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Full Length Research Paper

Electromyography: A quantitative measure of the degree of prosthesis' retention

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Purpose: Could quantitative electromyography be an objective method to determine which degree of retention is suitable for cases of mandibular unilateral distal extension retained by an extra-coronal attachment? Methods: Twenty one partially edentulous patients, age ranging from 35-45 years were randomly selected from the outpatient clinic. The OT-Cap attachment system with three different degrees of retention was used. The patients were randomly divided into three groups according to the retention used; the yellow cap- extra soft (group I), the pink cap- soft (group II) and finally the white cap- standard (group III). Case evaluation included patient satisfaction; clinical evaluation of the supporting abutments which included recording of the gingival index and the clinical attachment level as well as surface quantitative electromyography of the maseter muscle bilaterally. Results: The mean MUPs amplitude of the masseter muscle of the denture side increased significantly immediately after delivery of the denture as the degree of the prosthesis' retention increased. Conclusion: However patient satisfaction is an important role to determine the degree of removable partial denture retention, surface quantitative EMG of the masseter muscle could play an important role as a non-subjective measure particularly when oral hygiene is a matter of question.

Keywords: Degree of retention, extra-coronal attachment, Mandibular unilateral distal extension, Patient satisfaction, Quantitative EMG, Removable partial denture.

INTRODUCTION

Masticatory performance is affected by the loss of teeth especially in free end saddle cases even if the edentulous area was short. The conventional treatment with partial dentures is required to fulfill three basic functions: mastication, esthetics and speech. (Tumrasivn et al., 2005) The uses of clasp retained removable partial dentures are considered unaesthetic. (Miller, 1976) Removable partial dentures incorporating attachment are better alternative as long as the concepts and techniques of construction are accurately followed. (Jenkins, 1999) Precision attachments are being esthetically superior as they direct the forces parallel to the long axis of the teeth improve mechanical retention and provide vertical and horizontal stabilization of tooth. They are more tolerable due to the absence of tongue, lip and cheek irritation. (Preiskel 1996)

One of the principles of the removable partial denture design is to provide the minimum amount of retention necessary through the direct retainer. It has been well documented that the greater the amount of retention, the greater the force transmitted to the abutment tooth. (Ku et al., 2000) Extra-coronal attachments are existing external to the crown portion of the tooth. They subdivided into projection units, connectors and combined units. (Preiskel, 1984)

Electromyography of the masticatory muscles has been used to investigate the muscle behavior during different functions of the stomatognathic system. (Armijo-olivo et al., 2007) The relationship between muscular activities and food properties has been reported by Kohyama et al (2007). Muscle activity depends also greatly on the presence of the teeth; the edentulous group had to reach

Figure 1. (a) Preoperative intra-oral view of the mandibular arch.

higher activity level (EMG value) than the dentate group in order to perform the same mandibular movements. EMG activity was also higher on the working than on the balancing side. (Alajbeg et al., 2006) Denture retention and stability are other important factors impacted in masseter muscle activity. (Van Kampen et al., 2002) By default minimal retention is preferred but is it enough to saturate the patients' needs of better mastication effort?

Objective

Could quantitative electromyography be an objective method to determine which degree of tension is suitable for cases of mandibular unilateral distal extension retained by an extra-coronal attachment?

Subjects

Random study carried on twenty one partially edentulous patients; ages ranging from 35-45 years. (We chose this age group to minimize the age effect on patient performance). Patients were selected from the outpatient clinic of Prosthodontics Department. Faculty of Oral and Dental Medicine, Cairo University, Egypt according to the following criteria: Kennedy class II arches with second premolar as the last standing abutment opposed by natural maxillary teeth. Angle class I maxillo-mandibular relationship. A distance of not less than 7 mm should exist between the occlusal surface of the upper teeth and the lower edentulous ridge. (Figure 1a) Patients with history suggestive of neuromuscular or medical systemic diseases, TMJ (temporo-mandibular joint) disorders were excluded. Bad oral habits or bad oral hygiene and previous denture wearing experience were also excluded.

METHODS

Medical and dental history, careful extra- oral, intra- oral and abutment examination was carried for each patient. Radiological examination including panoramic and peri-apical radiology was done to evaluate the bone condition, any pathological lesions and the crown/root ratio of the proposed abutment teeth. Then diagnostic wax up and set up to obtain diagnostic casts.

Prosthetic procedures

At the beginning supra and sub- gingival scaling was done to achieve a hygienic base line for all patients. Carious teeth were restored or crowned when necessary.

After the diagnostic wax-up and set up confirmation was done, temporary crowns were constructed and cemented. The impression was made using heavy then light rubber base impression then poured in improved stone to obtain the master cast.

Metal try of the bridge- attachment was carried out intra-orally to evaluate fit of the crown, occlusion, and crown margin and attachment- ridge relationship.

At least 1 mm clearance space was created all around the attachments' metallic housing and a hole was created in the lingual acrylic flange. The yellow nylon cap was snapped into its metallic housing, and then snapped onto its patrix.

Complete and proper seating of the denture was ensured. Figure (1b)

Patient instructions for oral hygiene and cleaning of the denture, not wearing the denture during sleep and keep it soaked in water.

Grouping

For each patient one denture was constructed and randomly seated in a group depending on the type of the elastic nylon retentive cap picked up by the patient:

Group I: extra soft retention using yellow cap.
Group II: soft retention using pink cap.
Group III: standard retention using white cap.

Each patient needed 2 weeks of adjustment before delivery of the denture. First evaluation was one day after delivery of the denture, and then followed up one and two months later.

Figure 1. (b) Finished removable partial denture in the patient's mouth.

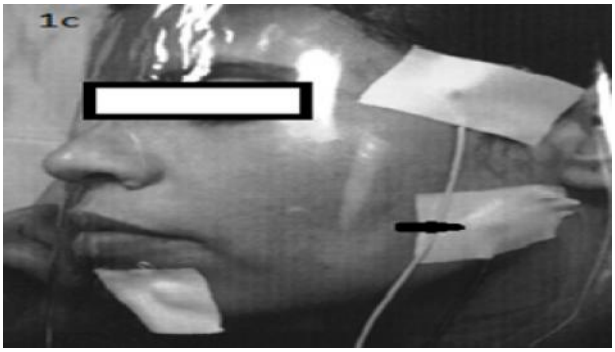

Figure 1. (c) Position of the EMG surface electrodes marked on the transparent face template. The arrow pointed to the active electrode over the belly of the masseter muscle.

Case evaluation

a. Patient satisfaction: at the end of the follow up period by means of a questionnaire regarding comfort, retentive strength, chewing efficiency, as well as the ease of the insertion and removal of the denture. They asked to rank their prosthesis in each question as bad =1, fair=2 or good =3. Patient satisfaction was graded from 1 to 3; 3= highly satisfied, 2= satisfied, 1= not satisfied. Clinical evaluation was done before denture delivery then one month and 2 months after, including; gingival index evaluation around the first and second premolar into normal, mild, moderate and severe inflammation. Clinical attachment level at the first and second premolar abutments was also measured using a graduated periodontal probe.

Electromyography evaluation

For each patient, quantitative EMG study of the superficial masseter muscle of the experimental side (side replaced by the attachment- retained removable partial denture) as well as the sound side was done as follow:

One day after delivery of the denture, one month and then two months later.

Technique: The Electromyography's machine used was a Nihon Kohden; Neuropak MEB-9200G/K EP/EMG measuring system (Neuropak M1)- 4 channels-version 08.11, in the Clinical Neurophysiology unit, Kasr Al Ainy hospital, Cairo university, Egypt.

The patient was seated with the head erect. The active surface electrode was located over the most contractile part of the masseter muscle and marked over a transparent face shield individually adapted on each patient's face to be used in the following follow up. Reference surface electrode 3 cm distally and ground surface electrode over the zygomatic ridge. Figure (1c)

Recording: The amplitude (uV) of four motor unit potentials (MUPs) were recorded simultaneously and then the mean amplitude was automatically calculated (figure 1d) under three functional activities; clenching, chewing soft food (banana) then hard food (raw fresh carrot) one centimeter slice, chewing one slice at a time. Standardization of food particles was done using special food cutter. All chewing process was unilaterally at the

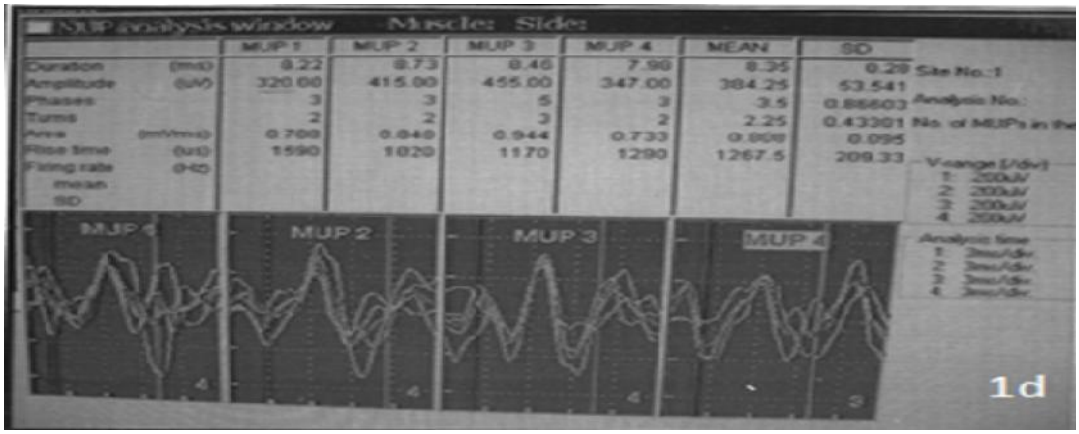

Figure 1. (d) Electromyography recording is showing four MUPs and their automatic calculation.

Table 1. Patient satisfaction rank at the end of the follow up period.

Satisfaction Rank	Numbers and % of patients					
	Group I (7)		Group II (7)		Group III (7)	
1= not satisfied	0		0		0	
2=satisfied	2	28.6%	0		2	28.6%
3=highly satisfied	5	71.4%	7	100%	5	71.4%

Score from 4-6 ranked as not satisfied=1, score from 7-9 ranked as satisfied =2, score from 10-12 ranked as highly satisfied =3.

examined side.

Written consent was taken from each patient before starting the dental procedure as required by the ethical board. The work was reviewed and accepted by the ethical community board.

Statistical analysis:

Data were presented as mean and standard deviation (SD). Data were explored for normality using Kolmogorov- Smirnov test, and no significant departures from normality were observed (all P-values > 0.05). Homogenesity of variances among the groups was tested using Levene test (P-value >0.05) ANOVA was used to compare the results between groups as well as that of the 3 functions of mastication. It was also used to study the effect of time on MUPs' amplitude. Least Significant Difference (LSD) post-hoc test was used to determine significant differences between the means when ANOVA test was significant. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with SPSS 16.0 ® (statistical package for scientific studies) for windows, Chicago, IL, USA.

RESULTS

Patient satisfaction

Table (1) shows the satisfaction rank in the 3 groups. All of them experienced further improvement in their chewing ability throughout the follow up period but with group III some had difficulty in inserting and removing the prosthesis and in group I two patients were not comfort with the stability of the denture.

The best rank was for group II.

Gingival index

At the end of the follow up period; for both abutment teeth, there was a minimal insignificant increase in the gingival index scores in all groups. Group III had the greatest increase and group I was the lowest. (Figure 2a)

Clinical attachment level (mm)

For both abutment teeth there was an insignificant increase in the clinical attachment level score in the 3 groups throughout the study period. (Figure 2b)

Electromyography evaluation

The mean amplitude of the MUPs of the masseter muscle of the experimental side was significantly increased as the degree of retention increased immediately after the denture delivery for all functional activities. Group I still showed significant improvement in the MUPs amplitude

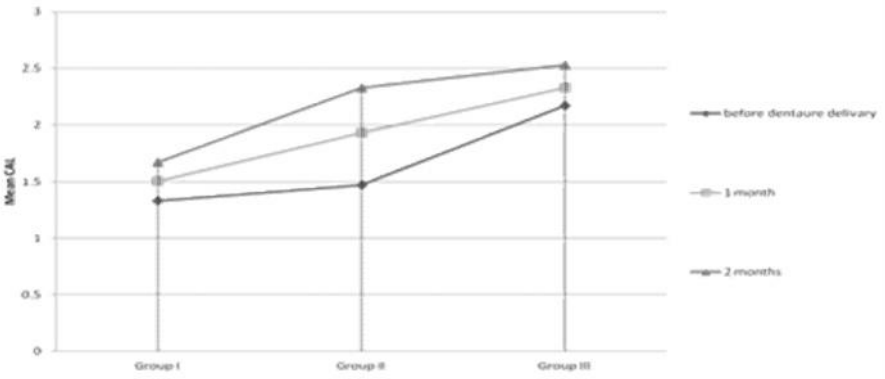

Figure 2. (a) Mean gingival index (GI).

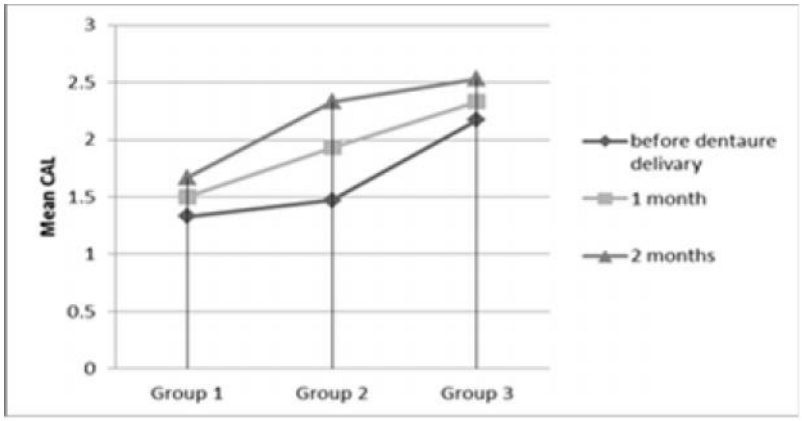

Figure 2. (b) Mean clinical attachement level (CAL measured in mm) for the first premolar in the three groups during follow up period.

with time for soft and hard food which did not noticed in the other two groups. (Table 2)

The MUPs amplitude of the masseter muscle of the sound side (Table 3) was relatively homogeneous with insignificant difference throughout the follow up period, for all functions.

Comparing the mean MUPs amplitude of the experimental side to that of the sound side; group I and II showed high significant difference (P-value = 0.00& 0.008 respectively) while group III was insignificant (P-value = 0.09) (Figure 3)

Discussion:

Regarding patient satisfaction the highest ranking was recorded for soft retention-pink cap (group II). From the patients' point of view, the removable partial denture with the soft retentive cap was adequately retentive and stable. More importantly they did not experience any difficulty in inserting or removing the prosthesis as those did with the white standard cap (group III). The chewing ability and denture stability was scoring high than that of the extra-soft yellow cap (group I). In spite of continuous instruction of maintaining oral hygiene measures, there is gradual increase-however not significant- in the clinical attachment level and inflammation of the gingival tissue surrounding the abutment teeth particularly recorded with standard retention. Which could be contributed to qualitative as well as quantitative changes in plaque formation, the preparation of the abutments and construction of fixed crowns with gingival placed margins may change the flora of the gingival crevice. (Zlatarić et al, 2002).

Immediately after denture delivery a linear relationship was found between the degree of denture retention and the muscle activity which became insignificant during the follow up period. If the stability is not provided by the dentition, the jaw muscles contribute to the stabilization and reduce the magnitude of the maximal contraction to avoid damage to the structures. (Jimenez, 1987) As with more retention the denture was more stable with less partial movement during chewing. It is hence expected that more muscle power would be directed towards chewing process. All patients did in fact experience improvement in their chewing ability after removable partial denture treatment which implies an improvement in the masticatory ability of the masseter muscles. Electromyography of the masseter muscle of the

Table 2. Effect of degree of retention (groups) and time on the mean amplitude of the MUPs of the masseter muscle of the experimental side for the three functions.

Activity	Groups	Group I		Group II		Group III		
	Time	Mean	SD	Mean	SD	Mean	SD	P-value
	One day	338[b]	17.1	417.6[a]	40.7	421.3[a]	45.3	0.045[*]
	One month	413.8	95.7	436.2	23.4	543.1	64.4	0.1866
Clenching	Two months	414	37.7	461.4	45.9	570.8	87.4	0.08
	P-value	0.127		0.257		0.079		
	One day	339.7[c]	5.3	410.4[a]	30.4	440[a]	37.2	0.046[*]
	One month	370.7[b]	14.7	426.9	22.1	478	90	0.114
Soft food	Two month	415[a]	49.3	465.4	59.7	520.1	36.9	0.064
	P-value		0.018[*]	0.72		0.211		
	One day	331.4[c]	43.1	407.6[a]	7	469.5[a]	29.5	0.015[*]
Hard food	One month	366.7[b]	12.7	426	21.8	470	85	0.11
	Two months	470[a]	50	438	60	535	46.9	0.164
	P-value		0.045[*]	0.391		0.182		

Means with different letters are significantly different according to LSD test.
* P-value $\leq$ 0.05 is considered significant.

Table 3. Effect of degree of denture retention (groups) and time on the mean MUPs amplitude of the masseter muscle of the sound side for all three functions.

Activity	Groups	Group I		Group II		Group III		
	Time	Mean	SD	Mean	SD	Mean	SD	P-value
	One day	390.6	70.6	444	40.3	547	85.6	0.055
	One Month	405.9	37.3	475.5	29.8	504.6	80	0.145
Clenching	Two Months	404.6	24.1	476.3	58.7	520	34.4	0.197
	P-value	0.872		0.392		0.682		
	One day	476.7	89.9	476.4	49	423.4	19.9	0.319
	One Month	398.8	38.3	490.8	43.7	448.3	13.6	0.116
	Two Months	416.1	65.2	476.9	67.7	492.1	70.2	0.069
Soft Food	P-value	0.268		0.791		0.19		
	One day	483.6	57.4	492.3	12.5	466.5	31.7	0.607
	One Month	527.5	31.1	498.7	42.8	458.5	96.1	0.368
Hard Food	Two Months	443.7	61.3	499.9	21.8	549.5	86.8	0.212
	P-value	0.268		0.772		0.241		

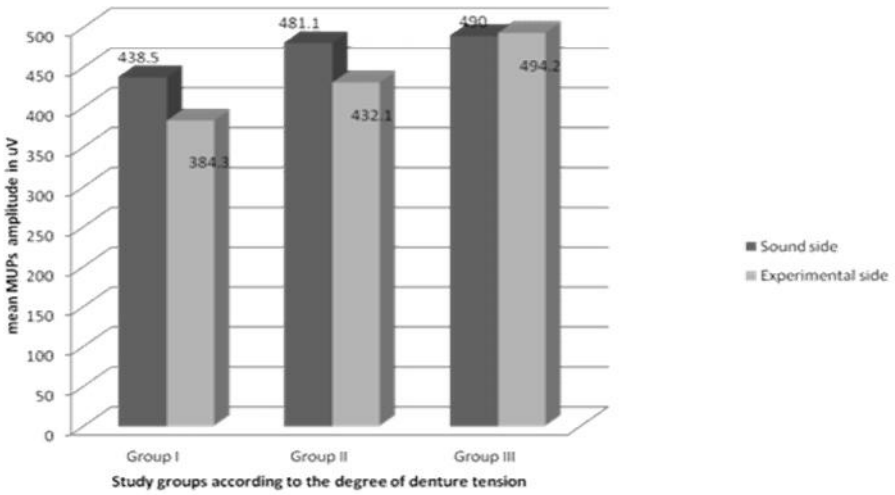

Figure 3. The mean MUPs amplitude of the denture side was significant smaller than the dentulous side in group I& II (extra soft and soft tension).

experimental side did reach the level of the intact side with the standard level of retention (group III) only. Tumrasivn et al (2005) attributed this difference to the impaired oral sensori-motor function in the denture side as compared to the dentulous side with the soft retention. Van Kampen et al (2002) studied the influence of the degree of retention and stability on the maximum bite force and the EMG activity in completely edentulous patients. After implant placement, the maximum bite force was nearly doubled and the EMG of the masseter and temporalis muscles was significantly increased. Denture instability probably prevents denture wearers from using the full potential of their jaw muscles, especially during unilateral biting and chewing, even with two implants supporting the mandibular dentures. (Caloss et al, 2011) The EMG values of the masseter muscle significantly increased when an implant attachments was used in the over denture. (Uçankale et al, 2010) but unfortunately with this degree of retention the patients were less satisfied, increased gingival index and attachment level.

In the extra soft retention group only, the masseter's activity during chewing soft and hard food unlike clenching improves significantly by time. Clenching is a static loading condition, while chewing is a dynamic functional process. In the latter, the role of the muscle is not only to exert high occlusal forces, to select place and break the food but also to functionally move the jaws. The activation of the masticatory muscle depends on the size and texture of the food bolus to facilitate efficient food crushing. The harder the food the greater is the chewing cycle, with longer masticatory time involving many chewing strokes, and consequently an increase in the muscle activity. (Kohyama et al, 2007 and Piancino et al, 2007)

A significant benefit in increasing the retention will be paralleled by a significant increase in the electromyography activity of the masseter muscle, but with this level of retention some patients may be unsatisfied with their prosthesis. This could be related to the gingival inflammation or lead to it. Patient adaptation by time may be as influential as the degree of retention, so sufficient amount of retention is enough to achieve a satisfactory and acceptable level of masticatory function.

CONCLUSION

Patient satisfaction and adaptation are important factors to determine the degree of removable partial denture retention. Surface quantitative EMG recording of the mean MUPs amplitude of the experimental side masseter muscle could play an additional role as a non-subjective measure to the degree of muscle activity improvement, particularly if oral hygiene is a matter of question.

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