

ELECTROMYOGRAPHIC EVALUATION OF THE MASSETER AND TEMPORALIS MUSCLES ACTIVITY IN PATIENTS WITH COMPLETE DENTURE, IMPLANT SUPPORTED AND IMPLANT RETAINED MANDIBULAR OVERDENTURES. A CROSS-OVER STUDY

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ABSTRACT

Purpose: This study was conducted to compare the electromyographic [EMG] activity of both masseter and the anterior temporalis muscles in patients with: Conventional complete dentures, Implant supported overdentures without attachments and, Implant retained overdentures with locator attachments.

Material and methods: Six completely edentulous male patients with atrophied mandibular ridges received upper and lower conventional complete denture. EMG activity were measured for both masseter and the anterior temporalis muscles during clenching without food, clenching hard (carrot) and soft (banana) foods. Measurements were made at time of denture insertion, one month and two months after. Two implants were installed in canine regions of the mandible. After osteointegration, healing abutments were connected and the mandibular denture were relined with hard acrylic resin. Measurements were repeated, then healing abutments were replaced with locator attachments, and measurements were repeated again.

Results: The highest EMG activity/amplitude of masseter and temporalis muscles, were noted with locator overdentures, and the lowest values were observed with conventional dentures. There was no statistically difference in muscle activity between implant supported overdentures and complete dentures. For all groups, muscle activity for masseter and temporalis muscles increased with advance of time. For both groups, muscle activity was significantly higher during clenching of hard food than clenching without food or with soft food

Conclusion: Within the scope of this study, implant retained overdentures are recommended for edentulous patients rather than conventional complete dentures or implant supported overdentures as it improves EMG activity/amplitude of masseter and temporalis muscles.

KEY WORDS: Complete denture, dental implant, overdentures, attachments, EMG activity.

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INTRODUCTION

Atrophic mandibular ridge represents many problems for patients seeking a complete denture due to insufficient area for distribution of masticatory force, pain during mastication, mucosal inflammation, poor retention and instability of the denture, difficulty in speech, and poor patient toleration. All these problems can cause dissatisfaction of the patient and poor quality of life¹. Bone resorption that occurs in case of conventional complete dentures can render the current prosthesis inadequate in terms of both function and esthetics and can lead to the necessity of fabricating a new denture. Over time occlusion, esthetics and function may be compromised². Implant insertion for edentulous patients have reported to contribute to the preservation of residual ridges, improvement of the masticatory parameters and patient satisfaction³. The use of implant supported over denture has excellent outcomes for the edentulous patients compared with the conventional dentures, due to reduced residual ridge resorption and improved retention and support of the prostheses⁴ resulting in better quality of life function⁵, chewing and masticatory functions⁶, nutritional status and general health^{7,8}.

Mandibular implant overdenture treatment showed improved support, retention and stability as compared with conventional mandibular complete denture⁹. This creates a more stable occlusion which provides better distribution of occlusal forces and a significant decrease in soreness and stomatitis in the anterior mandibular tissues in comparison with conventional dentures¹⁰. Compared to conventional dentures, the implant retained overdentures improve masticatory ability and patient perception of functions related to mastication¹¹ especially for patients with resorbed mandibles¹². In addition, these overdentures enhance maximum bite force¹³ and increase patient satisfaction and comfort during mastication.

Several attachments can be used to connect overdentures to the implants such as ball, bar, Locator, and resilient telescopic attachments¹⁴. Atrophied ridge requires stabilization, especially to horizontal forces¹⁵. The widely used Locator system has been advocated as an alternative single attachment to the established ball anchor¹⁶. Locators are low-profile resilient studs that can also provide a limited hinge movement and compensate for implant angulation up to 40 degrees¹⁷. Moreover, it was estimated that the time required to fabricate a mandibular overdenture retained by implant with locator attachments was not significantly different than the time needed for the conventional denture treatment¹⁸.

Electromyography of the masticatory muscles has been used to investigate the masticatory muscle behavior during function of the stomatognathic system during normal or abnormal conditions as occlusion and bruxism to evaluate the effectiveness of muscle activity with treatment¹⁹. The objective evaluation of masticatory function includes measurement related to the activity of masticatory muscles, the maximum biting force, the mastication time, and the particle size of different test foods²⁰. The electrical output of a muscle, measured by electromyography (EMG), is proportional to the energy consumed to produce contractions²¹. Several investigations proved that the masticatory muscles activity increased when chewing hard food when compared to soft food²². The evaluation of the effect overdentures supported only by implants without attachment on EMG activity of masticatory muscles was not sufficiently investigated. Accordingly, the aim of the present study was to evaluate, within patient, the electromyographic activity of the masseter and temporalis muscles in patients wearing conventional dentures, implant supported overdentures without attachments and implant retained mandibular overdentures with Locator attachments.

MATERIAL AND METHODS

Patient selection

Six completely edentulous patients (3 males and 3 females, age ranged from 55 to 60 years) with atrophied mandibular ridges were selected. The patients were selected according to the following criteria: 1) Patients free from any systemic disease that may interfere with dental implant placement and/or Osseo integration e.g. uncontrolled diabetes, hypertension, blood diseases and bone diseases. 2) Last extraction was at least 6 months before, 3) No T.M.J. disorders. 4) Patients were with angles class I. 5) Patients had healthy mucosa and adequate bone height in the anterior mandibular region. Patients who had bone metabolic disorders, and diseases that may complicate surgical procedure as liver, heart, autoimmune diseases, radiation to head and neck and diabetes mellitus were excluded. Also, Heavy smokers (>10 cigarette per day) were excluded. All Patients were instructed about the treatment protocol and objectives prior to obtain an informed consent. The study was conducted according to the ethical principles of Helsinki declaration (<http://www.wma.net/>) and approved by the faculty of dentistry, Beni-Suef University ethical committee. (Approval no: # FDBSUREC/09112020/SS).

Surgical and prosthetic procedures

All patients received new conventional upper and lower complete dentures constructed by bilateral occlusal balanced technique. The muscular activity (of the anterior temporalis and the superficial masseter muscles) was evaluated at time of denture insertion, one month and two months later after denture insertion. Each patient underwent a cone beam computerized tomography scan and lower denture was duplicated for making surgical stent. 24 hours before surgery, patients were premedicated by antibiotics (amoxicillin 628mg + clavulanic acid 125mg, augmenting® 1gm), and continued for five days after surgery. Two submerged root form endosteal implants 3.6 in width and 12mm in height (Dentium, super line, South Korea) were

inserted in the right and left mandibular canine regions following 2 stage surgical protocol using surgical stent. The implants were positioned in the osteotomy sites using the implant driver and were threaded into its final positions using a ratch with at least 35 Ncm torque. The titanium cover screw was screwed into the occlusal opening of the implant and tightened with the hex screw driver. The mucoperiosteal flaps were then repositioned and sutured by interrupted sutures using black silk number 0000. The patients were instructed to take their post-operative medications as previously prescribed. Patients were also instructed to use cold fomentation on the anterior region of the mandible for the first twenty-four hours, eat soft diet and avoid finger or tongue pressure at the implant sites. The mandibular dentures were relined with soft liner during the healing periods. One week later, sutures were removed. Patients were recalled after 3 months to allow osseointegrations. Fixture were uncovered with the aid of the surgical stent. A very small crestal incision was made over the implant exposing the covering screw. Then the cover screws were unthreaded, and 2 dome shaped healing abutments of suitable gingival height were selected according to thickness of mucosa to be extended above the mucosal surface about 2 mm (fig1). The soft liner was removed from the fitting surface of mandibular denture, the lower dentures were relined for making closed mouth relining impression technique while patients closed in centric occlusion with upper and lower dentures using medium body rubber base. After setting of the impressions, the dentures were sent to lab for relining of lower dentures with hard acrylic resin. The newly relined mandibular dentures were adjusted to fit the healing abutments and be sure that the healing abutments made contact with the fitting surface of mandibular overdentures with its top part only by using disclosing materials to avoid implant overloading. EMG activity (of the anterior temporalis and the superficial masseter muscles) were evaluated again at time of denture insertion, one month and two months later after denture insertion. After EMG measurements, the healing abutments were unthreaded and replaced

by locator abutments (Dentium Co., Ltd, EMERGO EUROPE). The locator abutments were threaded to the implants (Fig 2). Blocking rings were placed over the abutments to relieve acrylic resin around the abutments and prevent excess acrylic resin to enter in peri-implant sulcus. Metal housing with processing inserts were snapped on the locator abutments (Fig 2). Using disclosing media, sufficient relieve was provided in the mandibular dentures over locator abutments to provide a space for Locators metal housing. Lingual vents were drilled in the lingual flange of the denture to allow escapement of excess acrylic resin material during the pickup procedure. The metal housings were picked to the tissue surface of the mandibular denture using auto polymerized acrylic resin while the participants close in retruded contact position. After polymerization of the acrylic resin, the mandibular denture was removed, excess acrylic resin around the abutments was removed to avoid unnecessary loading of the implants and the denture was finished and polished. Black processing inserts were removed using locator tool and replaced with blue nylon insert (extra light retention) (Fig 2) and dentures delivered to the participants and

occlusion was refined. Patients were instructed to maintain strict oral and denture hygiene measures clinical evaluation was carried out to inspect the condition of the denture bearing structures, the implant abutments, the oral hygiene and the dentures. Electromyographic evaluation of both masseter and the anterior temporalis muscles was then repeated for all patients at denture insertion, one month and two months later after denture insertions.



Fig. (1) Connection of healing abutments for implant supported overdentures

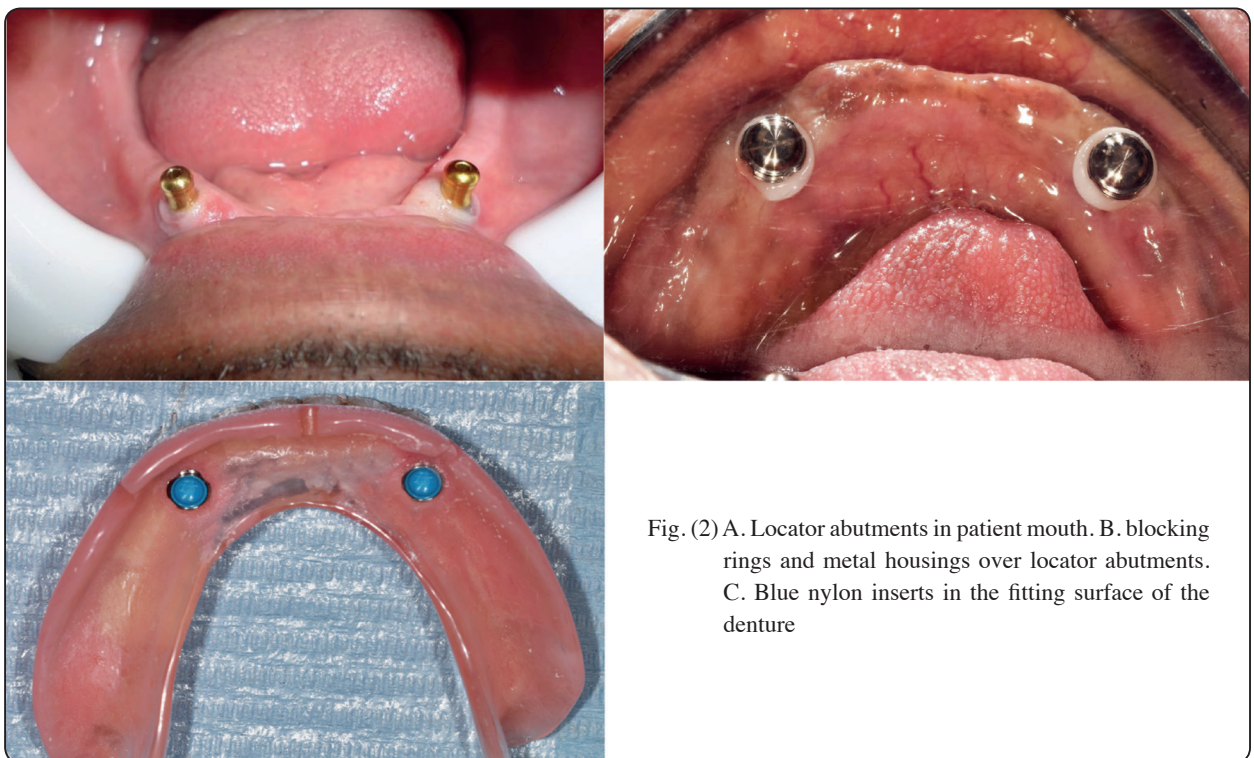


Fig. (2) A. Locator abutments in patient mouth. B. blocking rings and metal housings over locator abutments. C. Blue nylon inserts in the fitting surface of the denture

Evaluation of EMG Activity of Masseter and anterior temporalis muscles:

The muscular activity (of the anterior temporalis and the superficial masseter muscles) was evaluated at time of denture insertion, one month and two months' later after wearing each prosthesis (conventional dentures, implant supported overdentures, and Locator overdentures). The patients were seated in an upright position. The skin over the muscles was cleaned with alcohol. Surface electrodes were placed on the bellies of the masseter muscle of the preferred chewing side of the patient⁶. The active electrodes were positioned on mid-longitudinal fibers of the muscle parallel, and the reference electrode was placed on the patient's forehead. For temporalis muscle while the patient clenching the position of the surface electrodes were determined through an imaginary horizontal line drawn from the outer canthus of the eye to the upper margin of the external auditory meatus. The electrodes were placed about 3cm vertically upward from the midpoint of the horizontal line.

The electrodes were connected to the measuring system (MEB-9400K, NIHON KOHDEN). Electro conductive gel (Elefix, NIHON KOHDEN) was used on the electrode before fixing it to the skin using adhesive bandage tape. Each patient was instructed to clench on teeth without food and to clench on a sample (dimensions 3 × 1 × 1 cm) of hard (carrot) and soft (banana) foods⁶ until the foods became ready for swallowing. Analysis of EMG signals was performed with programs of EMG equipment. EMG signals were amplified and filtered (20 Hz to 10 KHz), full wave rectified, and smoothed electronically⁶. Four peaks of EMG muscle activity were evaluated and averaged. The operator repeated the test five times (separated by a rest period of at least 2 minutes) for each type of food, and the mean was subjected to statistical analysis.

Statistical analysis:

Data were collected, tabulated, and analyzed statistically, and illustrated in tables and figures. The data were summarized as mean and standard deviation values for the EMG results. The data collected were analyzed using IBM SPSS Statistics version 22.0 software (IBM Corp., Armonk, NY, USA). Mean values were compared by one-way ANOVA for comparisons between the three denture types (conventional dentures, implant supported overdentures, and Locator overdentures) and by repeated measures ANOVA for comparisons of the effect of time (at time of denture insertion, one month and two months' later) and clenching conditions (without food, with hard food and with soft food) in each group. The level of significance was set at 5% for all statistical analyses.

RESULTS

All patients completed the analysis without dropouts as the follow up period was small and all patients attend the follow up recalls. The implant survival rate was 100%. Comparison of the three groups regarding Masseter muscle activity at different follow up periods and different clenching conditions is presented in table 1. Comparison of three groups regarding Temporalis muscle activity at different follow up periods and different clenching condition is presented in table 2. There was a significant difference in Masseter and temporalis muscle activity between groups (conventional dentures, implant supported overdentures, and implant retained overdentures) at all clenching conditions at time of denture insertion ($p=.001$), one month ($p=.002$ for masseter, $.004$ for temporalis) and two months' ($p=.001$) later. At all observation times, implant retained overdentures showed significant higher Masseter and temporalis muscle activity than conventional denture or implant supported overdentures. No significant difference in Masseter and temporalis muscle activity between conventional denture or implant supported overdentures

TABLE (1) Comparison of three groups regarding Masseter muscle activity at different follow up periods and different clenching conditions

		At delivery		One month		2 months		P value
		Mean	SD	Mean	SD	Mean	SD	
Complete denture	<i>Max. cln</i>	45.57	19.65	65.54	18.68	80.54	14.58	0.0001*
	<i>Hard food</i>	80.32	10.22	100.45	16.24	122.32	12.24	0.001*
	<i>Soft food</i>	60.64	10.38	80.28	13.33	99.54	14.31	0.001*
Implant supported overdenture	<i>Max. cln</i>	50.55	12.29	70.47	19.27	85.58	15.27	0.001*
	<i>Hard food</i>	105.48	18.14	120.46	10.14	130.78	13.24	0.001*
	<i>Soft food</i>	70.73	17.57	85.78	18.55	105.78	16.65	0.001*
Implant retained overdenture	<i>Max. cln</i>	65.15	13.15	80.18	16.17	100.15	18.17	0.03*
	<i>Hard food</i>	112.25	15.42	130.75	14.44	150.55	15.54	0.02*
	<i>Soft food</i>	90.15	16.71	100.45	17.75	120.35	18.65	0.02*
P value		0.001*		0.002*		0.001*		

*p is significant at 5%

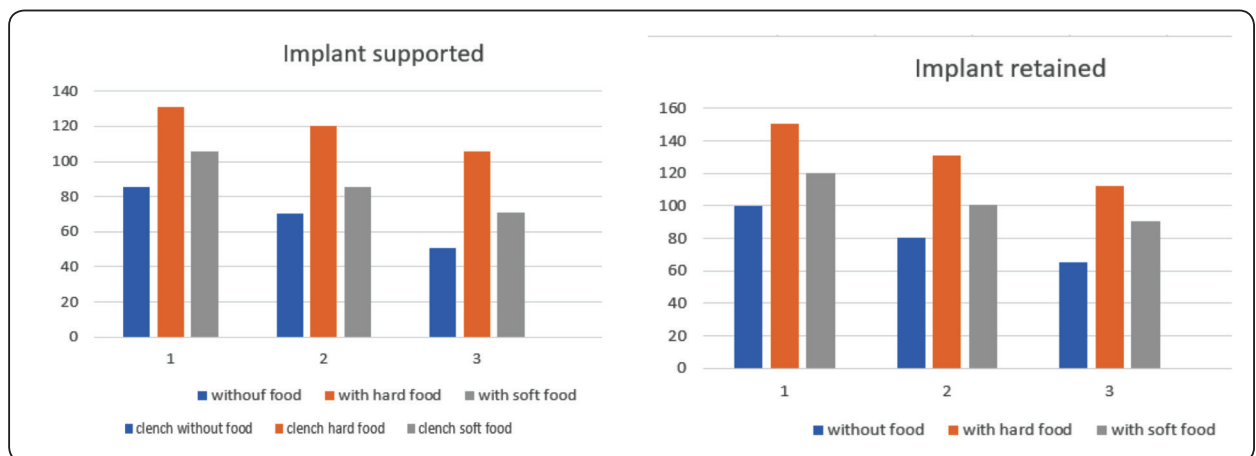


Fig. (3) Comparison of EMG activity of masseter muscle between clenching conditions (without food, with hard food and with soft foods)

TABLE (2) Comparison of three groups regarding Temporalis muscle activity at different follow up periods and different clenching conditions

		At delivery		One month		2 months		P value
		Mean	SD	Mean	SD	Mean	SD	
Complete denture	<i>Max. clen</i>	15.52	17.68	35.40	17.67	50.98	10.28	0.0001*
	<i>Hard food</i>	50.75	15.82	70.25	14.24	91.23	17.22	0.001*
	<i>Soft food</i>	30.12	13.58	50.10	16.63	65.10	10.32	0.001*
Implant supported overdenture	<i>Max. clen</i>	20.35	17.59	40.02	14.87	35.51	12.22	0.001*
	<i>Hard food</i>	72.78	12.84	80.78	11.14	90.68	10.21	0.001*
	<i>Soft food</i>	43.72	17.58	55.45	18.86	75.78	16.25	0.001*
Implant retained overdenture	<i>Max. clen</i>	33.15	19.35	52.10	16.99	77.85	13.13	0.02*
	<i>Hard food</i>	80.25	1.32	87.20	16.47	123.58	11.34	0.02*
	<i>Soft food</i>	60.13	18.61	77.03	12.22	95.78	11.35	0.02*
P value		0.001*		0.004*		0.001*		

*p is significant at 5%

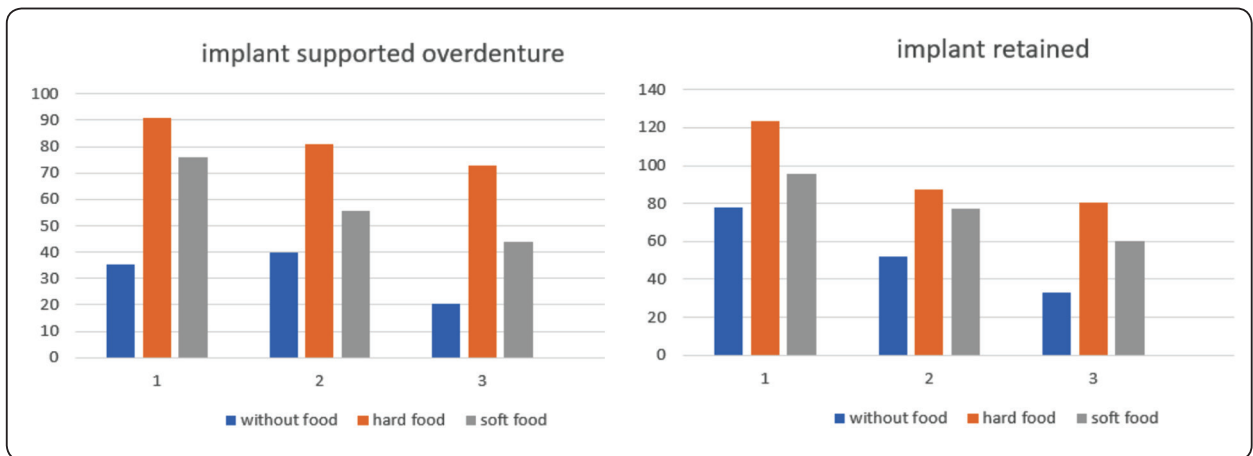


Fig. (4) Comparison of EMG activity of temporalis muscle between clenching conditions (without food, with hard food and with soft foods)

Comparison of muscle activity between observation times for Masseter and temporalis muscles are presented in table 1 and table 2 respectively. For all groups and clenching conditions, Masseter and temporalis muscle activity increased significantly with passage of time ($p < .031$). Multiple comparison revealed a significant difference between each 2 observation times

Comparison of muscle activity between clenching conditions for Masseter and temporalis muscles are presented in fig 3 and fig 4 respectively. For all groups at different observation times, there was a significant difference between clenching conditions. Clenching on hard food showed the highest Masseter and temporalis muscle activity, followed by clenching the soft food and clenching without food showed the lowest muscle activity.

DISCUSSION

The cross over study design standardized patient-based factors that may affect EMG activity such as age, gender, muscle activity, muscle power, neuromuscular control, and ridge morphology⁶. It also allow the use of reduced patient sample since the same number of patients received different treatments⁶.

The results of this study showed that implant retained overdentures had significant higher Masseter and temporalis muscle activity than conventional denture or implant supported overdentures. This finding is not surprising and in agreement with several previous studies^{8,11,22,23}. The increased chewing efficiency with implant retained overdentures compared to conventional dentures agrees with the findings of many authors^{11,24-26} and may be attributed to the improved stability and retention of conventional dentures by osseointegrated implants. It is well known that conventional denture wearers have impaired masticatory function, including lower maximum voluntary bite forces and lower levels of muscular effort during maximum clenching and mastication^{27,28}. This could be attributed to denture instability probably prevents denture wearers from

using the full potential of their jaw muscles, especially during unilateral biting and chewing²⁹.

On the other hand, implant retained overdentures provide increased retention and stability of the mandibular dentures and consequently provide a considerable improvement in muscular activity and mandibular movements, mainly because of their association with a more stabilized occlusion, satisfaction and comfort of patients³⁰. Furthermore, implants improved the functional state of the masticatory apparatus. They aided in the establishment of better neuromuscular coordination and enhanced masticatory efficiency by improving the support, stability, and retention of the prosthesis to an extent that is comparable with healthy dentate individuals. It seems that when implants were used, muscle activity, for both anterior temporalis and superficial masseter muscle, was directed towards masticatory function and no effort was required to stabilize or retain the prosthesis³¹. Moreover, implant stabilized overdentures, elevate bite force and chewing performance, improve patient satisfaction and decrease discomfort during chewing^{32,33}. The increased muscle activity caused by improvement of retention and stability of mandibular dentures is in line with several studies^{24, 34, 35} and may be attributed to the increased ability to comminute food during mastication³⁶. It has been reported that the more stable overdenture enabled reorganization of the neuromuscular system leading to more effective masticatory activity, resulting not only in more effective power-strokes but also in a long-term exercise effect and to more active masticatory muscles³⁷. The improvement of muscle activity could be attributed to the activation of periosteal mechanoreceptors through bone deformation which allow most implant patients to discriminate interocclusal thickness and perceive loads, in a phenomenon called 'osseoperception'³⁸⁻⁴⁰.

The use of healing abutment contact with the denture for support only was reported to decrease soft tissue irritation and preserve alveolar bone. Despite these advantages, it was interesting to

find that implant supported overdentures without attachments did not provide a significant increase in EMG activity of masseter and temporalis muscle than conventional dentures and still far lower in EMG activity than implant retained overdentures with locator attachments. This may be due to this type of prosthesis still lacks the adequate retention and stability due to absence of attachments and may move during clenching. These movement may irritate the soft tissue and provide discomfort to the patient so he is not be able to exert increased occlusal pressure and increased muscle activity during clenching. Moreover, the healing abutments may act as a fulcrum during maximum clenching which may cause denture base deformation⁴¹ and mucosal irritation on the distal extensions of the ridge, thus may contribute to the decreased muscle activity. In contrast the locator attachments have internal and external flanges that provide double retention and act as guiding planes¹³ that limit the lateral movements and increased denture stabilization. Thus providing more comfort and satisfaction to the patient⁵ and may be responsible for increased muscle activity. Moreover, the locator have inherent vertical resiliency and not form a fulcrum during clenching thus reduce denture base deformation⁴¹

For all groups and clenching conditions, Masseter and temporalis muscle activity increased significantly with passage of time. This could be attributed to the increased neuromuscular adaptation to the dentures with time. In fact, neuromuscular control has always been considered as a vital influential factor on the retention and stability of removable restorations. Such finding might be attributed to the improved patient acceptance and adaptation to the prosthesis and better neuromuscular control that the patient naturally acquired by time, irrespective of the type of prosthesis used⁴². A similar observation was reported in another study³⁷ in which the authors found a significant improvement of masticatory performance after 3 months of adaptation which characterized by significant increase of maximum muscle contraction, and total muscle work as a re-

sult reorganization of the neuromuscular system and increased muscle adaptation accompanied by enhanced contractile capacity of the muscles studied.

The increased muscle activity with hard food compared to soft food is in line with the results of Karkazis³⁰. Also, Bakke, et al.¹¹ reported higher EMG amplitude with harder food items than soft foods. The authors concluded that the type and texture of the food can significantly influence the muscle activity. The increased EMG with hard foods probably reflects the modulation of the contraction mechanisms through information from intra-oral receptors^{43,44}

CONCLUSION

The limitations of this study included the small patient number and the short follow up period. However, it could be concluded that: Implant retained mandibular overdentures with locator attachments are preferred in terms of improving masseter and temporalis muscle activity compared to implant supported overdenture without attachments or conventional dentures. The stability and the retention (provided by the attachment) are much important than the support of the overdenture prosthesis in improving the muscle activity of patients rehabilitated by implant overdentures.

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