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ELECTROMYOGRAPHIC EVALUATION OF IMPLANT OVERDENTURE RETAINED BY TWO DIFFERENT TYPES OF ATTACHMENTS (RANDOMIZED CONTROL TRIAL)

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ABSTRACT

The objective of the present study was to evaluate and compare the influence of two different types of attachments on the masticatory function of complete denture wearers through studying the electromyographic (EMG) activity of the masseter and anterior fibers of temporalis muscles.

Material and methods: Fourteen completely edentulous patients with problematic existing mandibular dentures received new conventional complete dentures. Two implants were installed in the mandibular canine regions. After verification of Osseointegration. Patients were randomly divided into two groups by using closed envelope according to the type of attachments used (ball and locator) were installed onto each implant. Electromyographic (EMG) activity of masseter and anterior fibers of temporalis muscles was measured during chewing hard and soft food with conventional dentures before implant placement, one month and three months after implant retained overdentures with the two types of attachments. Data was collected and statistically analyzed.

Results: The results obtained from thisstudy revealed a statistically significant increase in the muscles activity after attachment of mandibular dentures onto the implants in the studied groups. The highest activity values were reported for the locator attachment group followed by ball attachment however, the least values were recorded for the conventional complete denture. Nevertheless, the comparison between the two groups at the end of follow up period revealed a statistically insignificant difference .

Conclusion: Muscles activity significantly increased after implant treatment. Thus, implant treatment greatly improves oral function. The design of implant attachments did not affect significantly the muscle activity; as no significant differences were observed among the studied attachments (Ball and locator) .

KEY WARDS: Implant attachments, mandibular overdenture, muscle activity.

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INTRODUCTION

Patients wearer complete denture frequently report problems with their mandibular prostheses concerning retention, stability and problems with oral functions. Maintaining normal diet may not be possible due to the mobility of the denture. [1]

Commonly, overdenture is used by denture wearers to increase the retention and stability of the complete denture [2, 3] also, to improve the chewing and masticatory ability. [4] Many studies have reported high success rate with respect to the placement of implants to anchor an overdenture [5-8] The survival rate of implant supporting mandibular overdentures is high regardless of the number of implants. [9]. Long term studies have indicated that two implants supporting mandibular overdentures opposing maxillary dentures are globally accepted treatment option. [10-12] Many different systems of attachment are used with implant retained mandibular overdenture to provide retention and stability. [13, 14]

The relation between maximum bite force and masticatory efficiency was investigated in individuals rehabilitated with partial dentures, complete dentures, implant supported overdentures. They observed that increased bite force is directly related to the increase in masticatory efficiency, and they reported greater bite force values for the group of individuals rehabilitated with upper complete dentures and lower implant- supported overdentures compared to the conventional complete dentures group [15].

The improvement in oral function after implant treatment may depend on the degree of retention and stability of the denture and also, on the type of attachment.[16]. Ball attachments were considered the simplest type of attachments for clinical application with implant-retained overdentures.[17]. On the other hand, the Locator attachment system has two main advantages .The one was the self aligning feature of locator . It works the same way as the guide plane for a removable partial denture.

The patient can easily align the prosthesis without damaging the attachment components. The other important factor was the dual retention innovation . The combination of inside and outside retention increases the retentive surface area, when compared to most attachments. [18-20]

Loss of teeth leads to reduced masticatory forces, alveolar bone resorption, changes in the oral mucosa and reduction in the number of functional motor units leading to decreased muscular activity. [21] Also, the poor fit and the lack of stability of the full denture clearly affects the masticatory function. [22]Oral functions and masticatory performance could be improved after implant overdenture treatment due to stabilization of the overdentures [1, 4, 23] that provides a regular chewing pattern with higher electrical activity of the masseter muscles compared with conventional denture. [24] The type of attachment may affect the retention and stability of the overdenture and hence, the masticatory performance and the oral functions. [1, 16, 25] However, excellent results were recorded irrespective to the attachment type. [4, 26]

Evaluation of oral functions and masticatory performance may include the measurement of the biting force, the jaw movements as well as surface electromyographic signal of masticatory muscle. [27] Electromyography (EMG) measures the electrical output of a muscle which is proportional to the energy consumed to produce contractions. Thus, estimation of the total energy expended during chewing a piece of food can be done by recording the total EMG activity of major masticatory muscles. [28] EMG assessment was used as a reliable method for clinical evaluation of chewing efficiency in complete denture wearers as well as implant supported overdentures. [1, 4, 26]

Complications associated with the attachment systems of interest (ball and locator) were studied and it was concluded that the locator system showed superior clinical results than the ball , with regard

to the rate of prosthodontic complications and the maintenance of the oral function.[29] Therefore, the present study was designed to compare the ball and Locator attachment systems regarding the masseter muscle activity using EMG.

MATERIALS AND METHODS

Patients selection: Fourteen completely edentulous male patients with age ranged from (56 to 68) years, were selected from the outpatient clinic of Faculty of Dentistry, Misr University for Science and Technology. They were referred to the Prosthodontic Department because of persistent complaints regarding their conventional mandibular dentures. All patients were completely edentulous for an average of 8 years and had worn more than one denture. Their bone height in the inter-foraminal region of the mandible exceeded 15 mm. The patients were free from any medical, psychiatric and physical condition that might affect neuromuscular coordination or contraindicate implant surgery as well as their participation in the study. Written informed consent was obtained from each patient after a full explanation of the clinical trial. All patients were examined clinically and radio- graphically before performing any treatment to evaluate bone quality and quantity in the proposed implant site to exclude any pathologic lesions.

Prosthetic Procedures

Conventional complete dentures were fabricated for all patients prior to implant installation to assure ideal implant placement in harmony with osseous anatomy, esthetics and abutment connection. Following denture placement and patient adaptation, the mandibular denture was duplicated in clear acrylic resin and used as a surgical stent. Electromyographic records for masseter and anterior fibers of temporalis muscles was measured for each patient after denture placement and adaptation to be recorded as a baseline for this study.

Implants

Two endosseous Legacy implants (Implant Direct LLC, USA, Canada) measuring 3.7 × 13 mm in dimension, with 3.5 mm diameter platform and internal connections were used. The two implants were placed in the canine region guided by a surgical stent constructed from the previously fabricated dentures.

Immediately after surgery, no prosthesis should be used over the implant surgical site so that early healing can occur without functional loading. After 2-weeks period, the tissue surface of the existing overdenture was relieved in the area overlying the healing collar. Resilient relining material (Permsoft Myerson Chicago IL. USA) was placed into the relieved areas to assure intimate tissue contact. Six weeks after surgery, the denture was successively fitted with locator, and ball and socket attachments.

Patients grouping:

Patients were randomly divided into two groups by using closed envelope according to the type of attachments were installed onto each implant.

Group I, Patients had received ball and socket attachment. Ball abutment heads (3.5 mm diameter with collar height 1.6 mm, Zimmer dental, USA) were placed into each fixture and tightened to 30 Ncm with a torque wrench, ensuring 2mm of height above the mucosa. Stainless steel Cap Attachment Housing ("CAH", Zimmer dental; USA), was inserted onto the ball abutment. **Fig. (1)**

Group II, Patients had received locator attachment. Locator attachment system (Zest Anchors, Inc, homepage Escondido, CA, USA.) was utilized which consists of a matrix (female) and a patrix (male).The matrix is composed of a Locator abutments made of Titanium with a Titanium-nitride coating, it is inserted into an implant and tightened to 30 Ncm. with a torque wrench; ensuring 2mm of height above the mucosa. The patrix is a Locator cap; with an interchangeable nylon insert (pink). The patrix was inserted into the matrix. **Fig.(2)**

Fig. (1): Ball attachments

Fig. (2): Locator attachments

Post operative care included oral analgesics and antibiotics and a daily mouth rinse with 0.12% chlorhexidine for 7 days. The fitting surface of the overdenture was relieved opposite to the healing abutment in order not to overload the implants during osseointegration period. Direct picking-up was carried-out through the relieved areas made opposite to the attachment sites using injection self-cured acrylic resin under closed- mouth technique. The protective discs were used during picking-up to avoid infiltrations. Once the resin is hardened, the denture was cleaned and polished.

Patients were recalled for follow up 24 hours, 3 days and one week after overdenture wearing. Panoramic radiograph was made to evaluate the case .

Electromyographic (EMG) measurements:

For all patients Electromyographic (EMG) records were done at Physical Medicine & Rehabilitation Department, Faculty of Medicine, MUST University by an Electromyographic apparatus *(TOENNIES NEM- 7102A/K- made in Japan)*. **Fig.(3).**

Evaluation was carried at time of insertion (base line), one month and, three months at intervals. The patient was instructed to seated upright, comfortable and unstrained position. EMG records were performed by means of a bipolar electrode connected to a measuring system with compact low noise amplifier on Microsoft windows operating system that detects motor unit action potential (MUP). MUP wave forms were automatically detected and 8 wave forms were selected and average was taken and automatically the calculated data was displayed in terms of duration (ms.), amplitude (mv.) and phases.

The bipolar surface electrode recorded the masseter muscle and anterior fibers of temporalis activity bilaterally, where the electrodes were positioned on the bellies of the muscles and asking the patient to clench on the posterior teeth. Electrodes were positioned on the most palpable contractile fibers of masseter muscle parallel to the fiber orientation by means of adhesive tapes. The temporalis muscle was located by asking the patient to open and close with palpation just in front of the anterior border of the hair line in the area of the greatest lateral distention. The ground surface electrode was located on the patient's forehead, **Fig.(4).**

A transparent template was made for each patient, the position of electrodes were marked on it in relation to certain facial anatomic land marks e.g.: Outer canthus of the eye, corner of the mouth and tragus of the ear. The transparent template was

Fig.(3): Electromyographic apparatus

Fig. (4): Attachment of surface electrod

used to reposition the surface electrodes accurately during subsequent assessment visits.[30].

Patients were instructed to chew on equal sized pieces of test food, (banana as an example of soft food and peanuts as an example of hard food). Tasks were separated by a recovery rest period of at least two minutes. The EMG readings were calculated in microvolts, tabulated and statistically analyzed.

STATISTICAL ANALYSIS

Data were presented as means and standard deviation (SD) values. One Way- ANOVA was used to study the effect of time, difference between procedures on mean Electro-Myogram (EMG) (m V). Tukey's post –hoc test was used for pair-wise comparison between the mean when ANOVA test is significant. Statistical analysis was performed by IBM® and SPSS® Statistics Version 20 for Windows. Paired t- test was used to study the effect of time and food texture on masseter muscle activity for each type. [31]. The significant level was set at $P \leq 0.05$.

RESULTS

The EMG activity was measured from the beginning of chewing until swallowing. The sum of both mean values amplitude of the left and right masseter muscle activity were used, and statistically analyzed.[23] Statistical analysis revealed insignificant difference between the right and left EMG amplitude.

The difference in the effect of the conventional complete denture and implant mandibular overdenture retained by ball and socket (group I) and locator (group II) is presented in table (1 &2). Statistically insignificant difference ($P \geq 0.05$) in the mean EMG amplitude of masseter and temporalis muscle action potential was evident between overdentures retained with ball and socket while chewing soft and hard food at one month and three months of their use. Both showed significantly ($P < 0.001$) higher mean muscle activity than the conventional complete denture.

Effect of food texture on the studied muscles (masseter and temporalis) activity:

Statistically significant increase ($P<0.001$) in mean muscle activity was evident with hard food than with soft food for the conventional complete denture and the implant retained mandibular overdenture with both types of attachment . While when comparing the mean value of the EMG amplitude of the masseter muscle activity of both groups (I) & (II). There was not statistically significant difference were found between the two groups in all intervals.

TABLE (1) Mean values of EMG amplitude of masseter muscle activity during chewing (microvolt) among the study groups at base line, after one month, three months from denture insertion.

Time of assessment		Electromyographic (EMG)		Z-test
		Group A (n=5)	GroupB (n-5)	
At base line	Range Mean± SD Median	500-700 611.43±79.67 640	450-720 612.86±103.07 650	0.257 ns 0.797
After 1 month	Range Mean± SD Median	430-650 540.29±99.30 580	400-640 514.29±76.35 500	0.384 ns 0.701
After 3 months	Range Mean± SD Median	306-600 511±110.07 540	270-540 424.29±99.64 420	1.544 ns 0.123

ns =not significant or P>O.05 Group A= Patients with ball attachment. Group B= Patients with locator attachment

TABLE (2) Mean values of EMG amplitude of anterior fibers of temporalis muscle activity during chewing (microvolt) among the study groups at base line, after one month, three months from denture insertion.

Time of assessment		Electromyographic (EMG)		P-Value
		Group A (n=5)	GroupB (n-5)	
At base line	Range Mean± SD	396.6 37.537	362.85 43.84	*P<0.0001*
After 1 month	Range Mean± SD	502.05 32.922	423.4 29.434	*P<0.0001*
After 3 months	Range Mean± SD	559.55 33.423	476.45 38.652	*P<0.001**

Significance or P<O.01 ns = not significant or P>O.01

Effect of time on the studied muscle (masseter and temporalis) activity:

The mean muscle activity showed statistically significant(P<0.001) improvement after 3 months of using each type of denture, while chewing soft and hard food.

Chewing time

Chewing time was measured from the beginning of chewing until swallowing in seconds. **Table (3)** showed the mean ± SD of chewing time in group (A &B), at baseline without denture was decreased to after one month and three months from denture insertion respectively. This decrease was statistically significant (*P*<0.05). This significant difference was

TABLE (3) Mean values of Chewing time among the study groups at base line, after one month ,and three months from denture insertion.

Time of assessment		Chewing time (seconds)		Z-test *P*
		Group A (n=5)	GroupB (n-5)	
At base line	Range Mean± SD Median	35-65 50.71±10.18 50.00	40-65 49.29±9.76 45.00	0.268 ns 0.793
After 1 month	Range Mean± SD Median	28-59 44.14±11.10 42.00	28-59 43.14±10.88 40.00	0.193 ns 0.847
After 3 months	Range Mean± SD Median	25-50 37.00±9.71 34.00	18-45 30.29±10.89 27.00	1.233 ns 0.218

Significance or P<O.05 ns = not significant or P>O.05

TABLE (4) Mean values of percentage of change of chewing time after one month and three months from base line among the study group.

% of change		% of change of chewing time among the study		Z-test *P*
		Group A (n=5)	GroupB (n-5)	
Change after one month from baseline	Range Mean± SD Median	↓ 40.00-↓ 16.67 ↓ 27.55±8.09 ↓ 28.57	↓ 55.00-↓25.00 ↓ 40.11±10.9 ↓ 40	1.096 ns 0.170
Change after three months from baseline	Range Mean± SD Median	↓ 64.44-↓ -23.64 ↓ 41.70±15.7 ↓ 40	↓ 69.23-↓ 55.55 ↓ 60.86±4.91 ↓60	2.175* 0.030

Significance or P<O.05 ns = not significant or P >O.05

found in comparison between the results at base line without denture versus after 3 months from denture insertion follow up. In comparing the mean values of chewing time of both groups (A) & (B), There was no statistically significant difference found between the two groups at baseline without denture, after one month and three months from denture insertion. The changes among the comparable values of chewing time in groups (A) & (B) are expressed in percentage as shown in the **table (4)** showed the mean values of percentage of change of chewing time after denture insertion, one and three months from base line among group (A) which was (27%) and more decrease (41%) respectively which is not significant.

DISCUSSION

One of the main goals of modern dental health care is to preserve a lifelong healthy masticatory function, restore or replace the oral tissues that facilitate oral function. Recent studies have shown that mastication is of great importance, not only

for the intake of food but also for the systemic and physical functions of the body(32). For edentulous patients that provided with conventional full dentures, some functional problems were reported due to a lack of stability, retention and support of the mandibular denture. In order to solve these problems implant overdenture treatment can be indicated.(33).

Many dental implant overdenture treatment modalities are used in clinical practice, in which the vary types of attachment, which provide different levels of retention and stability to the mandibular denture. (16) Therefore, this study was designed to compare two types of widely used attachments which are ball and Locator attachment systems regarding the masticatory muscle force measurements as an indicator to the oral function.

Completely edentulous male patients were selected for this study to avoid the difference in masticatory force between different sexes.(34).

Very old patients were excluded from this study to avoid atrophy of skeletal muscle due to senility which may affect muscle activity.(35). The masseter and temporalis muscles chosen in this study as they considered to bethe most powerful and obvious muscle of mastication and is highly active during mastication as stated by (El-Zawahry,.1998.(36)

In addition, they are more accessible to the surface electrodes. Fehrrenbach, and Herring, 2007) (37). The EMG activity of the studied muscle was evaluated before denture insertion , one month and three months after denture insertion to allow muscle accommodation as recommended by (E1Bagoury, 1995).(38).

Electromyographic was used in this study to evaluate muscle activity because EMG recordings of jaw muscle activity during chewing have revealed details of the pattern of activity of muscles that control the jaw as reported by (BradleY, 1995)(39). Surface electrode was preferred in this study and not needle electrode to eliminate the pain on insertion of the needle and stress which may affect the electromyographic records, and it is effective in recording both superficial and deep fibers of Masseter muscle activity without pain and allow good evaluation of the integrated activity of the muscle beneath them as found by (Belser andHannam, 1986)(40). Huang et al. (2005) (41) recommended surface electrode to be used in muscle recording because surface electrode has the advantages of easy to use, noninvasive, large recording region and more safe.

Randomization by closed envelope of using attachment type ensured unbiased evaluation and allowed for true comparison of the effect of the two attachment types.(42).

The locator and ball and socket attachments were used in this study as they are easy to be incorporated in the fitting surface of an existing denture. (25,43)

The purpose of this study was to ascertain whether using of implant retained overdenture would achieve acceptable functional improvement in masticatory muscle activity expected from implant treatment. Hence, EMG recording was selected as an evaluation method. It has been estimated that surface electrodes could detect a large number of motor units in a contracting muscle. (44) Also, it was suggested that electrodes should be placed parallel to the muscle fibers so that higher electric activity could be recorded. (45). A significant improvement in masticatory function was observed after the overdenture was attached to the implants.

All patients chewed soft and hard food better; this was reflected by the significant increase in muscles ctivity with mandibular overdenture retained by implant. This was in accordance to previous results of studies that used implant retained mandibular overdenture. (1,4). . Karkazis (24) studied the influence of food texture on the surface EMG activity of the masseter muscle in a sample of mandibular implant overdenture wearers, he reported that implant retained mandibular dentures may provide regular chewing patterns due to increased retention and stability resulting in higher electrical activity of masseter muscles, thus improving the chewing function.

The lower muscle activity recorded for the conventional complete denture may be contributed to the instability of the denture during function that lead to limited muscular effort. Jaw muscle weakness in complete denture.wearer was demonstrated to be due to disuse,atrophy contributed to instability of the complete dentures. Increasing stability of dentures by osseointegrated implants allow patients to use greater muscular effort and possibly strengthened,their weakened jaw muscles. [46]. The presented data showed no statistical differences in muscle activity between the two attachment types while chewing soft and hard food. This was in agreement with other studies. [4, 23]. Hard food requires more muscle effort to be cut and crushed into small pieces, consequently masseter and temporalis more energy and strong contractions are made during chewing hard food increasing the amplitude of motor unit action potential on the EMG. [23].

The significant increase of muscle activity was evident after 3 months of the use of implant retained mandibular overdenture while chewing soft or hard food could be explained on the basis of adaptation and increase control of the dentures. Piancino et al [47] investigated the adaptation process of masticatory patterns to a new complete denture in edentulous patients. They reported that at the delivery of a new denture, the EMG activity of the masseter muscle decreased and recovered after 3 months. The recovery occurred due to increased adaptation to the new denture and reestablishment to previous experience with denture control.

CONCLUSIONS

Within the scope and limitation of the present study, it may be concluded that:

- The use of implant retained prostheses greatly improves the masseter and anterior fibers of temporalis muscle activity and hence, the masticatory performance and oral functions for complete denture wearer.
- There are no significant differences in muscle activity between the two design of implant attachments (Ball and Locator) while chewing different types of food.

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