THE INFLUENCE OF AGE AND DENTAL STATUS ON THE DURATION OF CHEWING CYCLES DURING MASTICATION

Iva Z. Alajbeg*, Melita Valentic-Peruzovic*, Ivan Alajbeg**, Mario Cifrek***

*Department of Prosthodontics, School of Dental Medicine, University of Zagreb, Croatia
**Department of Oral Medicine, School of Dental Medicine, University of Zagreb, Croatia
***Department of Electronic Systems and Information Processing, Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia

ialajbeg@sfzg.hr

Abstract: In elderly subjects chewing mechanisms act with some marked differences when compared to young subjects. Moreover, chewing efficiency is considerably reduced when natural teeth have been replaced by complete dentures. The objective of this study was to determine whether the duration of the contractile phase of chewing cycles during mastication is affected by age and dental status. Seventy subjects participated in this study, and they were divided in 3 groups (young dentates, elderly dentates, edentulous subjects). Surface electromyographic (EMG) recordings were obtained from the anterior temporal (T), masseter (M), and depressor muscles (D). Muscle activity was recorded during maximal voluntary contraction (MVC), maximal opening (Omax) and during five minutes of mastication. During that period EMG recordings were made once a minute during a period of 10 seconds and the duration of the contractile phase of chewing cycles (the mean of six consecutive cycles) in each minute of mastication was evaluated. The duration of the contractile phase of chewing cycles was shortest in young dentate subjects and longest in denture wearers. It is possible that reduced muscle activity in denture wearers is accompanied by an increase in the mean duration of the contractile phase of chewing cycles for achieving satisfactory mastication.

Introduction

One of the most complex neurophysiological mechanisms in human motor performance is the one involved in mastication [1]. Muscle activity during mastication is the result of the interaction between central commands and the peripheral input. It is well known that in the elderly subjects chewing mechanisms act with some marked differences when compared to young subjects since some age related changes, such as deterioration in the fast and slow fibres in the striated muscles, result in impaired muscle force in elderly people [2]. Moreover, chewing efficiency is considerably reduced when natural teeth have been replaced by complete dentures and the loss of teeth and elimination of periodontal afferent flow lead to changes in the neuro-muscular pattern [3,4].

Review of the relevant literature reveals that diverse methods have been used for masticatory function analysis. Some of them record and measure jaw movements (kinesiographic studies) while others analyse muscle activity (electromyographic studies) [5-7].

In our previous study [8], by using electromyography, we found that muscle activity during five minutes of mastication depends greatly of the presence of the prosthetic appliance in elderly patients. In the present investigation we extended our experiment on the sample of young dentate subject in order to determine whether the duration of the contractile phase of chewing cycles during mastication is affected by age and dental status.

Materials and methods

The experimental group (E) consisted of 30 edentulous individuals (65.7 ±7.8 years) who had worn an upper and a lower complete removable denture for an average period of six months. The edentulous participants were chosen upon the criteria that their dentures had satisfactory interocclusal and maxilomandibular relationship. All participants reported an adequate masticatory efficiency and were satisfied with their dentures. The oral mucosa was free of irritation and clinical signs of inflammation.

The first control group (G1) consisted of 20 healthy younger dentate subjects (26.7±2.8 years), and the second control group (G2) consisted of 20 older dentate individuals (60.9±7.8 years). All dentate subjects had natural teeth and they had to be free of periodontal diseases and none of them was being treated orthodontically at the time of examination. An inclusion criterion was that subjects had to be free of signs and symptoms of any dysfunctions of the masticatory system. All of them had complete dentition with Angle Class I occlusion, and there were no occlusal interferences in any mandibular excursions. They had no history suggesting neuromuscular disease or a disease affecting neuromuscular performance, not undergoing treatment for any medical problem.

EMG registrations were taken on the 8 channel PC based electromyographic apparatus. The instrument was directly interfaced with a computer which presented the data graphically and stored them on hard disc for further quantitative and qualitative analyses. This system allows simultaneous recording of myoelectrical activity from 6 muscles (6 differential EMG channels, input impedance 100 MΩ, CMRR> 95 dB at 50 Hz, bandwidth 2 Hz-1 kHz, programmable input sensitivity from 100μVpp to 20 mVpp, an 12 bit resolution A/D conversion, 2 kHz sampling rate). EMG activity was obtained from anterior temporal (T), masseter (M) and from the submandibular group of muscles in the region of the anterior belly of the digastrics muscle (D) on the left and right side. Disposable surface disc electrodes (Ag/AgCl, diameter 10 mm) were placed 2 cm apart in the main direction of the muscle fibres.

The investigation was made according to the study protocol [9]. First the continuous biting with the maximum voluntary contraction (MVC) in the position of maximal intercuspation of teeth (MI) was evaluated, in order to establish the maximal activity of the elevator muscles. The subjects clenched maximally for 3 seconds and repeated the clench 5 times with 15-second intervals of rest. On the five clenching tasks, the highest total EMG activity was considered the maximum clenching EMG activity. The recording system was connected to the clenching level indicator, which was used for visual feedback information about the clenching level. The mentioned indicator is an additional unit, which rectifies and smoothes the amplified myoelectric signal obtained from one of the amplifiers of EMGA-1 apparatus and visualises the average myoelectrical activity (voltage) through switching of a correspondent number of light emitting diodes (LED) on. Next maximal wide opening (Omax) was evaluated, in order to establish the maximal activity of the depressor muscles.

For chewing tests subjects hat to chew a stick of rubber dental silicone for 20 seconds to ensure uniform consistency. Each subject was asked to chew "as normal" for five minutes. During that period EMG recordings were made once a minute during a period of 10 seconds and the duration of the contractile phase of chewing cycles (the mean of six consecutive cycles contractile phase durations) in each minute of mastication was evaluated.

The design employed was one-way between subjects ANOVA design. The post-hoc Bonferroni tests were used to determine the differences in the duration of the contractile phase of chewing cycles regarding the influence of age (young dentates versus elderly dentates) and dental status (natural teeth versus complete dentures).

Results

Table 1 reports the mean values of myoelectrical signals recorded in group 1 (young people), group 2 (elderly dentates) and in edentulous group (complete denture wearers) during maximal voluntary contraction in the position of maximal intercuspation of teeth (MI) for elevator muscles and during maximal wide opening (Omax) for depressor muscles. Values are expressed in μV.

Table 1: EMG registrations recorded in maximal voluntary contraction (MVC) at the intercuspal position and in maximal wide opening in three examined groups

		RT	LT	RM	LM	RD	LD
G1	MVC	239,19	239,76	198,10	228,52	25,99	24,31
	Omax	15,01	12,52	26,71	28,56	142,24	132,11
G2	MVC	147,16	134,16	162,96	144,58	20,93	22,29
	Omax	17,48	14,70	13,11	11,33	89,69	86,99
E	MVC	77,67	84,03	80,08	85,89	26,27	27,94
	Omax	23,88	20,73	24,98	17,44	89,59	82,08

(MVC=maximal voluntary contraction at the intercuspal position, Omax=maximal opening, RT=right temporal muscle, LT=left temporal muscle, RM=right masseter muscle, LM=left masseter muscle, RD=right depressor muscle, LD=left depressor muscle)

Mean values of elevator muscle activity during maximal voluntary contraction, as well as mean values of depressor muscle activity during maximal wide opening, were highest in young dentate group, and lowest in edentulous subjects with complete dentures. To compare the pattern of myoelectrical activity between the three groups, muscle activities were expressed as percentages of maximal voluntary contraction in intercuspal position for the elevator muscles, and as percentages of maximal wide opening for the depressor muscles.

Muscle activity, expressed in percentages of the maximal muscle activity, during five sequences of mastication in three groups is shown in Figure 1. Edentulous subjects showed higher percentages of maximal muscle activity in comparison to dentate subjects during five minute mastication interval. In the edentulous group myoelectrical activity continuously decreased from the first to the fifth minute. In the group of elderly dentate subjects the highest myolelectrical activity was obtained during the first minute, and the lowest during the third minute, while myoelectrical activity again increased from the third to the fifth minute. In group 1, however, increases and decreases of muscular activity interchange.

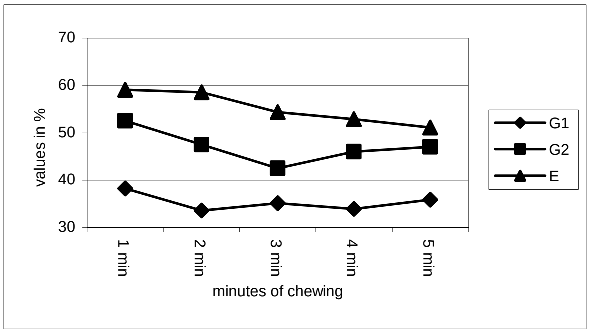

Figure 1: Evaluation of myoelectrical signals during five minute period of mastication (values are expressed in percentages of the maximal muscle activity)

Mean values for the durations of the contractile phase of chewing cycles (of six consecutive cycles) in three groups, as well as the results of the analysis of variance are summarized in Table 2. Values are expressed in ms.

Table 2: Differences in contractile phases of chewing cycle's duration in three tested groups (ANOVA)

mastication	group	contractile phase of chewing cycles (ms)	F	P
1st minute	G2	398,013	6,761	0,002
	E	539,6725		
	G1	345,5784		
2nd minute	G2	417,827	5,355	0,007
	E	463,29		
	G1	335,828		
3rd minute	G2	368,165	4,012	0,022
	E	503,3923		
	G1	345,4002		
4th minute	G2	406,349	6,347	0,003
	E	465,511		
	G1	319,048		
5th minute	G2	394,94	2,758	0,07
	E	459,62		
	G1	345,66		

(G1=young dentates, G2=elderly dentates, E=edentulous group, F=F value, P=sig.)

Regarding all three examined groups, significant differences in the durations of the contractile phase of chewing cycles were found in first, second, third and fourth minute of mastication ($P<0,05$), with shortest contractile phase duration in young dentate subjects and longest in denture wearers.
There was no significant differences in the durations of the contractile phase of chewing cycles in dentate subjects of different age (young dentates – elderly dentates) ($P>0,05$ - post-hoc Bonferroni tests).
The differences in the durations of the contractile phase of chewing cycles regarding the dental status (elderly dentates – edentulous subjects) were found in first and third minute of mastication ($P<0,05$ - post-hoc Bonferroni tests). Elderly dentate subjects, however, showed lower values of contractile phase duration in comparison to subjects wearing complete dentures during whole five minute period of mastication.

Discussion

Considering muscle activity in maximal voluntary contraction and during chewing, presented in our study, the highest values of myoelectrical signals during five sequences of mastication (in µV) were found in young dentate subjects and lowest in complete denture wearers. During mastication the amounts of muscle activity in proportion to its maximal activity, however, were highest in edentulous subjects and lowest in young dentate subjects. This indicates that the elevator and depressor muscles in the edentulous group change a pattern compared to dentate group in order to perform optimal mastication with the reduced absolute muscle activity due to denture insertion and protective reflex mechanisms of neuromuscular control. Different tendencies were recorded during five minute interval of mastication. Complete denture wearers gradually decreased muscle activity to the end of chewing task while elderly dentate subjects succeeded to increase muscle activity after third minute of mastication. In the group of young dentate subjects, however, increases and decreases of muscular activity interchange.

In order to determine whether chewing mechanisms act with some marked differences regarding age and dental status, we compared the duration of contractile phases of chewing cycles during mastication in dentate subjects of different age, as well as in subjects of similar age and different dental status.

The results showed no significant differences in the durations of the contractile phase of chewing cycles in dentate subjects of different age, while differences in the durations of the contractile phase of chewing cycles regarding the dental status were found in first and third minute of mastication. During five minute period of mastication the contractile phases of chewing cycles were shortest in young dentate subjects and the longest in complete denture wearers.

In the study of Karkazis and Kossioni [10] chewing cycle duration in denture wearers was lower than that recorded in the young dentate subjects, probably due to avoidance of extreme chewing movements because of the instability of dentures. The mean duration of chewing burst was statistically longer in denture wearers than in dentate subjects.

According to Moller et al. [11], the relative contraction period expresses to some extent the load put on the muscle. It is, therefore, possible that reduced muscle force in complete denture wearers is accompanied by an increase in the contractile phase duration during mastication, so that required energy per stroke remains at constant level [12].

Conclusions

Contractile phases of chewing cycles were shortest in young dentate subjects and longest in denture wearers. It is possible that reduced muscle activity in denture wearers is accompanied by an increase in duration of contractile phases of chewing cycles for achieving satisfactory mastication.

References

[1] BISHOP, B., PLESH, O., MCCALL, W.D. (1990): 'Effects of chewing frequency and bolus hardness in human incisor trajectory and masseter muscle activity', Archs. Oral. Biol., **35**, pp. 311-318

[2] GRIMBY, G., SALTIN, B. (1983): 'Mini-review. The ageing muscle', Clin. Physiol., **3**, pp.209-218

[3] SLAGTER, A.P., BOSMAN, F., VAN DER GLAS, W., VAN DER BILT, A. (1993): 'Human jaw elevator muscle activity and food comminution in the dentate and edentulous state', Archs. Oral. Biol., **38**, pp. 195-205

[4] VEYRUNE, J.L., MIOCHE, L. (2000): 'Complete denture wearers: electromyography of mastication and texture perception whilst eating meat', Eur. J. Oral. Sci., **108**, pp. 83-92

[5] KUWAHARA, T., MIYAUCHI, S., MARUYAMA, T. (1992): 'Clinical classification of the patterns of mandibular movements during mastication in subjects with TMJ disorders', Int. J. Prosthodont., **5**, pp.122-129

[6] MURAI, K., OKIMOTO, K., MATSUO, K., TERADA, Y. (2000): 'Study on masticatory movement and its ability: efficacy of a test capsule in the evaluation of masticatory movement', J. Oral.Rehabil., **27**, pp. 64-69

[7] BARCIELA CASTRO, N., FERNANDEZ VARELA, J.M., MARTIN BIEDMA, B., RILO POUSA, B, SUAREZ QUINTANILLA, J, GONZALEZ BAHILLO, J., VARELA PATINO, P. (2002): 'Analysis of the area and length of masticatory cycles in male and female subjects', J. Oral. Rehabil., **29**, pp. 1160-1164

[8] ALAJBEG, I.Z., VALENTIC PERUZOVIC, M., ALAJBEG, I., ILLES, D., CELEBIC, A. (2005): 'The influence of dental status on masticatory muscles activity in elderly patients', Int. J. Prosthodont., **18**, pp. 333-338

[9] ALAJBEG, I.Z., VALENTIC PERUZOVIC, M., ALAJBEG, I., ILLES, D. (2003): 'Influence of occlusal stabilization splint on the asymmetric activity of masticatory muscles in patients with temporomandibular dysfunction', Coll. Antropol., **27**, pp. 361-371.

[10] KARKAZIS, H.C., KOSSIONI, A. E. (1998): 'Surface EMG activity of the masseter muscle in denture wearers during chewing of hard and soft food', J. Oral. Rehabil., **25**, pp. 8-14

[11] MOLLER, E., SHEIKHOLESLAM, A., LOUS, I. (1984): 'Response of elevator activity during mastication to treatment of functional disorders', Scand. J. Dent. Res., **92**, pp. 64-83

[12] NEILL, D.J., KYDD, W.L., NAIRN, R.I., WILSON, J. (1989): 'Functional loading of the dentition during mastication', J. Prosthet. Dent., **62**, pp. 218-228

ISSN: 1727-1983 © 2005 IFMBE