles show a higher value of average change in frequency than painless muscles.

The relationship between the activity of m. masseter and painful musculoskeletal symptoms is an important problem in dental medicine. Attention is drawn to this by the authors Clark, Beemsterboer and Rugh [20]. They conducted a study on nightly masseter activity in relation to the symptoms of jaw dysfunction. They found that prolonged muscular hyperactivity is positively associated with the signs and symptoms of jaw dysfunction, furthermore - as EMG values are higher in a particular patient, the more likely is to have signs of CMD. Other authors [22] use EMG to study m. masseter in patients suffering from myofascial pain. In conclusion, the obtained results do not show a statistically significant difference in EMG records, at rest, in patients with pain and in healthy ones. However, there is a significant increase in the values during records made at the time of bruxomania, therefore increased muscle activity is observed.

Investigation of the motor pauses in the activity of the masseter musclein craniomandibular disorders

The motor pauses which can be observed in the EMG of m. masseter are the subject of a number of studies. Some authors [23] offer this silent period -SP for diagnostic criteria for CMD. They studied both healthy and affected

patients and find a difference in SP for both groups. In the affected patients this period average is from 23 to 152 ms, while normally it is usually between 20-30 ms. After treatment (eg with occlusal splints), SP is again within normal range. Later, Wildman [24] also finds that SP is significantly longer in patients with CMD and supports its use as a diagnostic test.

5. CONCLUSION

The use of EMG gives opportunity to track the electrophysiological behavior of muscles in various physiological and pathological conditions [25]. In conclusion, the following facts should be summarized:

- In investigation of m. masseter in static conditions, in healthy individuals, there is a lack of EMG activity at rest and in the case of voluntary contraction of the muscle - the potential of action. It was found higher muscular activity in men, a positive relationship between the thickness of m. masseter and its activity. Highest muscle activity is reported when opening the mouth by about 7mm and at maximum opening.
- In the study of m. masseter in healthy subjects during sleep, it was found an average number of contractions overnight of 71.9 ± 28.7 and mean amplitude of contractions of 26.2 ± 6.4%. Therefore, periodic contractions are reported which are considered to be short-term and low-intensity.
- In investigation of m. masseter in dynamic state (chewing) in healthy people higher muscle activity is reported for a more solid and larger volume of food, as well as higher values for the working side.
- When examining the different parts of m. masseter it was establishes a higher activity of the deep part when opening and closing the mouth, while during chewing the higher activity passes from the surface to the deep part of the muscle for the working side and opposite for the balancing.
- EMG of m. masseter with CMD show lower muscle activity at significant disorders, the slope of the tension curves are steeper, the amplitudes of the contractions have a lower height during clenching, the motor pauses are longer.
- In investigation of the activity of m. masseter during sleep in patients with bruxism it can be found appearance of ritmic contractions and high muscle activity during rest.

Despite that the applying techniques may vary in certain limits, electromyography of the chewing muscles is accepted [26] as one of the most useful and objective methods for diagnostic of chewing muscles in norm and as well in different conditions related to craniomandibular disorders.

REFERENCES

[1] Chowdhury RH, Reaz MBI, Ali MABM, Bakar AAA, Chellappan K, Chang TG. SurfaceElectromyography Signal Processing and Classification Techniques. Sensors (Basel, Switzerland). 2013;13(9):12431-12466.
[2] Visser A, McCarrolR.S, Oosting J. Masticatory electromyographic activity in healthy young adults and myogenous craniomandibular disorder patients. J Oral Rehabil 1994; 21: 67-76.
[3] Gallo L.M, Sallis Gross S.S, Palla S. Nocturnal msseter EMG activity of healthy subjects in natural environment. J Dent Res. 1999;78(8): 1436-1444.
[4] Bakke M, Tuxen A, Vilmann P, Jensen Br, Vilmann A, Toft M. Ultrasound image of human masseter muscle related to bite force, electromyography, facial morphology, and occlusal factors. Scand J Dent Res 1992; 100: 164-171.
[5] Manns A, Miralles R, Palazzi C. EMG, bite force and elongation of the masseter muscle under isometric voluntary contractions and variations of vertical dimension. J Prosthet Dent 1979; 42(6): 674-682.
[6] Frame J, Rothwell P.S, Duxbury A.J. The standartization of the masseter muscle in man. Archs oral Biol 1973; 18:1419-1423;
[7] Nascimento GKBO, Cunha DA, Lima LM, MoraesKJR, Pernambuco LA, RëgisRMFL, Silva H. Surface electromyography of the masseter muscle during chewing: a systematic review. Rev. CEFAC 2012; 14(4): 725-731.
[8] Peyron MA, Lassauzay C, WodaA. Effects of increased hardness on jaw movement and muscle activity during chewing of visco-elastic model foods. Exp Brain Res. 2002 Jan; 142 (1):41-51.
[9] Diaz-Tay J, Jayasinghe N, Lucas PW, McCallum JC, Jones JT. Association between surface electromyography of human jaw closing muscle and quantified food breakdown. Arch Oral Biol. 1991; 36 (12) :893-898.

[10] Kimoto K, Fushima K, Tamaki K, Toyoda M, Sato S, Uchimura N. Asymmetry of masticatory muscle activity during the closing phase of mastication. Cranio. 2000 Oct; 18 (4):257-263.
[11] Rahal A, Pierotti S. Eletromiografia e cefalometria na Fonoaudiologia. In: Ferreira LP, Befi-Lopes DM, Limongi SCO (Org.) Tratado de Fonoaudiologia. São Paulo: Roca; 2004. p. 237-253.
[12] Ferrario VF, Sforza C. Coordinated electromyographic activity of the human masseter and temporalis anterior muscles during mastication. Eur J Oral Sci 1996; 104:511-517.
[13] BlanksmaN.G, EijdenT.M.G.J. Electromyographic Heterogeneity in the human temporalis and masseter muscles during static biting, open/close excursios, and chewing. J Dent Res 1995; 74(6): 1318-1327.
[14] EijdenT.M.G.J, BlanksmaN.G, Brugman P. Amplitude and timing of EMG activity in the human masseter muscle during selected motor tasks. J Dent Res 1993; 72(3): 599-606.
[15] Dahlström L. Electromyographic studies of craniomandibular disorders: a review of literature. J Oral Rehabil 1989; 16: 1-22.
[16] PerryH.T. Musculararchangesassociatedwith temporomandibular jointdysfunction. J Am DentAssoc1957; 54: 644.
[17] Kotani H, Kawazoe Y, Hamada T,Yamado S. Quantitative electromyographic diagnosis of myofascial pain-dysfunction syndrome. J of Prosthet Dent1980; 43(4): 450-456.
[18] RedingGR, Zepelin H, Robinson J.E, ZimmermanSO,Smith VH. Nocturnalteethgrinding: all-nightpsychophysiologicstudies. J Dent Res 1968; 47(5): 786-797.
[19] Fusch P. The muscular activity of the chewing apparatus during night sleep. J Oral Rehabil 1975; 2: 35-48.
[20] Clark G.T, BeemsterboerP.L,RughJ.D. Nocturnalmassetermuscleactivityandthesymptoms of masticatory dysfunction. JOral Rehabil1981a; 8: 279-286.
[21] Kroon G.W, Naeije M. Electromyographic evidence of local muscle fatigue in a subgroup of patients with myogenous craniomandibulr disorders. Archs oral Biol 1992; 37(3): 215-218.
[22] Bessette R, Bishop B, Mohl N. Duration of masseteric silent period in patients with TMJ syndrome. J Appl Physiol 1971; 30: 864-869.
[23] Manfredini D, Cocilovo F, Favero G, Ferronato G, Tonello S, Guarda-Nardini L. Surface electromyography of jaw muscles and kinesiographic recordings: diagnostic accuracy for myofacial pain. J Oral Rehabil 2011; 38(11): 791-799.
[24] Widmalm S. The silent period in the masseter muscle of patients with TMJ dysfunction. Acta Odontol Scand1976; 34(1): 43-52.
[25] Cooper B, Cooper D, Lucente F. Electromyography of masticatory muscles in craniomandibular disorders. Laryngo-scope 1991; 101(2): 150-157.
[26] Bakke M, Michler L. Temporalis and masseter muscle activity in patients with anterior open bite and craniomandibular disorders. Scand J Dent Res 1991; 99(3): 219-228.