

Electromyography Assessment of Muscle Fatigue in Temporomandibular Disorder Patients

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Abstract: Introduction: Temporomandibular disorder (TMD) is multifactor disease with unclear etiology, but some etiologic factors such as trauma, emotional stress, orthopedic instability and muscle hyperactivity appear to be very important in development of this disorder. The problems connected with TMD are located in masticatory muscles, jaw joints and in dentition. The most common complaint in TMD patients are functional disorders of masticatory muscles, specially the development of fatigue in these muscles. Purpose: The intention of the study is to evaluate electromyographically the degree of muscle fatigue using fast Fourier transformation (FFT) of two elevator muscles, masseter and anterior temporal muscle. Material and methods: The assessment of fatigue in masticatory muscles was done in two examined groups. One group consists of 23 patients with clinically diagnosed TMD, and the second group was 15 healthy volunteers. Every patient gets a same amount of chewing gum as a test food. They chew the chewing gum for a period of ten minutes and on the end of this period masseter and anterior temporal muscles were electromyographically examined. The electromyographic power spectrum (EPS) was obtained from every patient by surface electromyography. Surface electrodes were located right over the body of the examined muscle. Every EPS was then evaluated with FFT and the obtained results were statistically analyzed. Results: Median frequency (MF) is useful parameter obtained by FFT and is in direct relation with the level of muscle fatigue. We noticed significantly ($p < 0.05$) lower value of median frequency in every TMD patient in comparison with healthy cases. The results are statistically evaluated and presented on tables in the study. Conclusions: MF of the EPS is a reliable and consistent parameter which is in direct relation with muscle fatigue. Muscle fatigue resistance of the TMD patients is significantly lower ($p < 0.05$) in comparison with healthy volunteers.

Keywords: Temporomandibular disorder (TMD), masticatory muscles, electromyography

1. Introduction

Temporomandibular disorder is multifactor disease with unclear etiology. Etiologic factors such as trauma, emotional stress, orthopedic instability and muscle hyperactivity were included as significant components. The major sites of potential breakdown in TMD are masticatory muscles, temporomandibular joints, and the dentition. In this study we are going to analyze two typical mandible elevators such as temporal and masseter muscle. There is a growing acceptance of the concept of neuromuscular discoordination which suggests that there may be an underlying muscle problem for which muscle hyperactivity is the suggested cause. Most of the patients suffering from TMD are totally aware of their symptoms, yet they may be not aware of their clinical signs. Functional disorders of masticatory muscles are probably the most common TMD complain and few major symptoms can be observed: pain, dysfunction and fatigue in these muscles. Our special interest in this study will be muscle fatigue in temporal and masseter muscles as a symptom. As it's already known a symptom is a description or complains by the patient. Most of the examined patients complain of feeling of fatigue during everyday chewing activities. According to its histological structure masticatory muscles belong to skeletal muscles and its performance is related to its ability to resist fatigue.

Muscle fatigue has been defined as inability to maintain the required or expected force. Electromyography is a useful tool for evaluating the condition of the examined muscle. The level of muscle fatigue can be analyzed by the evaluation of the obtained parameter median frequency which is in direct relation with the fatigue. We can use surface electromyography because its allows the

quantification of the occlusal equilibrium in dysfunctional patients, such as those with TMD, and this kind of exploring is better accepted by the patients.

Many authors were interesting in the use of electromyography as a method for masticatory system exploring. In that context the phenomenon of muscle fatigue in TMD patients as a sign in that disease is especially interesting. In the text below some characteristic findings and authors observations will be discussed.

Gotouda et al. [1] were interesting what is happening in jaw-closing muscles when they have to done light efforts like playing a wind instruments and conclude playing an instrument for a long time does not obviously induce fatigue of jaw-closing muscles.

Zuccolotto et al. [2] investigate electromyographic activity of the anterior temporalis and masseter muscles in edentulous patients with temporomandibular disorder in the mandibular rest position. Suvinen and Kempapainen [3] assess the value and contribution of clinical electromyographic research in the understanding of asymptomatic and dysfunctional muscle fatigue and function and its influence of the therapeutic effects of interocclusal appliances.

Tartaglia et al. [4] performed surface electromyography of masseter and temporal muscles during maximum teeth clenching on cotton rolls or in intercuspal position and the obtained muscle fatigue was evaluated between the two groups and sexes of the examined patients.

de Jong et al. [5] examined the role of the masticatory muscles in the ongoing daily loading of the bone and its

influence over the present fatigue. According to their study the authors concluded that there are no measurements describing this role over longer periods of time.

Daif [6] assessed the effect of occlusal splint therapy on the electromyographic amplitude records of masticatory muscles in temporomandibular disorder (TMD) with muscle fatigue and myofascial pain.

Many authors are interesting about the masticatory muscles activities and its fatigue especially in temporomandibular disorder (TMD) patients. As it was already mentioned the parameter median frequency is in direct relation with the level of fatigue in examined muscle. Keeping this on mind the following aims awake our interest:

1. To evaluate the degree of fatigue in anterior temporal and masseter muscles on right and left side in TMD patients;
2. To compare the obtained results with symptom free subjects.

2. Material and Methods



Figure 1: Location of the surface electrode over the belly of examined muscles: anterior temporal muscle (left) and masseter muscle (right).

The assessment of the fatigue in masticatory muscles was done over a group of 23 TMD patients. Every patient get exact amount of chewing gum as a test food (Fig. 1). The gum was chewed 10 minutes and right of the end of the tenth minute electromyography (EMG) examination was done by surface electrode which was located over the muscle belly. The analysis time is 1000 msec, the incoming signal is filtered with analog filters for time constant of 10 msec and the upper frequency is 3 Hz. The amplification of the EMG apparatus is 500 micro volts (Fig. 2). The last electromyography power spectrum (EMGPS) which was obtained just before the end of the tenth minute was then calculated with fast Fourier transformation (FFT). The analyzed parameter was median frequency because it's in direct relation with muscle fatigue. Mean value of the median frequency was analyzed in every examined patient.

The same method of analysis was done in group of 15 healthy volunteers, with chewing the same kind of test food, for the same duration of time and then obtained results were compared with that one from the examined group Table 1.



Figure 2: Outside look of the 2 canal electromyography apparatus "Tonnie's"

Table 1: Distribution of the EMG examined persons

Examined persons	Mean age (yr)	Ratio female/male
TMD patients (23)	33.6	4:1
Healthy volunteers (15)	32.6	3:1

3. Results

After analysis of the obtained results from control and examine group the following results can be present Table 2.

Table 2: Mean value of the median frequency (Fmed) in Hz in healthy volunteers.

No. of healthy controls	T dex. Fmed.	Tsin. Fmed.	Mdex. Fmed.	Msin. Fmed.
15	177.6	175.7	178.7	175.0

Legend: Tdex=right temporal muscle, Tsin.=left temporal muscle, Mdex.=right masseter muscle, Msin.=left masseter muscle.

Our subject of interest was the value of median frequency in TMD patients also, and we have used the same method of analysis in the examined group with FFT. As a consequence of that analysis Table 3. was constructed.

Table 3: Mean value of the median frequency (Fmed) in Hz in TMD patients.

No. of TMD patients	Tdex. Fmed.	Tsin.Fmed.	Mdex.Fmed.	Msin.Fmed.
23	158.5	156.3	157.2	156.4

4. Discussion

Median or centre frequency is useful reproducible parameter which is in direct relation with the level of fatigue in examined muscle. The median frequency is defined as a frequency at which power spectrum is divided into two regions containing equal power. Median frequency of the power spectrum provides a reliable and consistent measure of muscle fatigue, say Guguvcevski [7]. Higher values of this parameter indicate that muscles in higher physiological condition, and vice versa lower values of median frequency inform that examined muscle is in state of low condition.

Sforza et al. [8] concluded that muscle fatigue is usually defined as the point at which a particular lever of force can no be longer maintained.

Guguvcevski [9] defined the muscle fatigue of striated muscle as the impossibility to generate the expected or required force during the repeated contraction. The power spectrum analysis is able to be carried out by a fast Fourier transform algorithm of the isometric contraction components of EMG bursts during mastication.

At the end of tenth minute the obtained electromyography power spectrum was analysed with fast Fourier transformation. Decreases in median frequency of the temporal and masseter muscles during gum chewing were significantly greater in TMD patients than in healthy group, indicating that fatigue-resistance of the TMD group was lower than the symptom free subjects.

The manifestations of fatigue as observed by reductions in the ability to produce a given force of power are readily apparent soon after the initiation of intense activity. The power spectrum shifted to a lower frequency immediately after fatigue induction and recovered along with time.

Changes in the EMG frequency spectrum in the temporal and masseter muscles during a chewing demonstrate a progressive shift of the median frequency to a lower level. As a consequence the median frequency of the EMG power spectrum provides a reliable and consistent measurement of muscle fatigue. As it's clearly seen from table 3 all TMD patients have lower value of median frequency then subjects in healthy group. This indicates that fatigue resistance of the TMD group is lower than the symptom free subjects. This finding is in relation with observations of Turker et al. [10] who concluded that eccentric contractions of jaw-closing muscles are difficult to perform. This may explain why fatigue inducing experiments so far suggest these muscles to be fatigue resistant.

Maillou et al. [11] stated that muscle fatigue and pain may result in positive feedback, which may contribute to the symptoms of temporomandibular disorder. EMG activity influenced the power spectrum and this kind of analysis may

be used as a possible future diagnostic aid for TMD syndromes.

5. Conclusion

From the obtained results we can conclude as follow:

1. Median frequency of the EMG power spectrum provides a reliable and consistent measure of muscle fatigue;
2. Muscle fatigue resistance of the TMD group is significantly lower than the healthy volunteers group ($p < 0.05$).

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