Electromyographic study of stomatognathic system muscles during chewing of different materials

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Abstract

Objective: *The aim of this study was to compare the behavior of the major chewing muscles (anterior temporalis, masseter and suprahyoid muscles) by using two commercial chewing gums (A and B) and two insipid materials (cotton ball and Parafilm M) through analysis of electromyographic signals.*

Method: *Ten female young adult subjects, aged from 18 to 27 years, with normal occlusion and no history of craniomandibular disorder were studied. The masticatory activity was performed with the subjects comfortably sat so that the Frankfurt plane was parallel to the floor. Electromyographic exams were carried out using bipolar surface passive mini-electrodes positioned on the anterior temporalis, masseter, and suprahyoid muscles. The subjects were guided to chew bilaterally and simultaneously each one of the materials, in aleatory sequence. For the study of the masticatory activity the electromyographic signals were processed through rectification, linear envelope and normalization, so that the coefficient of variation obtained from the procedure was comparatively analyzed. All data were submitted to analysis of variance (uni- and multi-varied).*

Results: *The results of this study indicated that the best materials for electromyographic studies on the chewing were Parafilm and cotton ball because they demonstrated the smallest coefficients of variation.*

Conclusion: *In addition, Parafilm showed the best palatability. In a general way, these materials are indicated for the accomplishment of electromyographic exams, since they demonstrated a smaller coefficient of variation as compared to the other materials.*

Key-Words: Electromyography (EMG) – Mastication muscles – Chewing gum.

Introduction

Clinical situations involving pain and sensibility in the chewing muscles, condylar sounds and limitation of the jaw movements characterize the Temporomandibular Disorders (TMD), also called temporomandibular dysfunction, syndrome of the pain and Temporomandibular Disorder or more simply TMJ Dysfunction (1).

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The etiology of the craniomandibular disorders is very discussed with respect to its semantics. Although TMD have etiologic components (occlusal, muscular, articular, psychological) that are related, a clear picture of cause and effect cannot always be defined (2).

One of the difficulties on the TMD evaluation has been to analyze and to qualify the electric activity of the muscles affected in the syndrome. For this purpose, since its introduction in Dentistry by Moyers in 1949, the electromyography (EMG) has shown to be an effective instrument of research, thus allowing the establishment of more precise diagnoses based on the muscular activity (3).

In addition to the diagnostic function, electromyography allows the evaluation of the effects of treatments for TMD on the masticatory musculature. Furthermore, functioning as biofeedback, electromyography can still be used as support therapeutics in TMD (4).

The electromyographic equipments have become more and more accessible to the dentists, thus allowing the enhancement of studies on the mastication muscle electromyography (5).

Although the chewing gum is usually used for electromyographic studies on the mastication the muscular response to various commercial chewing gums can show different electric activities during the masticatory activity (5, 6, 7, 8, 9). The analysis of the electric activity of the mastication muscles requires that the EMG trace is the most faithful and precise as possible, hence the importance of standardizing a material that allows the best results, since these could contribute to the study of several temporomandibular disorders (10).

Talebinejad et al. (2008) (11) stated that the EMG signal is complex, but currently due to the technological resources in electromyography a better understanding and utilization of this signal can be obtained, which had been previously studied in a rudimentary way by many authors.

Thus, due to the lack of scientific literature on the more suitable material for the EMG exam of the mastication muscles associated to a great demand of exams accomplished in the Laboratory of Electromyography, Department of Morphology, Faculdade de Odontologia de Piracicaba (FOP/UNICAMP), a study was developed with the purpose of comparing the performance of several materials with respect to generation of the electromyographic trace, by using two commercial chewing gums (A and B) and two insipid materials, cotton ball and Parafilm M.

Material and methods

Study Design / Place

This randomized longitudinal analytic study was executed at the *Laboratory of Electromyography*, Faculdade de Odontologia de Piracicaba (FOP/UNICAMP), São Paulo, Brazil.

Subjects

A total of 10 female young adult subjects, Graduation and Post-Graduation students of the Course of Dentistry of FOP/UNICAMP, age of the subjects was 23.7 years (± 4.15 years, range 18-27 years), with normal occlusion and no history of craniomandibular disorder was studied. In according to the ethical principles, the purposes of this study were carefully explained to the volunteers, who signed a formal consent. A questionnaire was also supplied to the volunteers for better investigation on the palatability of the materials.

The anterior portion of the temporalis muscle has been the more used in the electromyographic studies of the chewing muscles, since the interval between the myotendinous junction and the motor point does not present hair, thus representing the more suitable region for the placement of the electrodes. Therefore, the analysis of other portions of the temporalis muscle are not necessary, as reported by et al. (2006) (12) and Lyons et al. (1993) (13).

According to Dimitrov et al. (2003) (14), the surface electromyography recording contains some activity coming from another muscles that are being activated, synergistically or antagonistically to the studied muscle. This phenomenon is known as cross talk. Although the surface passive electrodes have been placed on the anterior face of the digastric muscle, the cross-talk in this region cannot be avoided (De Luca, 1997) (15), that is, as these muscles are small and thin, the signal captation might be arisen from the adjacent suprahyoid muscle group rather than a single muscle (m. digastric).

Procedures

Electromyographic Assessment

The recording of the electric activity was carried out on the temporalis (anterior portion) and masseter, bilaterally, and suprahyoid muscles through EMG exam.

For the captation and derivation of the electrical signals, Ag/AgCl surface passive bipolar mini-electrodes, type Beckman (Sensormed # 650950) (Figure 1), having 11 mm in diameter and 2 mm in detection surface were used. An electrode pair was used for each studied muscle. Surface electrodes were chosen because they offer high degree of precision and constitute a painless non-invasive instrument, causing no discomfort or risk to the subjects (16).

Electrode placement

The skin on the studied muscles was previously cleaned with alcohol to remove fat and dirtiness, thus improving the impedance and the captation of the signal, by reducing the electric resistance of the skin (14). The electrodes were placed on the skin through a double-face adhesive strip and positioned longitudinally and parallel to the muscular fiber direction, always keeping a distance of 1.5 cm between each electrode pair, starting from the center of the electrodes.

Each electrode pair was anointed with electroconductive gel. The ground electrode was also anointed with electroconductive gel and adhered in the anterior region of the distal portion of the subject's forearm, by a velcro ribbon and attached to one of the electromyograph channels. According to Dimitrov et al. (2003) (14), the ground electrode is used to minimize or preferentially to eliminate the noises of the EMG recording.

Recording the EMG signal

For recording the EMG signals the channels were calibrated allowing a gain of 600, with cutoff frequency of 20 Hz in the high-pass filter and 500 Hz in the low-pass filter through a bipolar analog filter, type Butterworth.

All the analog signals were amplified in the conditioning module of signals containing 16 analog inputs and DMA (Direct Memory Access) support interfaced to a standard microcomputer by a plate of conversion from Analog-to-Digital (A/D) signal of 12 bits, resolution and sampling frequency of 1.000 Hz, monitored by a data acquisition program.

For the acquisition and storage of the digitized signals the Aqdados software was used, with programmable sampling frequency and assay duration, allowing the treatment of the data after acquisition and the sharing with more universal formats.

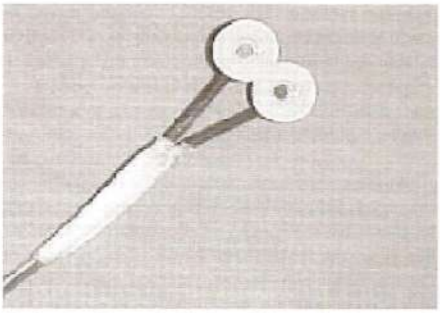

Fig. 1. – A surface passive bipolar mini-electrode pair, type Beckman (Sensormed # 650950).

Chewing procedures and materials

The next step was the volunteer's preparation to be tested. This stage had beginning with a brief explanation on the experiment and then the consent term was supplied to the subjects. They were comfortably seat in straight-backed chairs so that the Frankfurt plane was parallel to the floor, eyes opened and gone back to the infinite, feet supported on the floor, arms supported on the lower limbs.

Following the preparatory stages, the data collection was performed and the volunteers were trained and guided to chew bilaterally and simultaneously the materials, in aleatory sequence. The studied materials were two chewing gums, A and B, and two insipid materials, cotton ball and Parafilm ® M (manufactured by the American National Can. Industry).

The preparation of each material was made following the parameters found in the literature (17) for accomplishment of the mastication. All materials were adapted in according to the dimensions of material B, that is, the material A was cut out in width, thickness and length; the cotton ball was cut out in length; and the Parafilm was folded in 5 equal parts and doubled at the middle of its total length. Thus, its width and thickness became similar to the dimensions of the gum found in the literature regarding to the material B.

The volunteers carried out 10 chewing cycles for training, following the recording of another 10 chewing cycles. After this step, the subjects had a 30 second rest in order to begin the exam with other material, and so forth. The verbal command served to guide the volunteers for accompanying the rhythm established by the metronome (60 bpm)*.

Analysis of EMG signals

At the end of each assay, the EMG signals were examined in the computer screen itreatment of data" to guarantee the quality of the obtained data. At this time, the RMS (Root Mean Square) value of the respective signals was observed and scored in order to facilitate further analysis.

At the end of the data collection from each volunteer, the EMG traces were submitted to a selection of the intervals corresponding at the beginning and end of each period of isotonic contraction in order to be analyzed, obtaining a total of 10 chewing periods for each used material in each studied muscle.

After the selection of each trace of the chewing period, they were submitted to two different procedures: a) Processing of the trace signals concerning to chewing activity using the Microcal Origin (version 3.5) software; b) Statistical analysis of variance (uni- and multi-varied) of the variation coefficients.

Therefore, for the study of the chewing activity, the intervals of the EMG trace were submitted to further comparison and analysis as proposed by Winter (1990). The processing consisted of the following stages:

1) Total rectification of signal - also known as fullwave rectification that consists of obtaining the absolute value of the EMG trace, so that all negative signals are inverted, thus having just positive signals;
2) Normalization of the signal width - procedure that consists of submitting the values of the rectified EMG signal starting from a reference value that is common to all the signals, thus allowing comparisons among subjects, muscles, materials, etc. In this case the average of the rectified signal of the dynamic activity was used as reference value;
3) Linear envelope - obtained starting from the rectified signal, using a digital filter (low-pass) with cutoff frequency of 5 Hz that results in a envelope that follows the outline of the EMG signal;
4) Normalization of the time base - procedure that normalizes the time of activity of the different collected signals, where the time of the signal is transformed into activity percentage (0 to 100%). This sequence of signal processing can be observed in Figure 2.

EMG SIGNAL PROCESSING

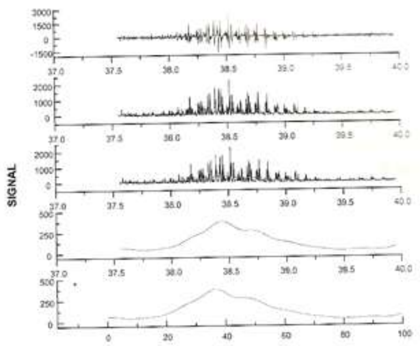

Fig. 2. – Example of a signal processing sequence: (1) electromyographic signal (RMS); (2) fullwave rectification of signal; (3) linear envelope on the rectified signal; (4) linear envelope; (5) linear envelope normalized at the time base.

Statistical Analysis

After processing each interval of the trace, the average of 10 traces of each material (n = 4) for each muscle (n = 5) of each subject (n = 10) was obtained so that the resulting final trace was representative of the chewing activity of the individual. Next, the average of traces from 10 subjects was obtained together with the standard deviation and the variation coefficient, that then were considered for analysis of the activity of each muscle for each material.

The data were tested for variance homogeneity, normality, error independence and model activity, and further submitted to analysis of variance - univaried to compare the effect of the materials in each muscle independently - and multivaried to compare the effect of the materials on the answer set of all the muscles.

The analyses followed the appropriate model for fortuitous experiments in blocks. The level of alpha significance (α) was adopted at 5%.

When evidences for the rejection of the hypothesis by the analysis of variance (univaried) were observed, the Bonferroni test was used for multiple comparisons of averages, with significance level at 5%. In the multivaried analysis, the rejection of the nullity hypothesis at level of 5% was complemented with comparisons of the materials through the study of contrasts.

Results

The results obtained in this study on the electric activity of the temporalis (anterior portion), masseter and suprahyoid muscles during the isotonic mastication of different materials – cotton ball, Parafilm, A and B – are demonstrated through coefficient of variation (CV) for each period of chewing activity for the different muscles and materials studied (Figures 3 to 7).

By the obtained results through the statistical analyses, it can be concluded that the cotton and Parafilm were the materials that presented the smallest coefficient of variation.

As regards to the questionnaire on palatability, the subjects preferred Parafilm to the cotton.

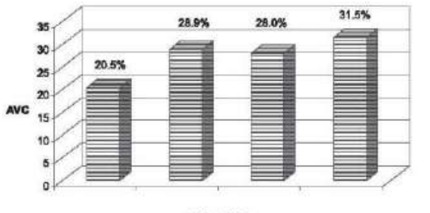

Fig. 3. – verage of the variation coefficients (AVC) (N = 10) obtained from the anterior portion of the right temporal (RT) muscle, calculated for each studied material.

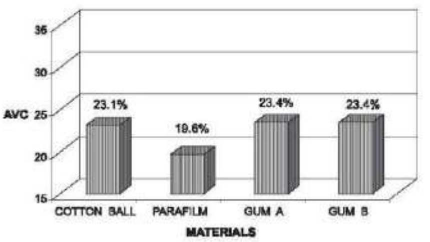

Fig. 4. – Average of the variation coefficients (AVC) (N = 10) obtained from the right masseter (RM) muscle, calculated for each studied material.

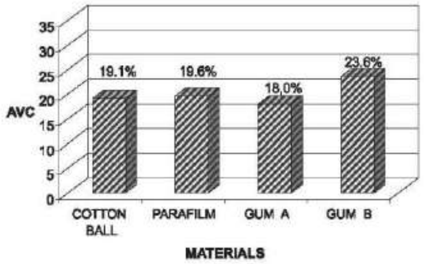

Fig. 5. – Average of the variation coefficients (AVC) (N = 10) obtained from the anterior portion of the left temporalis (LT) muscle, calculated for each studied material.

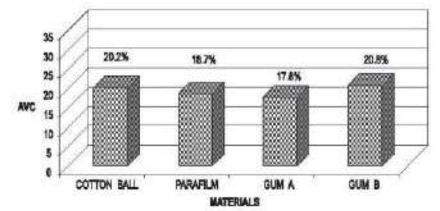

Fig. 6. – Average of the variation coefficients (N = 10) obtained from the left masseter (LM), calculated for each studied material.

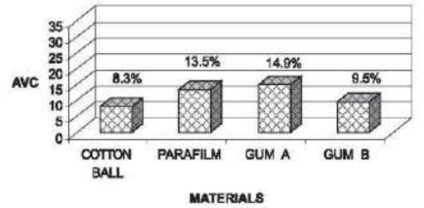

Fig. 7. – Average of the variation coefficients (N = 10) obtained from the suprahyoid (SH) muscle, calculated for each studied material.

Discussion

The study of EMG comprises not only the handling of an electromyograph and the analysis of captured signals but also the knowledge of the equipment, the recommended technique and the benefits that it offers.

It should be taken in consideration that besides the non-standardization of the materials used in the mastication analysis, the used electromyographs were manufactured for using in Dentistry, with generally 8 bits and low sampling frequency. In addition, its signals were expressed only in crude volts, allowing no more accurate analysis of the signal.

At first no comparison with the literature on the muscles and materials here studied was possible because there is no concern with the normalization of the signal and the standardization of the material in several reports (18, 19). For this reason the research about the standardization of a material that is indicated for the accomplishment of the EMG exam during the mastication was developed, allowing a more accurate analysis of the temporalis (anterior portion), masseter and suprahyoid muscles.

After having done the analysis proposed by Winter (1990) and observing the performance of each material for each studied muscle, it can be concluded that cotton and Parafilm were the materials that showed the smallest CVs. Next, the data were submitted to the analysis of variance - multivaried, thus making possible to analyze the existence of differences among the treatments, when all the variables are evaluated together. In addition, it could also be detected general effects, instead of the independent effects on each muscle. In this last analysis, statistically significant differences among the materials were found, where the cotton and Parafilm materials showed again a behavior with smaller variation coefficient.

The questionnaire applied after the EMG exam allowed that the subjects expressed your discomfort or displease with one or more of the used materials. A significant part of the samples (60%) did not like to chew the cotton. This difference of palatability among the materials should be studied in a more detailed way. Similarly to the efficiency analysis of the materials here studied, a sensorial analysis with a larger number of subjects would be important for better characterization of the amounts of the materials with respect to its acceptability by the users.

Therefore, based on the obtained results and the used experimental conditions, it can be concluded that:

1. The best materials, statistically significant with the smallest variation coefficients, were the cotton and Parafilm, following its indications for the accomplishment of the EMG exam of the chewing muscles.
2. The Parafilm material showed a better palatability in relation to the cotton, according to a sensorial analysis of the materials through a questionnaire, thus choosing it among the studied materials as the more indicated for EMG exams.

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