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RESEARCH ARTICLE

Electromyographic values of masticatory muscles in middle-aged dentate patients

Mihail Mostovei[1*], Oleg Solomon[1†], Andrei Mostovei[2†], Nicolae Chele[2†]

[1]Department of prosthetic dentistry „I. Postolachi", Nicolae Testemitanu State University of Medicine and Pharmacy
[2]Department of OMF surgery and oral implantology „A. Guțan", Nicolae Testemitanu State University of Medicine and Pharmacy.

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Corresponding author:
Mihail Mostovei, PhD fellow
Department of prosthetic dentistry „I. Postolachi",
Nicolae Testemitanu State University of Medicine and Pharmacy,
42, Toma Ciorbă street, Chișinau, Republic of Moldova, MD-2004
Email: mihail.mostovei@usmf.md

Short title: *Electromyography of dentate patients*

What is not known yet about the topic

Surface electromyography of masticatory muscles is highly dependent on different factors including age, sex, ethnic group. There is no available data about the surface electromyographic activity of masticatory muscles in middle-aged Moldavian people.

Research hypothesis

Middle-aged people that have most of the teeth healthy should be in the normal range of the muscular activity according to the mean values of the device.

The novelty added by the manuscript to already published scientific literature

The obtained data can be used further as a reference for comparison of masticatory muscle activity in healthy individuals vs patients of the same ethnical group and age with different treatment options to assess the differences or the quality of the provided treatment. The values in healthy subjects differ with 20.5% from the average values provided by the manufacturer for the percentage overlapping coefficients.

Abstract

Introduction. Surface electromyography has proven to be a useful instrument for the assessment of success rate for different dental treatments. However, due to numerous variables that may influence the data like age, gender, fat tissue thickness etc. it is necessary to adjust the obtained values to a reference group with the same parameters.

Material and methods. A number of 33 patients were included in the study (21 women and 12 men) aged between 43-67 years old (mean 54± SD1.26). Surface electromyography of masticatory muscles was used in these patients to assess the average value in a time span and overlapping coefficients. Totally 10 parameters from each patient were recorded: TAL, TAR, MML, MMR, PocTA, PocMM, BAR, Asym, TORS, Impact. Data were stored in an Excel spreadsheet and then analyzed statistically using RStudio software.

Results. Based on the results of our study, the main EMG activity indices in middle-aged Moldavian individuals had the following values: for the left temporalis (TAL) was 42 μV, median 18.8 with a minimum of 3.8 and a maximum of 190 μV. For the right temporalis (TAR) the mean was 51.4 μV, median – 32.9, a minimal value of 7.9 and a maximum of 248 μV. The left masseter had a mean of 48.7 μV, median 12.3, a minimal value of 1.5 and a maximum value of 439 μV. The right masseter had a mean of 42.1 μV, a median of 16.3, minimum value 11.4 and maximum 243 μV. The overlapping coefficients deviated with 20.5% from the normal range provided by the manufacturer.

Conclusions. Electromyographic activity of masticatory muscles in healthy patients can be used for comparison with patients that had various dental treatment but have the same age, gender, ethnicity, etc. The overlapping coefficients did not perfectly match in the normal range provided by manufacturer even if these subjects had previously minimum dental procedures.

Key words: surface electromyography, middle-aged individuals, overlapping coefficients.

Introduction

After the first record of muscle contraction in 1890 by Marey, electromyography has known a huge development being constantly upgraded and having its applications in different medical pathologies like temporomandibular disorders, dystonia, lesions of cranial nerves, sports medicine etc. [1-3]. Surface electromyography (sEMG) is often used due to the lack of tissue damage, ease of use and it provides often similar data to the needle EMG [4, 5]. Despite its extensive use, recording is influenced by many factors such

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as electrode type and positioning, fat tissue thickness, sex, age etc. [6, 7]. Different researches have shown that elder patients have less muscle activity than younger ones, which can be explained by the possible decrease of motor units [8]. Dentists often use investigations like x-ray, MRI, functional analysis with standard parameters to assess the skeletal or functional symmetry in patients. In this perspective, asymmetrical work of masticatory muscles can lead to different complications both in dental structures, temporomandibular joint (TMJ) or even muscles themselves. In most cases, the electromyographic activity is assessed as mean values of muscle activity in a time span. However, this data is hard to compare between different groups due to numerous variables that influences the data [2, 5]. EMG activity of masticatory muscles in dentistry is mainly influenced by the occlusal changes that dentists perform. There are many articles that analyze the change in EMG activity in numerous dental procedures like implant-supported dentures, complete dentures, orthodontic treatments etc. [9-12]. In order to be able to use this data for comparison, a group of healthy subjects is required that would have also similar age, ethnicity, gender as the study group.

Material and methods

The study was based on analysis of electromyographic activity of masticatory muscles in 33 dentate subjects (21 women and 12 men) aged between 43-67 years old (mean/SD – 54±1.26 years). Patients were included in the study from three dental clinics based on the following criteria:

1. Lack of TMJ or masticatory muscle pathology.
2. Lack of fix dental or implant prostheses that exceed more than 2 teeth per arch.
3. Edentulous spans that don't exceed 1 tooth on the same side of dental arch.
4. Lack of heart pacemakers or any electronic device that may interfere with the muscle signal.
5. Patients that have signed the informed consent.

The study was conducted according to the criteria of Helsinki Declaration and the protocol was approved by the Ethic Committee of N. Testemiţanu State University of Medicine and Pharmacy on 16th of March 2018, no. 43. Taking into account the age of patients there were no patients completely without dental procedures performed in the past. From overall number of subjects 12 had single unit edentulous spans on one or both arches, 9 had implant supported restorations, 12 had fixed tooth supported restorations, 25 patients had associated tooth attrition with the dentin isles exposed in molars and premolars. Only patients with class I malocclusion were accepted and those with removable prostheses were not accepted in the study. After routine dental examination, patients were sited upright in the chair with the Frankfort line parallel to the ground. Muscles were identified through manual palpation, and the electrodes were positioned on the most prominent area of masseter and anterior temporal muscles (Figure 1a). Placement of bipolar electrodes may influence the amplitude of EMG records [13]. In this research, we have used the 4 channel electromyograph (ForEMG, Quatrotii, Italy) with concentric electrodes which are not such susceptible to positioning. The acquired data are available both as raw and as mean values in a time span (Figure 1 b, c). Patients were instructed to stay relaxed for first 3 seconds of registration then, to clench on their teeth for another 3 seconds. The values were related as percentage of initial values that were obtained during 3s clenching on cotton rolls as described previously by Ferrario [5]. Having the same time span, only the average values were compared. Besides the 4 basic values (TAL, TAR, MML, MMR) another 6 parameters were evaluated (Figure 1c): Percentage overlapping for temporalis (PocTA) and masseter (PocMM), Percentage overlapping for both masseter and temporalis (BAR), torque coefficient (Tors), percentage overlapping of right and left side muscles (Asym), muscular work related to vertical dimension of occlusion (IMPACT). The acquired data were introduced into RStudio software for descriptive statistical analysis. Shapiro-wilk test was applied for normality distribution, mean and median values were calculated.

Results

Statistical analysis of electromyographic indices has shown a wide distribution of values that can be explained by the small number of subjects included in the study. However, a wide range of parameters has been also reported in other studies [14]. Statistical data have been shown in Table 1. The average value for temporalis left (TAL) was 42 μV, median 18.8 with minimum of 3.8 and maximum of 190 μV. For temporalis right (TAR) the mean was 51.4 μV, median 32.9, minimal value 7.9 and maximum of 248 μV. Masseter left had a mean of 48.7 μV, median 12.3, minimal value of 1.5 and maximum 439 μV. Masseter right 42.1 μV, median 16.3, minimum value 11.4 and maximum 243 μV.

The obtained value can be also analyzed depending on their relation toward the normal range provided by the manufacturer for assessment of muscle symmetrical work. For this, another 6 parameters previously emphasized are available. They are formed depending on the interaction of first 4 main parameters of muscle activity. The result of statistical analysis is given in table 2.

The percentage overlapping coefficients have a range in which the value indicates a symmetrical function. For PocTa and PocMM it is between 83 and 100%, BAR and Tors coefficients have a normal range between 90 and 100% and Asym from -10 to 10% range.

Even though, the subjects in this study had minimal dental procedures, they did not fit perfectly in the normal range provided by the manufacturer. The value with highest deviation from the normal range was IMPACT. This might be due to wider range that this coefficient has (from 85 to 115%) or instability of vertical dimension of occlusion that is changed after full mouth rehabilitation procedures. The overall mean deviation percentage was 20.5% from normal parameters of the device.

Table 1. *Descriptive analysis of EMG activity indices in healthy subjects*

		LC (N=33)
TAL, µV	Mean (SD)	42.0 (48.5)
	Median (IQR)	18.8 (36.3)
	[Min, Max]	[3.80, 190]
	Shapiro-Wilk normality test	W = 0.72061, p = 1.361e-06
TAR, µV	Mean (SD)	51.4 (56.8)
	Median (IQR)	32.9 (35.2)
	[Min, Max]	[7.90, 248]
	Shapiro-Wilk normality test	W = 0.67751, p = 3.031e-07
MML, µV	Mean (SD)	48.7 (107)
	Median (IQR)	12.3 (24.8)
	[Min, Max]	[1.50, 439]
	Shapiro-Wilk normality test	W = 0.45479, p = 5.957e-10
MMR, µV	Mean (SD)	42.1 (64.4)
	Median (IQR)	16.3 (16.7)
	[Min, Max]	[11.4, 243]
	Shapiro-Wilk normality test	W = 0.51507, p = 2.646e-09

Note: SD – standard deviation; IQR – interquartile deviation; Min – minimal value; Max – maximal value; TAL – temporalis left; TAR – temporalis right; MML – masseter left; MMR – masseter right.

Discussions

The obtained data were a part of broader study conducted in a PhD thesis that require healthy patients of middle age to be assessed and compared to the ones that had full mouth implant-supported rehabilitation. The electromyographic signal can vary during the same registration due to different factors that influences the muscle contraction. In order to provide reproducibility of acquired signals there are different protocols that aim to position the electrodes depending on different landmarks [13, 15]. In this case, the concentric electrodes allow their positioning without taking into account the interelectrode distance that can in some cases lead to „crosstalk" signals from other muscles. Analysis of percentage overlapping coefficients allows a better understanding of muscle interaction during dental rehabilitation procedures with the modification of occlusal surfaces [5].

The acquired data has shown that even in cases were dental procedures were minimum; there is a deviation from the normal range in the percentage overlapping coefficients of 20.5%.

The wide range of value distribution inside the sample group shows that surface electromyography is hardly comparable due to high individuality of evaluated parameters. It cannot be said that these parameters are high or low in accordance with the data from the literature because there are various devices available in the market with different electrode types that can provide non-comparable data and different reference values. The registration method is technique sensitive and depends also on the positioning of the electrodes, tissue thickness, age, sex, anatomical peculiarities etc.

Table 2. *Statistical analysis of percentage overlapping coefficients*

		LC (N=33)
POCTA	Mean (SD)	74.7 (17.2)
	Median (IQR)	81.0 (18.9)
	[Min, Max]	[29.0, 90.9]
POCMM	Mean (SD)	73.6 (17.2)
	Median (IQR)	76.2 (18.1)
	[Min, Max]	[14.5, 98.7]
BAR	Mean (SD)	76.4 (14.7)
	Median (IQR)	80.1 (21.4)
	[Min, Max]	[23.4, 93.1]
TORS	Mean (SD)	80.5 (12.4)
	Median (IQR)	83.5 (15.8)
	[Min, Max]	[40.2, 93.9]
ASYM	Mean (SD)	12.7 (13.5)
	Median (IQR)	6.60 (11.3)
	[Min, Max]	[0, 56.4]
IMPACT	Mean (SD)	95.0 (28.2)
	Median (IQR)	95.0 (31.0)
	[Min, Max]	[0, 150]

Note: SD – standard deviation; IQR – interquartile deviation; Min – minimal value; Max – maximal value; PocTA – temporalis muscle overlapping; PocMM – masseter muscles overlapping, BAR – masseters and temporalis muscles overlapping, TORS – torque coefficient, Asym – right and left muscles overlapping, IMPACT – vertical dimension correlated index.

The middle-aged patients are hard to be found with most of the teeth sound. Most of the patients already have dental treatment of different type and extent that can disturb the acquired data. Additional to that, the low awareness of Moldovan people towards the oral health leads to early tooth loss, which minimize the number of healthy subjects for establishing normal reference values.

Conclusions

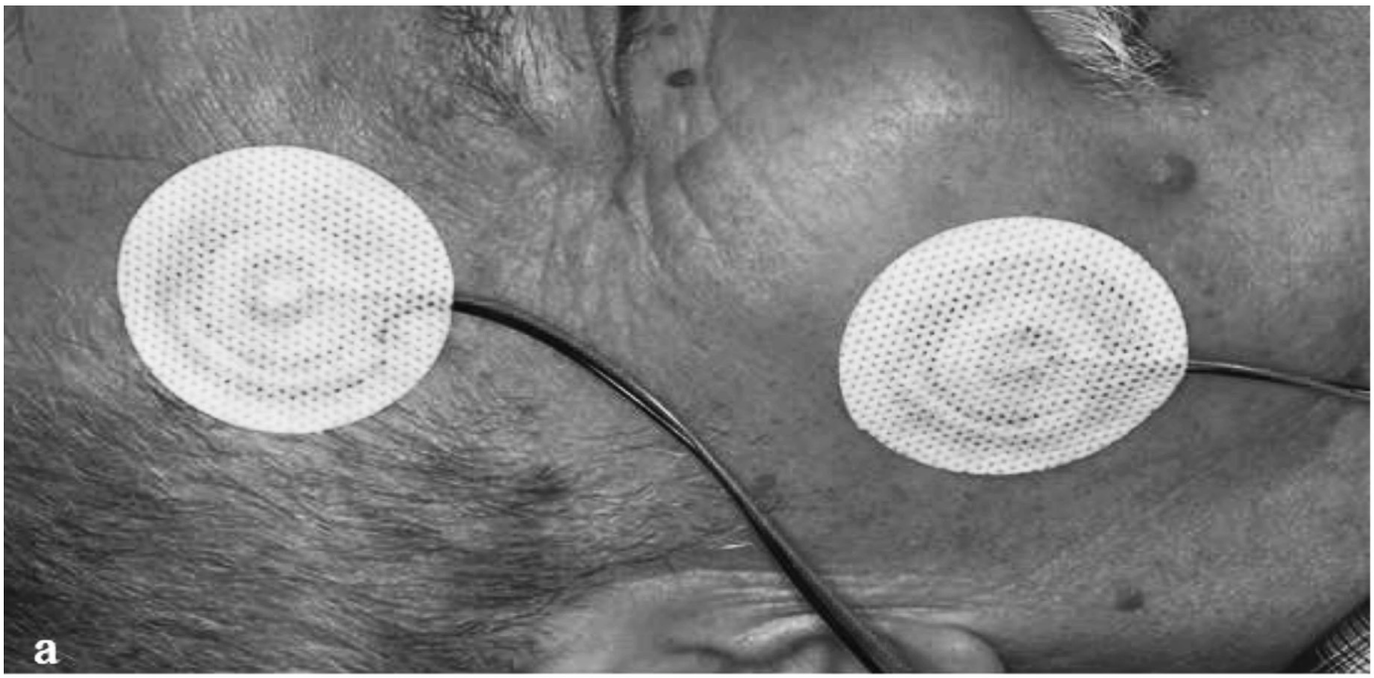
Surface electromyography has been widely used in dentistry to validate the dental treatment and try to create the most suitable restorations that would integrate into stomatognathic system. However, there is a big number of variables that can influence the acquired data among different population. Thus, in order to say if a treatment is valid or interfering with the muscular system, a reference group of the same age, sex and ethnicity is required.

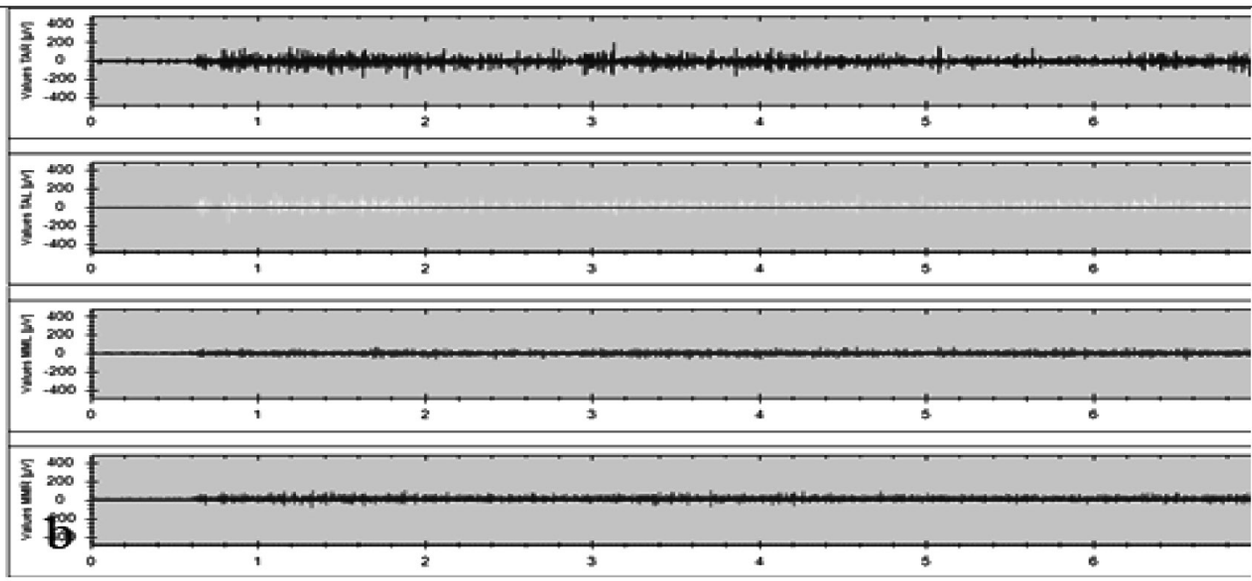
Declaration of conflict of interests:

Nothing to declare.

Authors' contributions:

AM – Conception and design of study; MM – Acquisition of data and manuscript drafting; NC – Analysis and interpretation of data; OS – Revising the manuscript critically for important intellectual content.





	Value
TA L	15.9uV
TA R	22.2uV
MM L	10.2uV
MM R	16.6uV

	Value	Range
POC TA	87.6R (51)	83≤(%)≤100
POC MM	88.9R (70.9)	83≤(%)≤100
BAR	91.5A (68.5)	90≤(%)≤100

	Value	Range
IMPACT	94	85≤(%)≤115
TORS	92.7L (64.4)	90≤(%)≤100
ASYM	2.4	-10≤(%)≤10

c

Fig. 1. *Evaluation of masticatory muscle EMG activity.*

a – placement of concentric electrodes, b – raw data of EMG activity, c – average values in a time span and percentage overlapping coefficients.

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Authors's ORCID ID:
Mihail Mostovei https://orcid.org/0000-0002-8112-4798
Oleg Solomon https://orcid.org/0000-0002-7341-1711