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ELECTROMYOGRAPHIC EVALUATION OF MASTICATION AND SWALLOWING IN ELDERLY INDIVIDUALS WITH MANDIBULAR FIXED IMPLANT-SUPPORTED PROSTHESES

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ABSTRACT

This study evaluated the effect of implant-supported oral rehabilitation in the mandible on the electromyographic activity during mastication and swallowing in edentulous elderly individuals. Fifteen patients aged more than 60 years were evaluated, being 10 females and 5 males. All patients were edentulous, wore removable complete dentures on both dental arches, and had the mandibular dentures replaced by implant-supported prostheses. All patients were submitted to electromyographic evaluation of the masseter, superior orbicularis oris muscles, and the submental muscles, before surgery and 3, 6 and 18 months postoperatively, using foods of different textures. The results obtained at the different periods were analyzed statistically by Kruskal-Wallis non-parametric test. Statistical analysis showed that only the masseter muscle had a significant loss in electromyographic activity ($p<0.001$), with a tendency of similar response for the submental muscles. Moreover, there was an increase in the activity of the orbicularis oris muscle during rubber chewing after treatment, yet without statistically significant difference. Mandibular fixed implant-supported prostheses in elderly individuals revealed a decrease in electromyographic amplitude for the masseter muscles during swallowing, which may indicate adaptation to new conditions of stability provided by fixation of the complete denture in the mandibular arch.

Key words: Swallowing. Mastication. Elderly. Implant-supported prosthesis. Electromyography.

INTRODUCTION

The aging process causes physiological changes that affect the whole organism. Specifically in relation to the stomatognathic system, in addition to tooth loss, there is reduced masticatory force[12], alveolar bone decomposition, changes in oral mucosa, and reduction in the number of functional motor units[23], leading to decreased muscular activity[1].

Within this context, changes in the sequence of muscular activation may also be observed in elderly, characterized by delay in recruitment of the submental muscles compared to young individuals. Moreover, in this population, the increase in food consistency causes an increase in amplitude and duration of electromyographic activity lower orbicularis oris, submental and infrahyoid muscles[4]. In dentate individuals, duration of activity of the orbicularis oris, masseter, submental and infrahyoid muscles during swallowing of saliva and water increases with age, more significantly for individuals older than 70 years, differently than which is observed in relation to the amplitude of electromyographic activity of the submental muscles, which is reduced in elderly individuals compared to adults[29,30]. The number of masticatory cycles required for food preparation during swallowing is also increased with age[21].

Observation of the effect of tooth loss in elderly individuals

shows that the presence of natural teeth allows a better masticatory performance compared to the use of removable complete dentures with regards to masticatory efficiency, masticatory time, selection of more consistent foods[33] and electromyographic activity[13]. Within this context, edentulous adults and elderly individuals wearing removable complete dentures exhibit reduced muscular activity at the working side, which is poorly adapted to the food texture, as well as decreased electromyographic activity, especially of the masseter muscle, when compared to dentate individuals[32]. The stability of complete dentures also influences the masticatory performance of individuals, as damages to this aspect would result in less regularity and uniformity of mastication cycles[15]. Moreover, use of prostheses damages the sensitivity, oral stereognosis and taste and may also influence the feeding, swallowing and nutritional status of elderly individuals[24].

Regarding the adaptation to new dentures, edentulous elderly individuals wearing removable complete dentures for several years exhibit temporary reduction in activity of the masseter muscle at the working side after placement of new dentures, while the activity of the anterior temporalis muscle remains reduced[22].

Adaptation of the stomatognathic system to food consistency in individuals wearing removable complete dentures may also be investigated by electromyography, which reveals differences in the number of masticatory cycles, amplitude and duration of mastication and of the masticatory cycle, according to the hardness of foods[15]. Similarly, in cases of adults and elderly individuals wearing implant-supported mandibular dentures, food consistency influences the parameters masticatory rate, amplitude and relative contraction period[14].

The type of dental treatment performed in adults and elderly individuals also influences the masticatory efficiency, which is greater in individuals rehabilitated with tooth-supported and implant-supported dentures compared to removable complete dentures. It should be highlighted that individuals wearing tooth-supported dentures exhibit greater electromyographic activity of the anterior temporalis muscle during masticatory function, both in the amplitude and value of integrated activity, compared to individuals wearing removable complete and implant-supported dentures in the mandibular arch[3]. Thus, the use of implant-supported prostheses leads to improved masticatory function, characterized by an increase in electromyographic activity and reduced masticatory cycle time[2], although neuromuscular coordination is lower compared to individuals with natural teeth[6].

The elderly population frequently needs prostheses. However, no study has yet evaluated the effects of oral rehabilitation on the physiology of mastication and swallowing in this age group. The purpose of this study was to evaluate the electromyographic activity in elderly edentulous individuals with mandibular fixed implant-supported prostheses.

MATERIALS AND METHODS

Patients

The research protocol was independently reviewed and approved by the Institutional Review Board of University of Sagrado Coração (protocol # 001/2003).

Fifteen elderly individuals were selected for this study, being 10 females and 5 males, aged 60 to 76 years old [mean ± standard deviation (s.d.), 66 ± 5 years]. All subjects were in good general health, were completely edentulous for at least 5 years, wore removable complete dentures with the maxillary arch in good clinical condition, and had adequate mandibular bone structure for placement of implants with minimum size of 10 mm.

The exclusion criteria included history of neurological or psychiatric disturbances, head and neck tumors or use of drugs that affect the central nervous system.

Surgical-Prosthetic Procedures

Before surgery, all maxillary and mandibular removable complete dentures were replaced. Preoperative evaluation was performed at 6 months after placement of the new prostheses.

The surgical protocol adopted comprised placement of 5 mandibular osseointegrated implants with 4-, 4.5- or 5-mm diameter in the mandibular arch. Arrangement of implants in the mandible was the same for all patients. After placement of implants, the prosthetic abutments were fitted, followed by preparation, finishing, polishing and fitting of the dentures, provided the minimum stability rates were reached to indicate the immediate load procedure.

The period between implant placement and denture installation was not longer than 24 h, thus characterizing the immediate load procedure. It should be mentioned that the same dentures previously worn by the patients were fitted.

Sutures were removed after 7 days. Patients were evaluated at this period for any occlusal adjustments that could be necessary. Radiographic and clinical follow-up was performed monthly until removal and reevaluation of dentures after 3 months. This period was of key importance for treatment success.

EMG Recordings and Measurements

Electromyographic evaluation of participants was performed at 4 different periods: immediately before surgery (Pre) and 3 (Post1), 6 (Post2) and 18 (Post3) months after surgery.

Recordings were made with the individual sat in a dental chair with the mandibular body inclined at 45° to the ground. The skin surface over the left and right masseter, superior orbicularis oris muscles and right submental muscles were cleaned with cotton wool soaked in 70% alcohol to remove the excess oiliness and enhance contact with the electrodes. The electrodes employed to capture the bioelectric potentials of muscles were 3M pediatric size and were attached to the skin using conductive gel and surgical tape. Three electrodes were used for each muscle, being one earth and two active electrodes. The latter were placed approximately 2 cm apart parallel to the muscle fibers, close to the earth electrode. For

the superior orbicularis oris muscle, two electrodes were placed equidistant from the labial filtrum without touching the labial mucosa. For the masseter muscles, one pole was placed where the lines of the nasal wing and corner of the mouth intersect towards the tragus; the other was placed below, towards the mandibular angle. Submental muscle activity (including anterior belly of digastric, mylohyoid and geniohyoid) was measured with electrodes placed two fingers below the chin horizontally to the right of facial center line. Records were obtained on a four-channel NeuroEducator® 3 Electromyography System (Therapeutic Alliances Inc., Fairborn, OH, USA), connected to a computer with data collection and analysis software.

During the test, the participants were required to chew normally on a 2-cm piece of natural rubber, as well as to swallow 10 mL of water and 10 mL of a paste prepared with 10 mL of low calorie grape juice mixed with three measures of Nutilis thickener (Support Produtos Nutricionais Ltda., Rio de Janeiro, RJ, Brazil).

Electromyographic data were recorded for 60 s during mastication on rubber. For liquid and paste foods, records were obtained for 10 and 20 s, respectively. Results were expressed in μV RMS (Root Mean Square) by selection of 40 values, each obtained at every 1.5 second of masticatory activity, as well as at every 0.5 and 0.25 second of recording during swallowing of paste and liquid foods, respectively. Thereafter, the mean of values observed for the left and right masseter, superior orbicularis oris and submental muscles was calculated.

Statistical analysis between periods was performed by Kruskal-Wallis non-parametric test at 5% significance level.

RESULTS

Results referring to the bioelectric activity of masseter, superior orbicularis oris and right submental muscles during chewing on rubber and swallowing of paste and liquid foods are presented in Tables 1 to 3.

Table 1 exhibits postsurgical reduction in electromyographic activity of the masseter muscles, with statistically significant differences ($p<0.01$) at 18 months for swallowing of pasty foods, and at 6 months for swallowing of water.

Concerning the activity of submental muscles during swallowing, there was reduction in electromyographic activity after treatment, though without statistically significant difference ($p>0.05$) among the recorded values (Table 2).

With regard to the superior orbicularis oris muscle, the results obtained for chewing on rubber exhibited a tendency of increased bioelectric activity after placement of implants, especially at 6 and 18 months after surgery. However, there was no variation in relation to swallowing of liquid and pasty foods, as observed in Table 3. No significant differences ($p>0.05$) were found among the periods.

TABLE 1- Descriptive amplitude measurements of action potentials (in μV RMS) generated by the masseter, during habitual chewing rubber swallowing of foods with different consistencies before (Pre), and 3 (Post1), 6 (Post2), and 18 (Post3) months after treatment

Material/ Food	Measurement Description	Time				Result of statistical analysis (p value)
		Pre	Post1	Post2	Post3	
Rubber	minimum value	6.30	11.30	7.40	7.40	p>0.05
	Median	26.40	28.70	19.70	24.40	
	maximum value	68.60	61.50	53.10	52.70	
	Mean	30.21	30.80	24.03	24.41	
	s.d.	18.16	12.74	13.32	11.53	
Paste	minimum value	5.50	6.30	4.50	2.20	p<0.01
	Median	14.60 b	15.40 b	12.10 b	6.80 a	
	maximum value	51.10	30.90	49.10	45.90	
	Mean	21.14	16.77	14.53	9.64	
	s.d.	15.47	7.44	10.79	10.53	
Water	minimum value	5.90	4.80	2.60	2.80	p<0.01
	Median	13.00 c	12.30 c	9.90 b	4.90 a	
	maximum value	49.40	30.40	17.80	40.70	
	Mean	19.95	13.72	10.07	7.91	
	s.d.	15.43	7.54	4.58	9.31	

Different letters indicate statistically significant difference among times.

TABLE 2- Descriptive amplitude measurements of action potentials (in μV RMS) generated by the submental muscles, during habitual chewing rubber and swallowing of foods with different consistencies before (Pre), and 3 (Post1), 6 (Post2) and 18 (Post3) months after treatment

Material/ Food	Measurement Description	Time				Result of statistical analysis (p value)
		Pre	Post1	Post2	Post3	
Rubber	minimum value	7.60	9.40	4.20	10.60	p>0.05
	Median	21.00	19.70	17.30	18.50	
	maximum value	85.90	36.100	46.00	52.30	
	Mean	24.77	20.93	20.80	22.17	
	s.d.	17.92	6.96	11.23	11.21	
Paste	minimum value	10.70	13.00	2.20	7.20	p>0.05
	Median	24.90	22.20	20.80	17.10	
	maximum value	52.00	37.90	53.00	38.60	
	Mean	25.26	24.70	22.09	17.99	
	s.d.	11.23	7.23	12.10	9.02	
Water	minimum value	5.90	11.10	1.90	5.30	p>0.05
	Median	17.50	16.90	15.90	14.60	
	maximum value	68.30	36.80	56.00	38.00	
	Mean	22.26	18.66	18.60	15.29	
	s.d.	16.29	6.53	14.32	8.03	

TABLE 3- Descriptive amplitude measurements of action potentials (in μV RMS) generated by the superior orbicularis oris muscle, during habitual chewing rubber and swallowing of foods with different consistencies before (Pre), and 3 (Post1), 6 (Post2) and 18 (Post3) months after treatment

Material/ Food	Measurement Description	Time				Result of statistical analysis (p value)
		Pre	Post1	Post2	Post3	
Rubber	minimum value	11.60	17.80	11.20	16.20	p>0.05
	Median	33.00	37.50	35.60	41.20	
	maximum value	68.30	74.70	91.30	238.50	
	Mean	36.59	38.59	40.85	53.30	
	s.d.	17.22	14.66	20.59	54.07	
Paste	minimum value	2.10	9.70	11.60	6.70	p>0.05
	Median	22.70	26.40	22.50	19.80	
	maximum value	45.30	54.10	77.70	81.80	
	Mean	25.30	30.35	31.29	25.90	
	s.d.	13.20	11.89	18.79	18.71	
Water	minimum value	6.40	4.60	4.80	4.50	p>0.05
	Median	15.50	18.60	21.10	18.50	
	maximum value	40.10	37.20	49.40	70.70	
	Mean	19.01	19.76	22.95	20.65	
	s.d.	10.92	10.17	12.63	16.74	

DISCUSSION

The study of neuromuscular behavior of the masticatory system to assess different dental intervention strategies has attracted many authors, both in oral rehabilitation with removable[3,7,13,15,18,19,25-27] and implant-supported prostheses[5,7,11,28] the latter providing better functional and esthetic conditions for users than conventional prostheses[3,8,9,20,31].

Such studies on elderly individuals are rare, even though this age group is particularly susceptible to tooth loss and therefore need to use prostheses to guarantee adequate food ingestion and consequently maintain a satisfactory nutritional state.

The objective of this study was to evaluate the muscular activity involved in processes of mastication on rubber and swallowing of foods of different textures in elderly individuals using electromyography to compare their performance before and after placement of implant-supported prostheses in the mandibular arch. The results showed statistically significant reduction in bioelectric activity after implant-supported oral rehabilitation in the masseter muscles for swallowing of both paste and liquid foods. Differences were more marked when preoperative values were compared to 6 and 18 months posttreatment. Similar performance was observed for the submental muscles, yet without statistically significant difference. The orbicularis oris muscle presented increased activity at all post-implant periods for mastication on rubber, yet without statistically significant difference in results between periods.

The reduction of muscular activity after implant-supported oral rehabilitation observed in this study is different from the findings of other investigations that reported increased masticatory activity after implant placement[2,3]. However, Chen, et al.[3] (2002) investigated adults and elderly and observed lower amplitude results for the masseter muscle in the group treated with implant-supported dentures, in agreement with the findings of the present study. Conversely, Haraldson, et al.[11] (1979), Haraldson and Inger-Vall[10] (1979) verified that electromyographic activity related to the masticatory muscles and the superior orbicularis oris muscle in adult women wearing implant-supported prostheses was similar to those with natural teeth at the same age range.

The presence of numerically lower values for the submental muscles after implant-supported oral rehabilitation seems to be associated to physiological adjustments expected during the aging process, since studies conducted on dentate individuals found reduction in electromyographic amplitude with age[29,30]. This population, however, was not investigated in the present study.

Moreover, the greater activity of masseter and suprahyoid muscles preoperatively might be explained by the recruitment of a larger number of motor units to retain mandibular removable dentures. According to Veyrune and Mioche[32] (2000), tooth loss and use of complete dentures affects the motor and sensorial aspects involved in the masticatory process. Information received centrally is not sufficiently accurate to allow adaptation of mastication patterns to the food texture in denture wearers.

It should be highlighted that the loss of teeth and consequently of periodontal receptors impairs the sensorial biofeedback[17], mainly due to information from the mechanoreceptors and muscle spindles[16]. Adaptation of the stomatognathic system to the anatomic-physiological conditions of individuals is certainly responsible for the partial release of mandibular elevator muscles after achievement of stabilization by placement of implant-supported dentures, inducing a decrease in muscular activity in the postoperative period. The opposite occurred in the case of the orbicularis oris muscle, where the probable loss of coordination or the need to adjust the maxillary removable prosthesis to the mandibular fixed prosthesis could have caused increased muscle activity in an attempt to hold the maxillary prosthesis in place.

Thus, the results of the present study indicate that use of implant-supported fixed dentures leads to physiological adaptations to the oral condition and aging process. Thus, limitations of the method employed should be taken into account, considering the physiologically expected circadian variations.

CONCLUSIONS

Treatment by implant-supported oral rehabilitation in the mandible in elderly individuals revealed a decrease in electromyographic amplitude for the masseter muscles during swallowing of pasty and liquid foods. The explanation for these muscular behaviors could be associated with functional adjustments induced by the implant-supported rehabilitation, modulated by the dynamic aging process.

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