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Silent Period of Masticatory Cycles in Dentate Subjects and Complete Denture Wearers

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Abstract

Purpose: The purpose of this study was to assess, through electromyographic activity (EMG), the silent period (SP) of masseter and anterior temporal muscles in dentate subjects (DS) and complete denture wearers (CDW).

Materials and Methods: The evaluations were performed at the initial and final period of the mastication for the DS group. For the CDW group, the evaluations were performed at the initial period of mastication, with old complete dentures worn for more than 10 years (OCDW) and at the final period of the mastication with new complete dentures (NCDW), 5 months after rehabilitation. Twenty-four asymptomatic subjects (12 DS, 12 CDW) answered a questionnaire based on the Research Diagnostic Criteria for temporomandibular disorders. The CDW group answered the questionnaire before and after new denture insertion and after 5 months of rehabilitation. The SP of the muscles was recorded through EMG at the initial and final periods of mastication using artificial food (Optocal). The operator monitored 35 chewing cycles performed to grind the artificial food and selected eight open-close-clench-chewing cycles for the record.

Results: The SP of the muscles analyzed with new complete dentures showed no statistical difference in comparison to the old dentures. There was a statistically significant difference in the SP between the CDW and DS groups for initial and final chewing.

Conclusion: Lowered muscular capacity and ability reduced the SP of muscles after rehabilitation with NCDWs.

The silent period (SP), or an inhibitory reflex, is a pause or complete inhibition of motoneuron activity following a stimulus in a contracting muscle.[1-3] In masticatory elevator muscles, the SP starts after functional contacts between opposing teeth or after some other stimulus applied to the oral and perioral region during muscle contraction.[2-7] The SP is a reflex motor pause of muscles and may be assessed by electromyographic (EMG) records.[8]

Authors have reported SPs in complete denture wearers (CDW) during voluntary tapping[9-11] and chewing.[11,12] The reduction in electrical activity of masseter muscles upon new denture insertion may be related to muscular capacity and ability.[13-15]

Tissue-supported prostheses generate longitudinal progressive alterations as well as misfit and deficient functional capacity. The masticatory system corresponds to a biomechanical interaction among three components: function/dysfunction, adaptive response, and temporomandibular disorders (TMD).[16] The reason for differences in some reflex mechanisms and parameters between dentate subjects (DS) and CDWs still remains unclear.[9,17]

EMG studies on the SP of mandibles during chewing cycles comparing edentulous subjects wearing old and new dentures and DSs are still scarce. Therefore, this study aimed to report and verify the SP of masticatory muscles on a longitudinal study in dentate and edentulous subjects wearing old and new dentures during chewing of artificial food.

Materials and methods

Twenty-four subjects, including 12 CDW and 12 dentate subjects were selected for the study. According to inclusion criteria, 12 edentulous subjects wearing maxillary and mandibular complete dentures for more than 10 years were selected after anamnesis and clinical exams. All subjects presented reduced occlusal vertical dimension (OVD) with deficient dental

occlusion. Eight women and four men aged between 64 and 84 years were selected for the study. All subjects presented severe bone resorption, mainly in the mandibular arch.

Twelve DSs with full compliments of natural teeth, normal occlusal relationship, skeletal Class I, and no occlusal interferences were included in the control group. Eight women and four men aged between 22 and 35 years were selected for the study.

All subjects were asymptomatic and presented no signs and symptoms of TMD as confirmed by the Dworkin and Leresche Research Diagnostic Criteria (RDC) questionnaire.[18] This questionnaire was applied for DS and for denture wearers before new denture insertion and also 5 and 12 months after new denture insertion, sufficient time for adaptation.[13] The questionnaires were administered by two examiners. Two calibrated examiners performed the clinical evaluations in accordance with RDC/TMD standards. The selected subjects were informed about the treatment and signed an informed consent form in accordance with the recommendations of the Human Research Ethics Committee (Proc. 116/05-FOA-UNESP).

Clinical evaluations revealed the following conditions for the CDW group: severe decrease in lower face height yielding deficient facial esthetics, inadequate fit of complete dentures, worn denture teeth, clinically perceptible deficiency in OVD, acquired protrusive maxillomandibular relationships secondary to resorption, or angular cheilitis.[19] The evaluation of the SP of the masseter and temporal muscles included a comparison between a control group represented by the DS group and the CDW group before (OCDW group) and after rehabilitation (NCDW group).

After the evaluation of the SP with the OCDW group, the deficiencies in OVD were corrected by adding increments of acrylic resin to the occlusal surfaces of the teeth in the old mandibular dentures. This procedure is used to adapt and facilitate the adaptation of the patient's maxillomandibular relation accurately.[20] The new complete dentures were made according to the procedure recommended by Zarb et al.[16]

The technique for denture fabrication consisted of preliminary impressions using stock trays and condensation silicone impression material (Zetaplus, Zhermack, Rovigo, Italy). The preliminary casts were fabricated to make custom trays for definitive impressions. Border molding was performed with heavy body condensation silicone (Zetaplus), and the definitive impressions were made with a paste impression material (Zinc Oxide-Eugenol Impression Paste, Lysanda, Sao Paulo, Brazil) spread over the entire fitting surface of the tray, including the molded borders of the trays. The definitive impressions were poured with type IV dental stone (Durone, Dentsply, Petropolis, Brazil) to obtain the master casts.

The maxillary cast of each subject was mounted on a semiadjustable articulator (Whip Mix Corporation, Louisville, KY) using a facebow transfer register. OVD was established using the physiological rest positions associated with phonetic and esthetic techniques.[31]

Centric relation was established according to dynamic records based on physiological jaw movements, including opening, closing, and lateral movements performed by the subject.[16] These records were used to position the mandibular casts on the articulators in the required relations. Artificial teeth were selected, and bilateral balanced occlusion was obtained. The dentures were waxed, processed, finished, and polished for insertion and follow-up.[16] The dentures were made with artificial teeth (Trilux, Vipi Manufacturer, Sao Paulo, Brazil) with a cusp inclination of 20°.[13] The CDW group was rehabilitated by the same professional, and the same technique was applied for fabrication of the new dentures for all subjects.[13,16]

The bipolar surface electrodes (Bio Research, Redmond, WA) were disposable duotrodes, 10 mm in diameter. A 21-mm interelectrode distance was determined, and the electrodes were connected to an amplifier by cables, which were in turn connected to a computer with Bio Research "Bio EMG" software to capture the electrical signal and analyze the electrical activity of muscles. The following parameters were used: sampling rate 1000 Hz, sample length 15 seconds, amplification 1X.[13]

The electrodes were positioned using palpation of the muscles. Each electrode was placed in the center of the masseter muscle at a point equidistant from the upper and lower insertions of the muscle with teeth in occlusal contact. The anterior border of the anterior temporal muscle was located during mandibular movement to place the electrode perpendicular to the sagittal plane. The localization was determined 1.5 to 2.0 cm superior to the zygomatic arch, immediately behind the frontal process of the zygomatic bone. During the EMG records, the subjects were kept in a comfortable sitting position with no headrest and with Frankfort plane parallel to the floor.[21]

Artificial food composed of Optocal (Piracicaba, São Paulo, Brazil)[22] was fragmented in a 10-mm^3 cube shape as suggested by Slagter et al[23] and applied for the EMG recordings. Each subject received 3 g of the artificial food, which was chewed for 35 cycles,[24] monitored by the operator. This number of cycles is very close to the moment of deglutition,[24] and each cycle corresponded to the maximum bite chewing performed for each subject to grind the food.[25,26]

SPs were assessed in open-close-clench-chewing (OCCCh) cycles. The OCCCh cycle is defined as a cycle when a subject firmly closes the mouth from the open mouth position, with the teeth in the habitual occlusal position during the chewing cycles. Eight subsequent OCCCh cycles[13] were recorded for each subject among 35 cycles. The SP duration measurement was done at the double-zoom option. The measurement error was 1.2 ms for the duration.[27] All measurements were made offline by a trained and experienced examiner. The duration of the SP was measured from the peak of the last significant spike preceding the inhibition to the peak of the first significant spike being a part of the ongoing muscle activity. If there was an SP with two or three inhibitory pauses (double or triple SP) or one appearing with a depressed muscle activity (DA) after complete inhibition of motoneurons, then the complete duration of all inhibitory pauses (CDIP) was measured or added to the duration of a DA after the last inhibitory pause.[28]

The SPs were recorded during food grinding in the first and last eight cycles according to the number required for the software records visualized on the computer screen. Each EMG record was made in each subject three times for each chewing cycle period (initial and final) for DSs, OCDWs, and NCDWs. Statistical analysis of the SP recordings was performed by

Table 1 Silent period and respective mean values (ms) in the anterior temporal muscles of 24 subjects recorded during initial and final chewing

	Right anterior temporal			Left anterior temporal		
Chewing	OCDW	NCDW	DS	OCDW	NCDW	DS
Initial	19.865 (9.008) Aa	17.490 (5.785) Aa	6.433 (0.752) Ab	20.004 (9.089) Aa	17.490 (5.785) Aa	6.216 (0.72) Ab
Final	18.632 (7.530) Aa	14.473 (5.264) Aa	6.250 (0.703) Ab	18.362 (7.53) Aa	14.973 (5.266) Aa	6.200 (0.638) Ab

Different uppercase letters indicate statistically significant difference at 5% level in columns.
Different lowercase letters indicate statistically significant difference at 5% level in rows.
DS = dentate subjects; OCDW = old complete denture wearers; NCDW = new complete denture wearers.

applying ANOVA, the normal data distribution test, and Tukey's student range (HSD) for $p = 0.05$.

Results

The test for the comparison of variation demonstrated no difference between the SP of the muscles, with the resulting homoscedasticity. After this test, the null hypothesis was accepted. The mean values and the statistical data of the SP recordings are shown in Tables 1 and 2. No statistically significant reduction occurred in the mean SP (ms) in the anterior temporal and masseter muscles when the beginning and end of mastication was compared.

Considering the muscles, a reduction in the SP was demonstrated at the end of chewing for all groups. The SP was higher in the OCDW group (Tables 1 and 2). Statistically significant differences were observed, with the lowest average values of SP (ms) in the DS group for all muscles (Tables 1 and 2).

Discussion

The contraction of skeletal muscles results in chemical, thermal, and/or electrical changes. It is, however, the electrical changes that allow evaluation of muscle characteristics. According to Sowman et al, there is low and high activity during opening and closing of the mouth, respectively, with minimal and stable activity at the rest position.[8]

According to a previous study related to intra and interindividual variability and intra and interobserver reliability, eight consecutive OCCCh cycles were considered sufficient for obtaining representative values of the SP parameters.[27] The values for SP in the DS group, in comparison to the OCDW and NCDW groups were lower, and the variations observed were statistically significant (Tables 1 and 2).

Considering that CDWs present no periodontal receptors due to loss of natural teeth, their neuromuscular feedback mechanisms may be impaired. They would thus be unable to provide enough sensory information to restore all natural feedback mechanisms for proper motor function or to compensate for normal tooth loading and force transfer.[6]

Different mechanisms, such as mechanical pressure of the oral mucosa receptors underneath the denture, may be responsible for SPs in CDWs; however, vibration of the contacts between opposing artificial teeth could also stimulate other receptors. Significantly longer latencies in the CDW group than in the DS group (Tables 1 and 2) could be attributed to the triggering of different receptors (mucosal vs. periodontal), possible slower conduction of the mucosal receptors, or more synapses involved in the reflex arch. The additional period after occlusal contact necessary for a denture to shift to the underlying mucosa and stimulate the receptors is also responsible for this result.[28]

Some studies[29–31] suggest the assessment of SP duration as a diagnosis, since normal occlusion may be associated with a reduction in SP. So, the EMG evaluation of SP duration is a method to verify the reestablishment of the neurophysiological equilibrium of masticatory muscles.

There was no statistically significant reduction of SP between the NCDW group and the OCDW group. The reduced OVD with old dentures allows reduced masseter muscle activity, with an alteration on physiological length, reducing muscular activity, and increasing SP duration.[32] The reestablishment of OVD results in slight muscular stretching while motor response causes shortening that makes the muscle more hyperactive.[32] In addition, occlusal harmony with correctly positioned cusps improves intercuspation and chewing.[13,15,33–35]

Table 2 Silent period and respective mean values (ms) in the masseter muscles of 24 subjects recorded during initial and final chewing

	Right masseter			Left masseter		
Chewing	OCDW	NCDW	DS	OCDW	NCDW	DS
Initial	20.835 (10.068) Aa	17.490 (5.785) Aa	6.433 (0.752) Ab	20.835 (10.068) Aa	17.490 (5.785) Aa	6.216 (0.720) Ab
Final	19.382 (7.475) Aa	14.973 (5.266) Aa	6.250 (0.703) Ab	19.382 (7.475) Aa	14.973 (5.266) Aa	6.200 (0.638) Ab

Different uppercase letters indicate statistically significant difference at 5% level in columns.
Different lowercase letters indicate statistically significant difference at 5% level in rows.
DS = dentate subjects; OCDW = old complete denture wearers; NCDW = new complete denture wearers.

SP duration can range from 7 to 12 ms in DSs during chewing[9] and from 14 to 25 ms[9,36] in CDWs according to the stimulus (higher values than those exhibited for DSs without TMD symptoms), agreeing with our results (Tables 1 and 2). The mean values of the SP are lower for chewing with the DS group than for the OCDW and NCDW groups (Tables 1 and 2). At the end of chewing, the means of the SP in the muscles indicated little reduction of activity for all groups (Tables 1 and 2).

In the present study, a major reduction of the SP between initial and final chewing was observed in the NCDW group. According to the literature, this may be because of the slight alteration of the electrical activity of the muscles 5 months after new denture insertion.[13] This result may be attributed to the lack of muscular capacity and ability to adapt to the new complete dentures.[13,14,16,20,34,37-40] This may occur since muscles are more active in raising the mandible, especially during masticatory function.[13,41,42] In addition, according to Lippold,[43] the mean of the electrical activities recorded at the surface of the muscles increases with the force of muscular contraction.

Ahlgren[44] and Ottenhoff et al[34] pointed out that after food grinding, the central nervous system recognizes the need for less muscular force and, therefore, muscle activity tends to diminish. This indicates a certain difficulty with food grinding at the end of chewing as explained by Kawazoe et al,[45] who affirmed that after a certain time of continuous chewing, the speed of contraction decreases while the electrical activity of the muscles increases. So, food becomes smaller and softer, associated with a reduction of the peaks of SP as observed in all groups.[46]

Conclusions

The DS exhibited reduced duration of SP in comparison to the old and new complete denture wearers. There was no statistically significant reduction of SP of muscles noted at the beginning and at the end of chewing in all groups.

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