ABSTRACT

The effect of two different occlusal schemes on the muscle activity in implant supported mandibular overdentures was evaluated in this study. The two occlusal schemes were, the medial positioned lingualized concept of occlusion and the monoplane occlusion concept.

The electromyographic activity of masseter and anterior temporalis muscles was recorded for patients rehabilitated with implant supported mandibular overdentures opposed by conventional maxillary complete dentures.

The results revealed slight increase in the muscle activity in patients rehabilitated with dentures constructed following the medial positioned lingualized concept of occlusion compared to those rehabilitated with dentures constructed following the monoplane concept of occlusion.

INTRODUCTION

The gradual reduction of edentulous residual alveolar bone supporting complete dentures is a major oral disease entity. Several longitudinal studies have indicated that morphologic changes of denture-bearing regions are inevitable even if they show greater individual variation. Changes of the prosthesis support, especially in the mandible, may compromise denture wearing and masticatory functions. The amount of bone reduction is generally greater in the mandible, which implies more clinical problems for the patient and the prosthodontist. The edentulous patient with such a ridge often loses hope of normal function and does not wear the denture (1-4).

Dental implants have been shown to provide a reliable basis for removable prosthesis and have resulted in a drastic change in the treatment concepts for management of the severely resorbed edentulous mandible (5).

Rehabilitation of edentulous patients with implant-supported prosthesis offers considerable functional and psychological advantages for individuals having difficulty to adapt to complete dentures. The biomechanical aspects of occlusal design, configuration and anatomy, significantly influence the ultimate success of implant. The development of occlusal concepts that are in harmony with the rest of the stomatognathic system is a major contributing factor in the long term success rate of the implant-supported prosthesis (6-8).
Some prosthodontists recommend protrusive record, semi adjustable articulators and anatomical teeth for balanced occlusion. Others deny the value of these principles and recommend simple instruments and monoplane occlusion.

The clinical success and longevity of endosteal dental implants as load-bearing abutments are controlled largely by the mechanical setting in which they function. The treatment plan is responsible for the design, number, and position of the implants. After achievement of rigid fixation, mechanical stress, and/or strain beyond the physical limits of hard tissues have been suggested as the primary cause of initial bone loss around implant. After successful surgical and prosthetic rehabilitation with a passive prosthesis, such noxious stresses and load applied to the implant and surrounding tissues result primarily from occlusal contacts. Complications reported in follow-up studies underline occlusion as a determining factor for success or failure.

Due to lack of the periodontal ligament, osseointegrated implants, unlike natural teeth, react biomechanically in a different fashion to occlusal forces. It is therefore believed that dental implants may be more prone to occlusal overloading, which is often regarded as one of the potential causes for peri-implant bone loss and failure of the implant/implant prosthesis.

Thus, the occlusal scheme for an implant-supported restoration should be designed to decrease cuspal interference, centralize forces along the long axis, and minimize lateral forces.

A mutually protected design is usually advocated when osseointegrated maxillary prosthesis or natural dentition opposes an osseointegrated mandibular prosthesis. This type of occlusion dictates the presence of anterior guidance to produce posterior disocclusion during excursive mandibular movements. It has been reported that this type of occlusion is the most physiological scheme that avoids overloading of the muscles and prevents posterior tooth wear.

On the contrary, the presence of anterior guidance should be avoided for an implant supported prosthesis opposing a mucosa-supported maxillary denture. The preservation of the maxillary anterior ridge should be considered, as such a scheme with excessive anterior contact will cause overloading of the maxillary alveolar ridge and may lead to the development of “combination syndrome”. It is comparable to the situation in which lower anterior teeth are opposed by a complete maxillary denture. Bone loss in the anterior maxilla and the posterior region of the mandible, and downward growth of the maxillary tuberosity are some of the possible sequelae with this occlusal scheme.

The concept of lingualized occlusion in which the lingual cusps of the maxillary posterior teeth contact the modified fossae of the mandibular teeth, and a balanced occlusion is created between these elements of the opposing teeth, with freedom of movement and anterior clearance is considered the occlusal scheme of choice for patients rehabilitated with implant supported prosthesis, opposing a mucosa supported maxillary denture.

In agreement of lingualized occlusal design, Misch modified the position of the mandibular lingual cusp and introduced the medial positioned lingualized occlusion. The concept of medial positioned lingualized occlusion developed by Misch emphasizes the axial load over the long axis of the implant. Misch observed that in the majority of individuals with natural dentition, the position of mandibular lingual cusps usually extends 2-3 mm medial to line drawn from the canine to the medial aspect of the retromolar pad, he added that in the mandible the body of the implant is usually placed in the middle of the alveolar crest which corresponds to the lingual cusp region of natural teeth so the central fossa lies over a line drawn from the canine to the medial aspect of the retromolar pad instead of placing the medial aspect of the lingual cusps with this line as described in the lingual concept of occlusion. This placement together with the palatal cusps forming the occlusal contact will ensure the axial loading necessary for osseointegration. In addition reducing the cuspal inclines minimizes the amount of horizontal or lateral
forces being transmitted to the implant. The concept of medial positioned-lingualized occlusion is now referred to as “implant protective occlusion I.P.O.” The primary goal of this occlusal scheme is to maintain the occlusal load transferred to the implant body within the physiologic limits of each patient.

Clinical success of dental implants is often evaluated through the peri-implant condition which affects the prognosis of osseointegration. The peri-implant condition can be evaluated either clinically by gingival index, peri-implant probing depth, and implant mobility or radiographically by assessing the level of the alveolar bone (24).

Electromyography has been also used to assess implant-supported prosthesis. Electromyography is frequently used for assessment of masticatory muscle function both quantitatively and qualitatively and so assessing the role of individual muscles and their contribution to oral function (28).

Electromyography is described as a research tool for evaluating the electrical activity of muscle function. Records from such system have been used to evaluate muscular activity during mastication and command mandibular movements (29).

The choice of an occlusal design or configuration for implant-supported prosthesis is broad and often controversial. This study aimed to evaluate and compare electromyographically the effect of medial positioned lingualized occlusion and monoplane occlusion in implant supported mandibular overdentures.

**MATERIALS AND METHODS**

Eight patients were subjected to the present study and selected from the outpatient clinic of prosthetic department; faculty of dentistry, Ain Shams University. Patients were completely edentulous, had reasonable inter-arch distance of at least 15 mm, free from any systemic disease as diabetes and hypertension, had Angle class I jaw relationship, and free from TMJ disorders. Patients who were excluded either lacked motivation, had parafunctional habits or smokers.

I- Patient Examination

Maxillary and mandibular ridges were examined for the presence of any inflammation, pathology, tissue flabbiness, bony undercuts, sharp ridge, tori or any abnormality.

**Ridge relationship evaluation**

Upper and lower alginate impressions were made for the selected patients and poured into dental stone to obtain diagnostic casts. A tentative centric jaw relation record was made and casts were mounted on fixed condylar path articulator to evaluate the interocclusal distance and ridge relationship. Only patients with adequate interocclusal distance and normal ridge relations were included in this study.

**Radiographic evaluation**

All patients were evaluated through panoramic radiographs to examine the condition of the bone height and a preliminary idea about the bone quality was concluded. Only patients with 19-20 mm bone height at least were participated in this study.

II- Presurgical Procedure

A- Patients preparation

- Patients were subjected to several sessions of patient education in implant importance, need, advantages, maintenance and care.
- Patients were prepared via proper oral hygienic measures and dental care instructions.
- Signed consent was drawn from each patient for agreement and approval of the surgical operation.

B- Patients grouping

The selected patients were randomly divided into two equal groups (group I & II):

**Group I:** In this group, patients were rehabilitated with complete dentures with modified anatomic teeth arranged following the guidelines of the medial positioned lingualized concept of occlusion.
**Group II:** In this group, patients were rehabilitated with complete dentures with non anatomic teeth arranged following the guidelines of the monoplane concept of occlusion.

**For group I:** The anterior teeth were arranged to satisfy the requirements of esthetics, phonetics and lip support. The posterior part of the lower record base was cut back to expose the retromolar pad. The central fossa of mandibular posterior teeth was set along a line drawn from the lingual border of the retromolar pad to the mesial aspect of the canine (Fig. 1).

The interlocking transverse ridges of lower posterior teeth were removed. The buccal cusps of the maxillary posterior teeth were reduced about 1mm to eliminate buccal cusp contact both in centric and eccentric jaw positions. The upper posterior teeth were arranged with their lingual cusps occluding in the modified central fossae of the lower posterior teeth.

**For group II:** Non-anatomic cross linked acrylic teeth were arranged following the guide lines of the monoplane concept of occlusion, mentioned by Jones. The upper and lower anterior teeth were arranged without vertical overlap. The lower occlusal plane was adjusted parallel to the mean foundation area. The height of the occlusal plane was made at the junction of the upper and middle thirds of the retromolar pad. Lower posterior teeth were positioned in a horizontal plane antero posteriorly and mediolaterally. The upper second molar was arranged 2 mm out of occlusion.

**For both groups:** Dentures were completed in the usual manner. The finished dentures were delivered to the patient after performing the needed occlusal adjustments following clinical remounting. Patients were instructed to perform oral and denture hygiene.

**C- Surgical Stent**

Duplicate of the patient’s lower denture was constructed using transparent acrylic resin to act as a surgical and radiographic stent. The stent was constructed with two metal balls of 5 mm diameter placed in the canine regions.

**D- Radiographic Examination**

The patient was subjected to panoramic radiography with the transparent acrylic stent in place with two balls to identify the sites of the mental foraminae.

**F- Implant Selection And Location**

Two screw type non submerged implants* 3.75 mm in diameter and nearly occupying 70% of the mandibular height at the selected area were used for all cases. The implants were located at the inter-symphesial area between the mental foraminae. The site of the two implants was marked by the aid of the panoramic radiograph taken with the acrylic stent containing the two metal balls. The stent was modified to serve as surgical stent. At least 3mm of bone was present between the distal implant and the adjacent mental foramen.

**III- The Surgical Procedure**

The surgical procedure was carried out after two to four weeks of denture insertion.

*SwissPlus Implant Centerpulse Dental Inc . Carlsbad, California, USA*
**a- Patient Preparation**

Premedication was given to the patient. The peri-oral region of the patient was cleaned by antiseptic solution. The surgical template was disinfected by antiseptic solution. The patient rinsed with 0.1% chlorhexidine mouth wash before surgery to disinfect the field of the operation. Inferior alveolar nerve block anaesthesia was administrated to the patient on both sides of the lower arch.

**b- Implant Insertion**

The stent was inserted in the patient’s mouth to indicate the length of the crestal incision.

A mid crestal incision was carried out to expose the alveolar ridge.

After bone exposure, the buccal flap was reflected by periosteal elevator. Copious irrigation through out the procedure was carried using internal and external irrigation with saline. Suction was carried out using a high suction machine. Flattening of implant sites was done by a large round surgical carbide bur. The cortical bone was penetrated firstly by 2mm pilot drill followed by successive drills 2.8mm, 3.4mm respective using a speed of 2000 rpm, high torque and internally irrigated handpiece. The implant was positioned according to the direction of the preparation site. The implant was tapped by manual wrench into its place in the osteotomy site.

Following insertion of the two implants healing caps were screwed into their corresponding implants.

**Flap repositioning and suturing:**

The surgical site was profusely irrigated with saline and cleaned. The flap was replaced and compressed in order to obtain complete closure of the soft tissue. Simple interrupted sutures were preformed using black silk 3-O suture material.

**c- Post surgical medication**

After surgery, Patients were instructed to apply cold pack for the first six hours, as for each half hour a 10 min cold application was recommended. Antibiotic, steroid and non-steroidal anti-inflammatory medications were prescribed. All patients were instructed to rinse 3 times per day post surgical with 0.2% chlorhexidine* mouth wash.

**IV- Prosthetic Procedure**

After placement of the implant and closure of the soft tissues, the mandibular dentures were relieved and relined with a tissue conditioner material and placed immediately after implant surgery.

After 1 month, the suprastructure was secured and metal coping was cemented to support the mandibular denture. Following cementation of the coping, the mandibular denture was permanently relined following an indirect relining procedure (Fig. 2,3).

Fig. (2) Intra-oral view showing the cemented metal copings.

Fig. (3) Mandibular denture following permanent relining after cementation of metal copings.
V- Recording the Electromyographic Activity:

The action potential of the masseter and anterior fibres of temporalis muscles representing the electrical activity was recorded by means of electromyography Fig. (4). The Micromed ISA 1002 Integrated stimulator amplifier was used with the following specifications: Two input channels, one storage sweep in EMG mode and 200 millisecond time base.

The patient was seated upright in a relaxed position. All records were done in the morning hours between 9 a.m. and 11 a.m. The patients were instructed for wearing their dentures at least two hours before making the records. The two muscles studied (masseter and anterior fibres of temporalis) were first located. The sites of electrodes placement were rubbed with abrasive gel and cleansed with a cotton pellet moistened with alcohol before electrodes placement. A conductive gel was applied to the inner side of the electrodes and fixed to the patient’s face with adhesive tape. Fig.(4)

The data for the EMG activity was recorded for the right and left sides separately. The EMG recordings of the two sides were summed for both muscles. The muscle activity for every patient was measured under three different conditions: During maximal clenching, eating soft diet (banana) and eating hard food (carrots). Banana and carrots were standardized in both size and consistency for all patients in all sessions using equal cubes of carrots and banana 1 cm³.

Statistical analysis

Data were presented as mean and standard deviation values. Student’s t-test was used to compare between the two groups. Paired t-test was used to compare between Masseter and Temporalis muscles and also between right and left sides in each group. The significance level was set at $P \leq 0.05$.

RESULTS

I. Comparison between the EMG of the two groups

The mean, standard deviation values and results of Student’s t-test are presented in tables (1 , 2):

1. EMG of temporalis muscle

The mean muscle activity of Temporalis muscle in patients provided with monoplane occlusion complete dentures was 602.8 μV, while the mean muscle activity of Temporalis muscle in patients provided with Lingualized occlusion complete dentures was 789.7 μV. Student’s t-test showed a statistically significant higher values of muscle activity in group I patients (medial positioned lingualized occlusion) during clenching activity ($P < 0.001$).

The mean muscle activity of Temporalis muscle in patients provided with monoplane occlusion complete dentures was 305.3 μV, while it was 764.2 μV in patients provided with complete dentures constructed following the medial positioned lingualized concept of occlusion. Student’s t-test showed a statistically significant higher values of muscle activity in group I patients (medial positioned lingualized occlusion) during eating soft food ($P < 0.001$).

The mean muscle activity of Temporalis muscle in patients provided with monoplane occlusion complete dentures was 502.3 μV, while it was 859 μV for group I patients (medial positioned lingualized). Student’s t-test showed statistically significant higher values of muscle activity in group I patients (medial positioned lingualized occlusion) during eating hard food ($P < 0.001$).


The mean muscle activity of Masseter muscle in patients provided with monoplane occlusion complete dentures was 727 μV, while it was 708 μV in patients provided with Lingualized occlusion complete dentures. Student’s t-test showed that there was no statistically significant difference between the two groups with clenching activity ($P = 0.234$).

The mean muscle activity of Masseter muscle in patients provided with monoplane occlusion complete dentures was 271.9 μV, while it was 499.2 μV for patients rehabilitated with complete dentures constructed following the medial positioned lingualized concept of occlusion. Student’s t-test showed that there was a statistically significant higher values of muscle activity in group I patients (medial positioned lingualized occlusion) during eating soft food ($P < 0.001$).

The mean muscle activity of Masseter muscle in patients provided with monoplane occlusion complete dentures was 576.3 μV, while it was 613.3 μV in patients rehabilitated with complete dentures constructed following the medial positioned lingualized concept of occlusion. Student’s t-test showed that there was a statistically significant higher values of muscle activity in group I patients (medial positioned lingualized occlusion) during eating hard food ($P = 0.04$)

### II. Comparison between right and left sides

The means, standard deviation values and results of paired t-test are presented in the following tables and figures:

#### TABLE (1) Means of EMG of the right and left sides of Temporals muscle in the two studied groups.

<table>
<thead>
<tr>
<th>Side</th>
<th>Group Activity</th>
<th>Monoplane</th>
<th>Lingualized</th>
<th>t-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of the two</td>
<td>Clenching</td>
<td>602.8</td>
<td>789.7</td>
<td>-10.842</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Mean of the two</td>
<td>Soft food</td>
<td>305.3</td>
<td>764.2</td>
<td>-27.839</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Mean of the two</td>
<td>Hard food</td>
<td>502.3</td>
<td>859</td>
<td>-17.756</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

*: Significant at $P \leq 0.05$

#### TABLE (2) Mean of EMG of the right and left sides of Masseter muscle in the two studied groups.

<table>
<thead>
<tr>
<th>Side</th>
<th>Group Activity</th>
<th>Monoplane</th>
<th>Lingualized</th>
<th>t-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of the two</td>
<td>Clenching</td>
<td>727</td>
<td>708</td>
<td>1.399</td>
<td>0.234</td>
</tr>
<tr>
<td>Mean of the two</td>
<td>Soft food</td>
<td>271.9</td>
<td>499.2</td>
<td>-30.761</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Mean of the two</td>
<td>Hard food</td>
<td>576.3</td>
<td>613.3</td>
<td>-2.909</td>
<td>0.044*</td>
</tr>
</tbody>
</table>

*: Significant at $P \leq 0.05$
I. Monoplane occlusion group

TABLE (3) The means, standard deviation values and results of paired t-test of the two sides in the Monoplane occlusion group

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Side Activity</th>
<th>Right Mean</th>
<th>Right SD</th>
<th>Left Mean</th>
<th>Left SD</th>
<th>t-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporalis</td>
<td>Clenching</td>
<td>592.7</td>
<td>36.9</td>
<td>613</td>
<td>9.8</td>
<td>-0.773</td>
<td>0.520</td>
</tr>
<tr>
<td></td>
<td>Soft food</td>
<td>246.7</td>
<td>25.2</td>
<td>364</td>
<td>5.2</td>
<td>-6.889</td>
<td>0.020*</td>
</tr>
<tr>
<td></td>
<td>Hard food</td>
<td>457.7</td>
<td>8.1</td>
<td>547</td>
<td>6.2</td>
<td>-26.407</td>
<td>0.001*</td>
</tr>
<tr>
<td>Masseter</td>
<td>Clenching</td>
<td>725</td>
<td>14.7</td>
<td>729</td>
<td>22.5</td>
<td>-0.281</td>
<td>0.805</td>
</tr>
<tr>
<td></td>
<td>Soft food</td>
<td>231.5</td>
<td>16</td>
<td>312.3</td>
<td>4</td>
<td>-11.684</td>
<td>0.007*</td>
</tr>
<tr>
<td></td>
<td>Hard food</td>
<td>440.7</td>
<td>22.9</td>
<td>712</td>
<td>10</td>
<td>-32.717</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

*: Significant at P ≤ 0.05

- **Temporalis muscle:**

  The mean muscle activity of the right Temporalis muscle in patients provided with monoplane occlusion complete dentures was 592.7 μV, while it was 613 μV in patients provided with monoplane occlusion complete dentures. Paired t-test showed that there was no statistically significant difference between the two sides with clenching activity (P = 0.520).

  The mean muscle activity of the right Temporalis muscle in patients provided with monoplane occlusion complete dentures was 246.7 μV, while it was 364 μV in patients provided with monoplane occlusion complete dentures. Paired t-test showed a statistically significant difference between the two sides when eating soft food (P = 0.020).

  The mean muscle activity of the right Temporalis muscle in patients provided with monoplane occlusion complete dentures was 457.7 μV, while it was 547 μV in patients provided with monoplane occlusion complete dentures. Paired t-test showed that there was a statistically significant difference between the two sides when eating hard food (P = 0.001).

- **Masseter muscle:**

  The mean muscle activity of the right Masseter muscle in patients provided with monoplane occlusion complete dentures was 725 μV, while it was 729 μV in patients provided with monoplane occlusion complete dentures. Paired t-test showed that there was no statistically significant difference between the two sides with clenching activity (P = 0.805).

  The mean muscle activity of the right Masseter muscle in patients provided with monoplane occlusion complete dentures was 231.5 μV, while it was 312.3 μV in patients provided with monoplane occlusion complete dentures. Paired t-test showed a statistically significant difference between the two sides when eating soft food (P = 0.007).

  The mean muscle activity of the right Masseter muscle in patients provided with monoplane occlusion complete dentures was 440.7 μV, while it was 712 μV in patients provided with monoplane occlusion complete dentures. Paired t-test showed a statistically significant difference between the two sides when eating hard food (P = 0.001).
2. Lingualized Occlusion Group

TABLE (4) The means, standard deviation values and results of paired t-test of the two sides in the Medial positioned lingualized occlusion group.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Side</th>
<th>Activity</th>
<th>Right</th>
<th>Left</th>
<th>t-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Temporalis</td>
<td>Clenching</td>
<td></td>
<td>612.7</td>
<td>11</td>
<td>966.7</td>
<td>27.7</td>
</tr>
<tr>
<td></td>
<td>Soft food</td>
<td></td>
<td>644.7</td>
<td>40.8</td>
<td>883.7</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Hard food</td>
<td></td>
<td>834.3</td>
<td>31.8</td>
<td>884.7</td>
<td>8.1</td>
</tr>
<tr>
<td>Masseter</td>
<td>Clenching</td>
<td></td>
<td>785.3</td>
<td>22.3</td>
<td>630.7</td>
<td>18.5</td>
</tr>
<tr>
<td></td>
<td>Soft food</td>
<td></td>
<td>597</td>
<td>14.8</td>
<td>401.3</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>Hard food</td>
<td></td>
<td>643.3</td>
<td>24.6</td>
<td>583.3</td>
<td>5.8</td>
</tr>
</tbody>
</table>

*: Significant at $P \leq 0.05$

- **Temporalis muscle**
  
  The mean muscle activity of the right Temporalis muscle in patients rehabilitated with complete dentures constructed following the medial positioned lingualized concept of occlusion was 612.7 $\mu$V, while it was 966.7 $\mu$V in the same group. Paired t-test showed a statistically significant difference between the two sides with clenching activity ($P = 0.011$).

  The mean muscle activity of the right Temporalis muscle in patients rehabilitated with complete dentures constructed following the medial positioned lingualized concept of occlusion was 644.7 $\mu$V, while it was 883.7 $\mu$V in the same group. Paired t-test showed a statistically significant difference between the two sides when eating soft food ($P = 0.006$).

  The mean muscle activity of the right Temporalis muscle in patients rehabilitated with complete dentures constructed following the medial positioned lingualized concept of occlusion was 834.3 $\mu$V, while it was 884.7 $\mu$V in the same group. Paired t-test showed no statistically significant difference between the two sides when eating hard food ($P = 0.244$).

- **Masseter muscle**
  
  The mean muscle activity of the right Masseter muscle in patients rehabilitated with complete dentures constructed following the medial positioned lingualized concept of occlusion was 785.3 $\mu$V, while it was 630.7 $\mu$V in the same group. Paired t-test showed a statistically significant difference between the two sides with clenching activity ($P = 0.004$).

  The mean muscle activity of the right Masseter muscle in patients rehabilitated with complete dentures constructed following the medial positioned lingualized concept of occlusion was 597 $\mu$V, while it was 401.3 $\mu$V in the same group. Paired t-test showed a statistically significant difference between the two sides when eating soft food ($P = 0.002$).

  The mean muscle activity of the right Masseter muscle in patients rehabilitated with complete dentures constructed following the medial positioned lingualized concept of occlusion was 643.3 $\mu$V, while it was 583.3 $\mu$V in the same group. Paired t-test showed a statistically significant difference between the two sides when eating hard food ($P = 0.034$).
III. Comparison between the two groups

TABLE (5) The means, standard deviation values and results of Student’s t-test of the two groups.

<table>
<thead>
<tr>
<th>Side</th>
<th>Group</th>
<th>Activity</th>
<th>Monoplane</th>
<th>Lingualized</th>
<th>t-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>Clenching</td>
<td>658.8</td>
<td>26.7</td>
<td>699</td>
<td>45.9</td>
<td>-0.801</td>
</tr>
<tr>
<td></td>
<td>Soft food</td>
<td>239.1</td>
<td>20.6</td>
<td>620.8</td>
<td>37.9</td>
<td>-21.680</td>
</tr>
<tr>
<td></td>
<td>Hard food</td>
<td>449.2</td>
<td>18</td>
<td>738.8</td>
<td>12.5</td>
<td>-6.226</td>
</tr>
<tr>
<td>Left</td>
<td>Clenching</td>
<td>671</td>
<td>25.4</td>
<td>798.7</td>
<td>28</td>
<td>-1.571</td>
</tr>
<tr>
<td></td>
<td>Soft food</td>
<td>338.2</td>
<td>28.6</td>
<td>642.5</td>
<td>46.4</td>
<td>-2.804</td>
</tr>
<tr>
<td></td>
<td>Hard food</td>
<td>629.5</td>
<td>30.7</td>
<td>734</td>
<td>56.2</td>
<td>-1.358</td>
</tr>
<tr>
<td>Mean of the two sides</td>
<td>Clenching</td>
<td>664.9</td>
<td>19.2</td>
<td>748.8</td>
<td>29.1</td>
<td>-2.422</td>
</tr>
<tr>
<td></td>
<td>Soft food</td>
<td>288.6</td>
<td>20.5</td>
<td>631.7</td>
<td>16.2</td>
<td>-5.692</td>
</tr>
<tr>
<td></td>
<td>Hard food</td>
<td>539.3</td>
<td>42</td>
<td>736.4</td>
<td>36.9</td>
<td>-3.372</td>
</tr>
</tbody>
</table>

*: Significant at $P \leq 0.05$

- **Right side:**

The mean muscle activity of both muscles in patients rehabilitated with complete dentures constructed following the monoplane concept of occlusion was 658.8 μV, while the mean muscle activity of both muscles in patients rehabilitated with complete dentures constructed following the medial positioned lingualized concept of occlusion was 699 μV. Student’s t-test showed no statistically significant difference between the two groups with clenching activity ($P = 0.442$).

The mean muscle activity of both muscles in patients provided with monoplane occlusion complete dentures was 239.1 μV, while the mean muscle activity of both muscles in patients provided with complete dentures constructed following the medial positioned lingualized concept of occlusion was 620.8 μV. Student’s t-test showed a statistically significant higher values of muscle activity in group I patients (medial positioned lingualized occlusion) during eating soft food ($P < 0.001$).

- **Left side:**

The mean muscle activity of both muscles in patients provided with monoplane occlusion complete dentures was 671 μV, while the mean muscle activity of both muscles in patients provided with complete dentures constructed following the medial positioned lingualized concept of occlusion was 798.7 μV. Student’s t-test showed no statistically significant difference between the two groups with clenching activity ($P = 0.147$).
The mean muscle activity of both muscles in patients provided with monoplane occlusion complete dentures was 338.2 μV, while it was 642.5 μV for patients rehabilitated with complete dentures constructed following the medial positioned lingualized concept of occlusion. Student’s t-test showed a statistically significant higher values of muscle activity in group I patients (medial positioned lingualized occlusion) during eating soft food ($P = 0.019$).

The mean muscle activity of both muscles in patients provided with monoplane occlusion complete dentures was 629.5 μV, while the mean muscle activity of both muscles in patients provided with complete dentures constructed following the medial positioned lingualized concept of occlusion was 734 μV. Student’s t-test showed no statistically significant difference between the two groups with hard food ($P = 0.204$).

- **Mean of the two sides:**

  The mean muscle activity of both muscles in patients rehabilitated with complete dentures constructed following the monoplane concept of occlusion was 664.9 μV, while it was 748.8 μV in patients rehabilitated with complete dentures constructed following the medial positioned lingualized concept of occlusion. Student’s t-test showed statistically significant higher values of muscle activity in group I patients (medial positioned lingualized occlusion) during clenching ($P = 0.036$).

  The mean muscle activity of both muscles in patients provided with monoplane occlusion complete dentures was 288.6 μV, while it was 631.7 μV in patients provided with complete dentures constructed following the medial positioned lingualized concept of occlusion. Student’s t-test showed a statistically significant higher values of muscle activity in group I patients (medial positioned lingualized occlusion) during eating soft food ($P < 0.001$).

  The mean muscle activity of both muscles in patients provided with monoplane occlusion complete dentures was 539.3 μV, while the mean muscle activity of both muscles in patients provided with complete dentures constructed following the medial positioned lingualized concept of occlusion was 736.4 μV. Student’s t-test showed statistically significant higher values of muscle activity in group I patients (medial positioned lingualized occlusion) during eating hard food ($P = 0.007$).

**DISCUSSION**

In this study the selected patients were free from any chronic systemic disease that may impair healing power or bone metabolism. Patients with sufficient labio-lingual width of the anterior part of the edentulous ridge were only selected to ensure at least one millimeter thickness of bone remaining labial and lingual to the implant after its placement. $(31)$.

All patients were motivated for good oral and denture hygiene. Regular home care was essential to ensure proper condition of the implants since one of the main causes of failure of osseointegrated implants is lack of proper oral and denture hygiene as was indicated by many authors $(32-34)$.

Cases with abnormal ridge relationship other than Angle’s class I were excluded from this study to facilitate implants insertion and avoid implants overloading $(27)$. Patients with bruxing or grinding habits were totally excluded to avoid force concentration especially horizontal stresses on the early loaded, osseointegrated implants which might affect the overall results $(33)$. Heavy smokers were excluded as smoking is considered an...
important factor in early implant failure due to anoxia of the oral cavity together with significant increase in plaque formation and calculus deposits as reported by many authors\textsuperscript{(33,34)}.

Since the type of opposing occlusion is a critical factor that influence the magnitude of forces transmitted to the implant bone interface, the opposing occlusion was selected to be mucosa-supported complete denture to standardize and control the amount of occlusal forces applied to the abutments. Complete dentures were proved to exert less amount of force compared to the natural teeth\textsuperscript{(35)}.

In this study two non interfering occlusal schemes were established: the medial positioned lingualized occlusion and the monoplane occlusion\textsuperscript{(36,37)}. Monoplane occlusion can adapt to the slight discrepancies between centric occlusion and centric relation that usually occurs due to processing errors of the acrylic resin denture base and / or settling of the dentures after wear. In addition the elimination of the cuspal inclines of posterior teeth reduces the horizontal forces transferred to the abutments, thus maintaining and preserving the alveolar bone surrounding the implants\textsuperscript{(36)}.

The medial positioned lingualized concept of occlusion was considered the occlusal concept of choice for mandibular implant supported overdenture opposed by a maxillary complete denture. This occlusal scheme provides contact of the lingual cusps only of the maxillary posterior teeth during centric occlusion thus stabilizing the maxillary denture and reducing the occlusal table.

Clinical remount and post operative adjustment visits were carried out to correct any occlusal error, as any premature contact can concentrate the occlusal forces on the abutment supporting structures\textsuperscript{(38)}.

The duplication of the lower denture using transparent acrylic resin to obtain a surgical stent helped in the proper determination of the implant sites labio-lingually and mesio-distally in an ideal position relative to the constructed denture.

The Swiss-Plus implant requires only one surgical procedure thus saving time for the clinician as well as eliminating a second surgical trauma to the patient. The soft tissue heals around the implant collar from time of implant placement eliminating the need for additional incisions or a second stage healing period.

Swiss-Plus implants, being of the Screw type provide primary fixation to the bone during the initial healing period as well as increase the area of contact between the implant and the surrounding bone\textsuperscript{(39,40)}. Implants in this study were 13mm. in length, 3.75mm. in diameter, as the proposed site for implants placement was the lower anterior region between the two mental foraminae where good bone quality is frequently found as reported by Chiapasco et al.\textsuperscript{(41)} As the early loaded implants should engage dense cortical bone to increase the primary stability needed for successful osseointegration. In addition, it is the area of greatest available bone height, showing thick cortical plates with dense trabecular bone\textsuperscript{(27,42)}.

An umbrella of antibiotics was prescribed and continued for a week post-operatively as a precaution against possible infection.

Proper control of frictional heat generation during preparation of the implants sites was carefully considered for preservation of the surrounding bone cells at the implant sites\textsuperscript{(43)}. Thus using handpieces with low speed, using light and gentle pressure and a series of sharp drills with a gradual increase in diameter together with copious irrigation during preparation of the implant sites to ensure sequential widening of the implants’ bed and initial stability after installation\textsuperscript{(44)}.

Implants were early loaded at four weeks as recommended by Fradera et al.,\textsuperscript{(45)} who reported that when an implant is inserted into bone only a small bone quantity proceeding from the trabecular bone of the bone marrow is in contact with implant surface. This coagulation phenomenon would be produced as an initial response loading to osteoid tissue production on the implant surface and lasts for approximately one month (osteophytic phase). Then another phase starts which is the osteoconductive phase in which the bone
would continue being placed on the implant surface, thus loading the implants would be delayed to four weeks in order not to interfere with this phase.

Following placement of the implant and completion of primary closure of the soft tissue around the necks of the implant, the mandibular denture was relieved and relined with a tissue conditioning material and placed immediately after implant surgery in order to minimize the load falling on the implant during the immediate postoperative period.

Surface EMG of masticatory muscles is currently a part of the quantitative assessment of patients in dentistry. Among the jaw elevator muscles, the masseter and temporalis muscles are the most often assessed in clinical evaluations because they are the most superficial, and they are the only accessible to surface EMG examination. In contrast, the medial and lateral pterygoid muscles can be evaluated only with needle EMG.

In the current study, to reduce patient variability, the EMG protocol comprised standardization of carrots and banana in both size and consistency for all patients in all sessions using equal cubes of 1 cm$^3$ using the same electrodes, cables, and EMG apparatus, and on the same cutaneous area in order to limit the biological and technical noise.

Standardized EMG potentials can allow the measurement of the actual impact of morphology on stomatognathic function from the standardized electric potentials produced by the single masticatory muscle, the muscular activity (integrated value in time) can be calculated to assess the actual effort made by the muscle.

Generally the patients who participated in this study were satisfied with their implant-supported overdentures. Statistical analysis of the results showed that the electromyographic activity of the masseter muscle was significantly higher than the temporalis muscle during chewing either hard or soft types of food with both types of dentures.

This may be attributed to the greater influence and the greater efforts exerted by the masseter muscle on the denture during chewing than the temporalis muscle as indicated by Landulpho et al(46).

Comparison between the right & left sides of the same muscle in the two studied groups showed no significant difference during clenching activity. These findings could be attributed to the fact that the patients in the two groups are exerting the maximum biting force during clenching activity. This is in agreement with Ferrario et al(47). It is worth mentioning that the insignificant difference recorded between the right and left sides of Temporalis muscle during chewing hard food may be attributed to the fact that the patients were allowed to use their preferable chewing side and not limiting the records to a specific side. These findings are in agreement with Ferrario and Sforza(48).

Data obtained for the muscle activity in patients rehabilitated with complete dentures constructed following the medial positioned lingualized concept of occlusion showed statistically significant increase in muscle activity during chewing either soft or hard food. This may be attributed to the medial arrangement of posterior teeth with the palatal cusps forming the primary occlusal contacts ensuring axial loading of the implant, more regular chewing patterns and improving the muscle activity during function as indicated by Van Kampen et al (49).

**SUMMARY**

This study evaluated the effect of two different occlusal schemes on the muscle activity in implant supported mandibular overdentures.

Eight completely edentulous patient were selected for this study and were rehabilitated with fully functional complete dentures two weeks before any surgical intervention. The cases were divided into two groups. Group I received implant supported mandibular overdentures with modified anatomic teeth arranged following the medial positioned lingualized concept of occlusion. Group II received implant supported mandibular overdentures with non anatomic teeth arranged following the monoplane occlusion concept.
The electrical activity of the masseter and anterior temporalis muscles was recorded by means of electromyography. The data for the EMG activity was recorded for the right and left sides separately.

The EMG recordings of the two sides were summed for both muscles. The results of this study revealed increase in the muscle activity in patients rehabilitated with mandibular implant supported overdentures constructed following the medial positioned lingualized concept of occlusion compared to those rehabilitated with mandibular implant supported overdentures constructed following the monoplane concept of occlusion.

**CONCLUSION**

Based on the results of this study, it could be inferred that the use of medial positioned lingualized concept of occlusion in implant supported mandibular overdentures opposed by maxillary complete dentures lead to an increase in the muscle activity.

**REFERENCES**


