Electromyography Activity of the Chewing Muscles During Adaptation among Complete Denture Wearers

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Abstract

The objective of this study was to evaluate masticatory efficiency among complete denture wearers and adaptation among patients with treatment needed with complete dentures, in the dominant side (DS) and nondominant side (NDS).

Eighty-eight patients with complete dentures were evaluated in the study. The masticatory functions have been examined by using the method of electromyography (EMG) registered standard masticatory task (SMT) as an electromasticatiogram on a paper of Dynograph. There were analyzed the dynamics of changes in the duration of the SMT, the frequency of the masticatory cycles during SMT, as well as changes in the maximum amplitude of the masticatory cycle during SMT. One way ANOVA repeated test was done for testing parametric data.

By analysis of variation, evident changes in the duration of SMT are observed in DS and NDS; F-DS measuring time = 85.27, p=0.0001; F - NDS measuring time = 22.84, p = 0.0001. On both sides, the significant change in the average values of the number of masticatory cycles is confirmed: F-DS measurement time = 158.3, p = 0.0001; F - NDS measurement time = 35.9, p = 0.0001. The measurement time follows the evident changes in the maximal amplitude of the masticatory cycle in DS and NDS: F-DS measurement time = 9.73, p = 0.0001; F-NDS measurement time = 6.26, p = 0.0001.

The behavior of researched variables that approximately determine functional adaptation to new complete dentures is dynamic and they oscillate around the balancing position more or less, with a pronounced tendency to restore stationary status after the fifteenth week.

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Introduction

Through the mastication, various biophysical and biochemical processes are developed for the preparation of the bolus. Muscle movements of the facial mouth and tongue have a major role in the distribution of the bolus in the occlusal surfaces of the teeth.[1,2]

Masticatory efficiency is outlined as the number of strokes needed to execute a certain particle size reduction.[3] The efficiency of mastication depends by few factors, as teeth and its condition, the size of occlusal surfaces, bite force, jaw, tongue and facial movements, nutrition consistency and regular distribution of the bolus during mastication, factors related to prosthodontics treatment. [4, 5] Masticatory ability is an important aspect of stomatognathic function that affects the oral health-related quality of life in everyone.[6]

Few methods have been used for evaluating the masticatory efficiency like fluctuation of the nutrition particles, tested by multi - sieve system, ultrasonography, and photo colorimetry - spectrophotometry, optical scanning methods, and measurement of the volume of masticatory muscle recorded by electromyography (EMG).[7,8] It's not that one or other method is more valuable, therefore the option is complex as some tests consume more time.

EMG is characterized as the graphic recording of the electrical potential of muscle's

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activity based on the analysis of electrical signals created during each muscle contraction.[9] For appraisal the muscle activity of the stomatognathic system it has been the only tool since its first use in dentistry by Moyers in 1949.[10] The EMG researchers suggest in general, the activity of mandibular elevator muscles among denture wearers does not significantly differ from subjects with natural dentition.[11] As a result of tooth loss, although muscle activity is maintained, there is a significant decrease of masticatory efficiency in patients with complete dentures. Therefore, there is no clear explanation of why tooth loss reduces the capacity of masticatory muscles to perform.[12] Few studies have shown that masseter and temporalis muscles are more preferential during EMG studies of masticatory function. Clinicians and researchers have historically used EMG to test the masticatory function of denture wearers.[13, 14]

Most authors have researched electrical quantity and EMG schemes, and less attention was committed to EMG time parameters research (duration and intervals) during chewing muscles.[15] Given the fact that the EMG time parameters are with high reproducibility, few researchers attempted to prove the objectivity of this hypothesis and, in case of its validation, they proposed the possibility of applying these parameters for the evaluation of the masticatory efficiency with EMG among patients with complete dentures.[16]

This study aimed to evaluate masticatory efficiency among complete denture wearers and adaptation among patients with treatment needed with complete dentures, in both dominant (DS) and nondominant side (NDS). Keeping this in view, the present research was designed to study the simultaneous of jaw muscle (masseter and temporal) activity and functional outcome (kinematic parameters) through EMG signals for six months after insertion the dentures.

Materials and methods

The research was approved by the Ethics Committee of the University Dentistry Clinical Center of Kosovo. The written consent was gained from each subject after an explanation of the purpose of the study. The sample of eighty-eight patients with complete dentures (CD) was divided into two groups. The first group was compromised by prosthodontics patients with treatment need (complete dentures), without previous experience (we-CD) (n=45). The second group was compromised by prosthodontics patients with no treatment need, wearers of complete dentures already with experience (e-CD) (n=43) (Table 1).

	Gender		Experience/without experienced group with complete dentures	
	Female	Male	Without	With
N	42	46	45	43
X	54.6	55.7	52.7	57.8
SD	5.4	6.1	5.7	4.1
max	66	68	65	68
min	42	44	42	49

Table 1. Comparison of gender, age, and Experience/without experienced group.

The research was based among patients with eugnatic jaws relation in the sagittal plane, and lacking signs of orofacial system dysfunction. From the study, there were excluded patients over 70 years old, with significant alveolar ridge resorption (i.e., negative alveolar ridge), and/or age with orthodontic anomalies in sagittal and transversal planes. All patients were matter to history taking, and clinical assessment of leading the masticatory side in function and monitored for six months. The effect of prosthodontic therapy was expected after the insertion of new complete dentures. The first observational measurement periods were at first week after inserting the new complete dentures, followed by 5, 10, 15, 20, and 25 weeks. During the observation period, each patient was tested three times by the same examiner, for reducing inter-observer error.

The masticatory functions have been examined by using the method of electromyography (EMG) registered standard masticatory task (SMT) as an electromasticatiogram on a paper of Dynograph (EMG-Dynograph R-511 A). This method enables:

- Direct analysis of the bioelectric activity of the masticatory muscles in vivo, during the apprehension of SMT;
- Analysis of the synchronized of homologous pair of the muscles;
- The utterance of the regularity of the masticator pattern;
- The utterance of the dynamics of the masticatory cycle and its elements (duration, frequency, and amplitude of the masticatory cycle) and,

- Finally enables documentation of the obtained results.

The standard masticatory task depends on the type of food (hard, soft and impulsive food). There are different types of nutrients, natural and/or artificial that can be used as a test food.[17] As reported in the literature, a peanut is the most commonly used food, due to its low cost; also it's relatively uniform in size and hardness, which facilitates standardization and can be used without any prior preparation. The other advantage of peanuts is that people consume a lot and are taught to develop chewing function. Natural nutrition positively affects healthy patients, and the testing time is very fast, so there is a wide range of appliance. This type of nutrition produces flavor and stimulates smelling by appropriately influencing the chewing.[18] Patients were recommended to chew naturally from one side to the other side. The standard masticatory task is determined by the consumption of the nutriments with same quality and quantity, determined with the first masticatory cycle, inside the masticating cycle, and with the initial degradation stage.

In order to evaluate masticatory efficiency, we have analyzed the dynamic changes in the duration of the SMT, the frequency of the masticatory cycles during SMT, as well as changes in the maximum amplitude of the masticatory cycle during SMT. Parameters: The duration of SMT and the frequency of mastic cycles determine closely chewing. These parameters are standardly used for masticatory efficiency analysis.

Data Analysis

Data analyses were performed using statistical analysis software BMDP (Biomedical Statistical Package, Dixon, 62, UCLA, University of California, Los Angeles USA), and MS Excel (Microsoft Office, Windows 2003, USA). One way ANOVA repeated test was done for testing parametric data.

Results

1. Dynamics of changes in the duration of the standard masticatory task

By analysis of variation, evident changes in the duration of SMT were observed in DS and NDS; F-DS-measuring time = 85.27, p=0.0001; F-NDS-measuring time = 22.84, p=0.0001. By the end of observation time in the DS, from the initial values 29 sec, the duration of SMT decreased on the third measurement and reached the stationary state approximately in 22 sec. In the NDS from the initial values of 28 sec, the stationary state 21 sec was reached, after the fourth measurement. The duration of SMT time was reduced in both DS and NDS for 7 sec (Table 2).

Measurement	Gender				experience				Total	
	F		M		Without		With			
	DS	NDS	DS	NDS	DS	NDS	DS	NDS	DS	NDS
N	42	42	46	46	45	45	43	43	88	88
1x	29	27	29	29	29	26	30	29	29	28
SD	0.42	1.14	0.52	0.57	0.42	0.69	0.52	0.84	0.33	0.63
2x	23	21	26	23	24	21	24	23	24	22
SD	4.1	2.8	6.3	4.6	6.5	5.3	4.8	3.8	4.1	3.4
3x	22	18	22	24	21	20	22	22	22	21
SD	0.47	0.60	0.37	0.46	0.33	0.69	0.48	0.62	0.29	0.47
4x	20	20	22	25	20	22	22	23	21	23
SD	0.53	0.50	0.42	0.39	0.54	0.64	0.48	0.61	0.37	0.44
5x	21	21	23	26	22	23	22	25	22	24
SD	0.46	0.70	0.35	0.32	0.45	0.68	0.45	0.60	0.30	0.46
6x	17	21	24	24	21	22	21	23	21	22
SD	0.49	0.50	0.26	0.42	0.61	0.56	0.64	0.51	0.40	0.39

Table 2. SMT duration value (sec) in DS and NDS in relation to gender, preliminary experience in function of time of measurement.

Gender as a factor participates in the discriminatory reduction of the time needed for SMT; F-DS-gender = 97.97, p=0.0001; F-NDS-gender =118.86, p=0.0001, as well as interaction with the measurement time: F-DS-interaction = 17.07, p = 0.0001; F-NDS-interaction = 2.98, p = 0.0115. Notwithstanding the initial identical value, in DS there was a significant reduction among females in the SMT duration compared to males (females =12 sec. and males =5 sec). In NDS the situation was relatively similar and the average duration of SMT was shorter in all measurements (Table 2, and Figure 1).

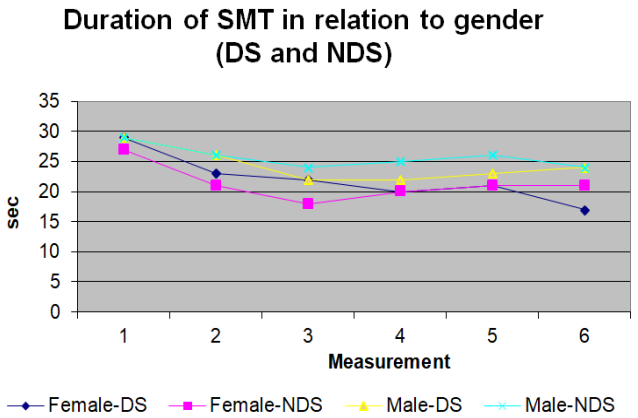

Figure 1. Duration of SMT in relation to gender (DS and NDS).

All patients without previous experience with complete dentures have a shorter duration of SMT in DS and in NDS; F-DS-experience = 9.13, p = 0.0026; F-NDS-experience = 20.16, p = 0.0001. However, in the last measurement, there was a similar duration of SMT values (Table 2, and Figure 2).

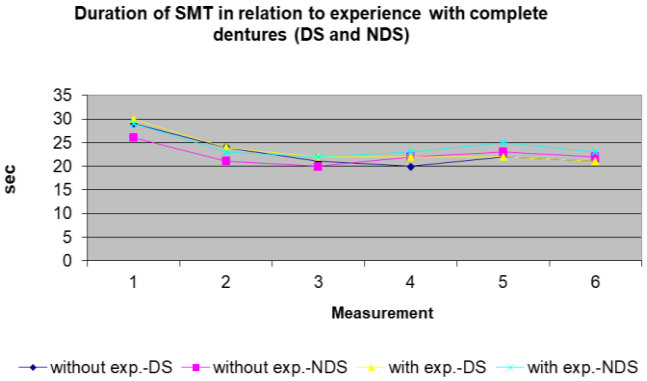

Figure 2. Duration of SMT in relation to experience with complete dentures (DS and NDS).

2. Dynamic of changes in the number of masticatory cycles during the realization of the standard masticatory task

On both sides, the significant change in the average values of the number of masticatory cycles was confirmed: F-DS-measurement time =158.3, p=0.0001; F-NDS-measurement time=35.9, p=0.0001. In DS the stationary value was reached in the fourth measurement, whereas in NDS this value was reached in the second measurement. Also, the number of cycle's decreased in relation to the initial values. In DS the number of stationary masticatory cycles was smaller than in NDS (Table 3).

Measurement	Gender				Experience				Total	
	F		M		Without		With			
	DS	NDS	DS	NDS	DS	NDS	DS	NDS	DS	NDS
N	42	42	46	46	45	45	43	43	88	88
1x	39	36	44	41	42	38	41	40	41	39
SD	0.6	1.1	0.8	0.5	0.42	0.8	0.9	0.9	0.8	0.6
2x	34	29	38	35	37	31	36	33	36	32
SD	0.3	1.0	0.2	0.4	0.4	0.9	0.5	0.7	0.3	0.6
3x	30	26	33	35	32	30	32	30	32	31
SD	0.6	0.7	0.3	0.3	0.5	0.9	0.5	0.9	0.4	0.6
4x	26	28	30	33	27	30	29	31	28	31
SD	0.8	0.50	0.42	0.39	0.54	0.64	0.48	0.61	0.37	0.44
5x	27	27	30	30	33	29	30	29	31	29
SD	0.30	0.60	0.40	0.30	0.5	0.70	0.40	0.60	0.30	0.50
6x	25	27	32	35	29	31	29	32	29	31
SD	0.40	0.50	0.40	0.30	0.60	0.80	0.70	0.70	0.40	0.50

Table 3. Average values and standard deviation in the number of masticatory cycles during the SDT's realization at six defined time intervals in DS and NDS, both sexes, with and without prior experience.

During realization of SMT in DS and NDS females needed fewer masticator cycles than males: F-DS gender = 238.55, p=0.0001; F-NDS-gender 353.39, p=0.0001 during realization of SMT. In addition interaction of gender and time of measurement contributed to this variability, as in both genders number of measurements of the frequency of masticatory cycles decreased: F-DS-interaction = 3.23, p = 0.0070; F-NDS-interaction = 14.3, p = 0.0084 (Table 3, and Figure 3).

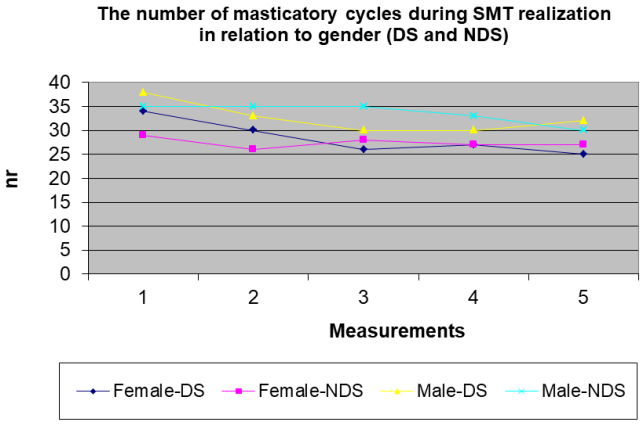

Figure 3. The number of masticatory cycles during SMT realization in relation to gender (DS and NDS).

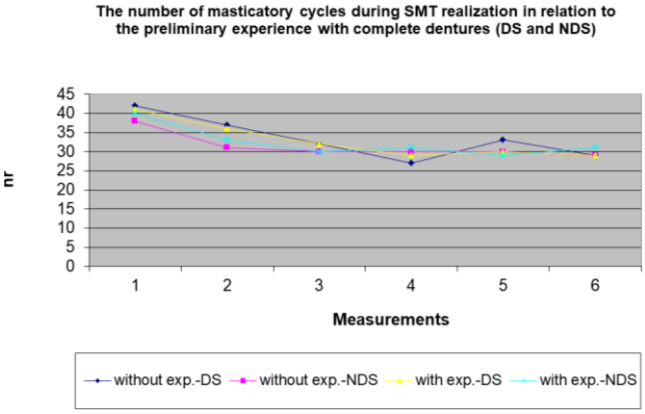

Figure 4. The number of masticatory cycles during SMT realization in relation to the preliminary experience with complete dentures (DS and NDS).

Preliminary experience with the complete dentures does not affect the reduction of masticatory cycles in DS: F-DS-experience = 0:18, p = 0.6687. The mean values of the number of masticatory cycles were the same in all measurements regardless of whether they have preliminary experience with the complete dentures or not. In the NDS the significant difference

existed between these two groups of respondents: F-NDS-experience = 12.72, p = 0.004. Patients without previous experience with complete dentures had fewer masticatory cycles compared to experienced patients with complete dentures (Table 3, and Figure 4).

3. Dynamics of changes in maximum amplitude of the masticatory cycle during the realization of the standard masticatory task

The measurement time followed the evident changes in the maximal amplitude of the masticatory cycles in DS and NDS: F-DS-measurement time = 9.73, p = 0.0001; F-NDS-measurement time = 6.26, p = 0.0001. In DS, the stationary state was reached in the fourth measurement, average values were significantly oscillating. In NDS, the stationary state was verified in the second measurement with the previous oscillations which were poorly expressed (Table 4).

Measurement	Gender				Experience				Total	
	F		M		Without		With			
	DS	NDS	DS	NDS	DS	NDS	DS	NDS	DS	NDS
N	42	42	46	46	45	45	43	43	88	88
1x	380	266	365	421	386	369	358	324	372	347
SD	11.9	10.5	25.3	14.9	22.9	17.8	17.0	16.7	14.4	12.4
2x	577	414	422	617	497	563	495	476	496	520
SD	21.1	27.0	20.5	104.6	24.3	108.9	23.6	25.0	16.8	56.9
3x	735	516	425	424	582	465	563	471	573	468
SD	25.4	27.0	17.8	13.1	34.1	18.9	29.4	24.7	22.5	15.4
4x	473	496	468	526	468	537	473	485	470	511
SD	21.1	27.6	22.9	22.3	23.0	24.7	21.2	24.7	15.6	17.6
5x	576	420	551	525	611	492	513	457	563	475
SD	17.7	16.7	80.6	17.5	81.4	19.6	19.2	17.8	42.7	13.3
6x	568	531	443	525	501	544	506	511	503	528
SD	15.5	19.6	18.9	22.0	21.3	22.6	18.1	18.1	14.0	14.8

Table 4. Maximal values of the amplitude of the masticator cycle (μV) during SMT realization at the defined time intervals in DS and NDS in both sexes, with and without preliminary experience with the complete dentures.

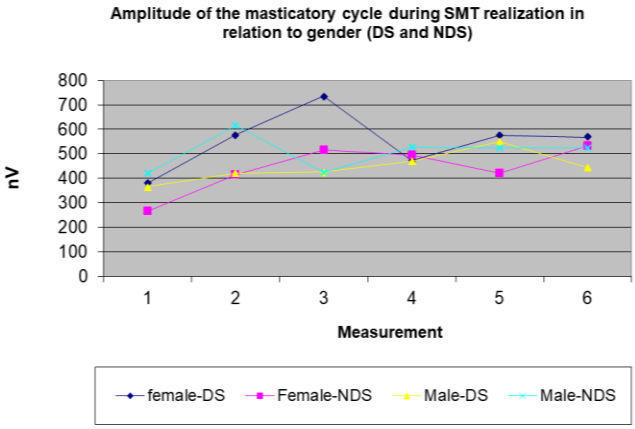

Figure 5. Amplitude of the masticatory cycle during SMT realization in relation to gender (DS and NDS).

In females the examined of maximum amplitude was significantly higher than in males in DS, whereas in NDS the situation was opposite: F-DS-gender = 34.58, p = 0.0001; F-NDS-gender = 9.38, p = 0.0023. The common gender impact and measurement time were also present: F-DS-interaction = 7.18, p = 0.0001; F-NDS-interaction = 4.33, p = 0.007. In both sexes, the oscillation was defined in the time of the measurements (Table 4, and Figure 5).

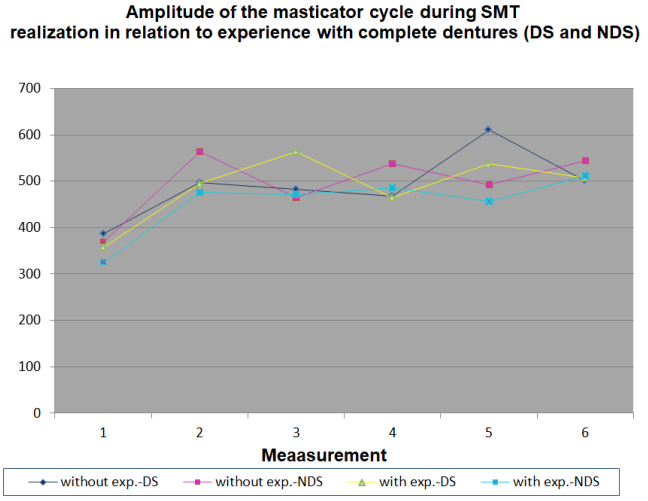

Figure 6. Amplitude of the masticator cycle during SMT realization in relation to experience with complete dentures (DS and NDS).

Preliminary experience with the complete dentures was not shown as important factors in changing the maximal amplitude of the masticatory cycle in the six measurements in DS and NDS: F-DS-experience = 1.39, p = 0.2387; F-NDS-experience = 3.46 p = 0.0636 (Table 4, and Figure 6).

Discussion

According to the aptitude of the reconstructive dental disciplines, the research of the mastication function has special diagnostic and therapeutic significance. By applying masticatory-functional analysis, it is possible to correctly diagnose the functional condition of the tooth – jaw - face system and correct selection of appropriate therapeutic procedures.

In our research, it has been in particularly evaluated the effectiveness of masticatory efficiency of patients with complete dentures, as this is an accepted method of functional evaluation of the effect of prosthodontics therapy.

The first parameter which described the adaptation of the prosthodontics patients with the new CD is the duration of EMG needed to realize SMT. The average initial value of 29 seconds decreases continuously during the observed time and the last measurement was 21 sec. The variation of these values was relatively small, i.e. the group as a whole has homogenous behavior concerning the measured time. However the duration of EMG was just one of the aspects of SMT, it has been necessary to be analyzed and the frequency of the masticatory cycles. The average number of masticatory cycles was reduced during the observed time in DS from 41 to 29 cycles and at NDS from 39 to 31. Similarly, for SMT realization the initial time or duration of EMG was longer and the number of masticatory cycles was higher, also the maximal EMG amplitude of the masticator string was significantly lower (37 μV) than at the end of observational period (503 μV). Therefore in our research, the reduction of the number of masticatory cycles appeared generally at the end of the mastication process. The decreasing of cycles in this particular chewing period may have appeared suitable to a greater ability of patients for chewing nutrition from the beginning related with adaptation to new dentures, stowage of bilateral balanced occlusion and/or presence of teeth.[19-23]

Mastication is established by the central nervous system and is adapted to nutrition hardness, i.e., greater of nutrition hardness generates an increased number of masticatory cycles, by this means increasing overall EMG activity and duration of masticatory cycles.[24-26]

Stability among DS was reached after a 15th week although before and after this time there were oscillations, while in NDS was reached during the second measurement. Our findings concerning the masticatory efficiency showed a noticeable increasing within time, which are similar to results reported by Karakazis et al.[27] This is due to improving denture adaptation suitable to the neuromuscular control which is gradually generated by the time.[28] Masticatory performances and the duration of using the current, complete denture also have a positive correlation with patients' satisfaction toward their denture.[29]

Several studies have shown that the patients with CD, the reduced mastication capacity do not reimburse with the duration of chewing time but with the ingestion of the largest bolus.[30]

Our findings suggest that there is a significant difference among final values of duration of the SMT of EMG among gender, where at females there was 17 sec and in males 24 sec. The possible explanation can be found in two directions, for example, it may be that female react more intense at the beginning and/or men need longer time for functional adaptation. The initial stage of the observed period of the SMT of EMG was found in identical initial conditions between genders. Also regarding dynamics of masticatory cycle, females showed identical reduction as males, with the difference that these mean values were considerably lower within female i.e., that for the same duty of female gender have used a smaller number of the masticator cycles but using the larger amplitude of EMG the masticator string. Furthermore, among females, the maximal amplitudes of the masticator string were defined higher time intervals than in males. With the increasing of EMG, the dynamically adjust the model which was to the female shorter and smaller number of masticatory cycles. With previous findings, this is in trustworthy, who disclose a significant gender difference in masticatory efficiency and suggests that the improved muscular potential of the males may be credited to the anatomic differences.[31-33]

The experience of the patient's wearing CD was the most important factor in which intensive reactions were observed during the observational period.[34] The patients without experience with the CD during the measurement phase had shorter EMG duration of SMT compared to denture wearers, but the final value of SMT duration in both groups (in relation to experience) was identical. The experience of patient's wearing CD was not shown as a factor which significantly affects the number of masticatory cycles and average values of the maximal EMG amplitude during SMT. By comparing the numbers of masticator cycles in DS and NDS was proved that the frequency varied, as was expected in NDS which was greater compared to DS. Moreover, the number of masticatory cycles was not shown as factors for the explanation of the maximum EMG amplitude of the masticator string. Our results are in agreement with previous research which confirms that wavelet-based EMG analysis was instrumental in appraising denture adaptation for

patients with CD replacement and denture adaptation increased within time.[35] According to Goiato et al., concluded that even though there was no statistically significant enhancement in the masticatory cycle time after five months of insertion of new CD, after one year the cycle time was significantly shorter.[36] There are few studies which do not support our findings, that the electrical activities were significantly greater after thirty days of insertion the new complete dentures.[37]

During this time, based on the implementation of the SMT prolongation, the time of bioelectric activity of masseter and temporal muscles was extended to account for the reduced period of bioelectric silence of tested muscles. Regarding the method, we noted that the applied method does not produce the quantitative responses on masticatory efficiency in terms of the degree of nutrition reduction. The applied method and parameters explain masticatory efficiency indirectly - with a qualitative evaluation of the EMG design of the muscles involved in the mastication process. Nevertheless, the EMG method, the electromyometric analysis is a more objective method for the evaluation and conclusion on the degree of masticatory efficiency and is not based on the determination of reference values as in the case of research.[38] Besides, this method is suitable for longitudinal research since it can be reproduced with tolerance.

Conclusions

The behavior of researched variables that approximately determine functional adaptation to new complete dentures is dynamic and they oscillate around the balancing position more or less, with a pronounced tendency to restore stationary status after the fifteenth week. In general, the patients, denture wearers having previous experience with complete dentures sooner reach the stationary state compared to the patients without previous experience.

Acknowledgements

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Declaration of Interest

The authors declare that they have no conflicts of interest.

Abbreviations

CD, Complete dentures; EMG, Electromyography; SMT, Standard Masticatory Task; DS, Dominant side; NDS, Nondominant side.

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