Evaluation of mini-implant-retained overdentures on the electromyographic activity and patients’ satisfaction in completely edentulous patients (randomized clinical trial)

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Abstract

Background: With the advance of the dental implants, the retention and stability of mandibular complete denture have been improved to a large extent. The implants could be placed interforaminally or in anterior and posterior ridge areas. The placements of the implant in the molar area increase denture support that reflects on improvement in patient mastication and muscles activity.

Aim: This study was conducted to evaluate the effect of the distribution of the mini-implants (MIs) on electromyographic (EMG) activity of masticatory muscles and overall patient satisfaction.

Materials and Methods: Ten completely edentulous male patients with severely resorbed mandibular ridge were enrolled in this study. Patients were randomly divided into two equal groups. Group (I and II) according to the MIs and distribution pattern. Group (I): Five patients had received four mini-dental implants in interforaminal area. Group (II): Five patients had received four mini-dental implants (two implants in the interforaminal area and two implants in the molar areas). All patients had received implant overdentures. Overdentures were connected to the MIs with O-ring attachments. For each patient, the EMG activity of masticatory muscles and a survey of therapeutic satisfaction before and after connection to the MIs was evaluated.

Results: The MI-retained overdentures of the Group II in which the implants placed in the interforaminal area and molar areas showed significant lower EMG values than Group I with soft and hard foods as well as clenching.

Conclusions: The distribution of MIs plays a role in the muscle activity, and the placement of implants in the molar area improves the muscle activity and patient satisfaction.

Clinical Significance: The placement of MIs to retain mandibular complete denture improves muscles activity and patient satisfaction, particularly, if placed in both anterior and molars areas.

Keywords

Mini-implant, muscle activity, overdenture, patient satisfaction

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Introduction

The patients with complete dentures need 7 folds more chewing strokes to reduce the size of food than those with a complete set of natural dentition.[1]

Several studies have shown that the oral function and the ability of complete dentures wearers to chew most foods improved significantly when the mandibular denture is supported by dental implant.[2,3]

Mini-implant (MI) is defined as dental implants with smaller diameter (2.7 mm or less) than regular implants.[4] The short implants are indicated to retain complete, partial removable dentures and to support fixed partial denture.[5,6]

Many researchers reported that the MI surgery is a non-invasive simple procedure offering numerous advantages, including decreased surgical time, less cost, improve soft tissue architecture, and hard tissue volume at the site of implant placement.[7,8]

The aim of this comparative study was to evaluate the effect of different positions (interforaminal and both inter-foraminal and posterior areas) of MI supporting mandibular overdenture on the masticatory function.
Materials and Methods

- Ten male edentulous patients were selected from outpatient clinic, Prosthodontic Department, Faculty of Oral and Dental Medicine, Cairo University.
- All patients were informed about the treatment plan, the recall visits, and the total study period and then signed written consent by them.
- Radiographic evaluation pre-operatively was done for every patient with panoramic radiograph to evaluate the alveolar bone quality and quantity at the proposed implant sites to detect the proper implant size, the presence of remaining teeth or pathological lesions, and the relation to vital structures.
- Conventional maxillary and mandibular complete dentures were constructed in traditional manner.
- Acrylic resin teeth were arranged using the bilateral balanced occlusal concept.
- To improve patient’s neuromuscular adaptation, they were encouraged to wear their new constructed dentures 1 month before implant surgery.
- Oral dose of 2 mg amoxicillin was given as per best current evidence.[9]

MI system

- Group I: Four MIs (3 M® 2.4 mm diameter, 10 mm length one-piece implant) were placed in the interforaminal region of the edentulous mandible.
- Group-II: Four MIs (3 M® 2.4 mm diameter, 10 mm length one-piece implant) were placed as following: Two in interforaminal area and two in the lower molar of the edentulous mandible.

Surgical protocol

- Local infiltration anesthesia was performed at the anterior mandible. The surgical template was seated over the mandibular ridge, and a tissue marking probe was inserted through holes in the stent performed corresponding to the proposed implant sites to mark bleeding points at the sites selected for implant placement. The preparation of the implant site was done by drilling the implant osteotomies according to manufacturer instructions.
- The direction of drilling was kept perpendicular to the bone, and midway buccolingually till reaching the desired depth, putting in consideration the parallelism between the four implants.
- After preparation of each osteotomy site, the implant was installed until the complete seating in its bed [Figure 1].
- After implants’ installation, the mandibular denture was properly relived to allow complete seating onto the implants without the housings, and pressure indicating paste was utilized to verify proper relief.
- Patients were recalled every 2 weeks to ensure the absence of any contact between ball attachments and the overdenture that might occur due to the settling of the denture.

Pickup procedures

- The pickup procedure was carried out after 3 months.
- Rubberband sheets were placed around the ball abutments, and then, rubber O-ring and metallic housing caps were placed on the MIs.
- Mandibular denture was seated into the patient’s mouth, and cold curing resin was injected in the relieved areas of the denture.
- The resin was left to polymerize while the patient was closing in maximal intercuspal position with gentle pressure.
- The overdenture was removed with the housings picked-up in its fitting surface; finished and polished the denture was delivered to the patient [Figure 2].

Outcomes

Surface electromyography (EMG) of masticatory muscles

- 4 weeks after overdenture loading and patients’ adaptation to their overdentures, EMG activity of masticatory muscles was evaluated.
- The patients were seated comfortably in upright relaxed positions, with their heads unsupported in an office-type chair, arms next to the body, and hands resting on their thighs.
- The skin areas where the electrodes were placed were cleaned with alcohol and shaved when necessary.
- Disposable bipolar surface electrodes were fixed with adhesive bandage tape on the bellies of masseter muscles (both sides) parallel to muscular fibers.

Figure 1: Implants placed in prepared sites

Figure 2: Pickup procedure for (a) Group I and (b) Group II
• Electrodes were placed over temporal muscle 2.5 cm posterior and 2.5 cm superior to the outer canthus of the eye.
• The EMG activity recording for the right and left sides at maximum intercuspal position in patients of both groups.
• Recording was carried out during maximum voluntary clenching without food, clenching on soft food (banana), and clenching on hard food (carrot) to evaluate the effect of the presence of food and food type on EMG of massetter muscles.
• The patient was instructed to clench for 5 s and to rest for 15 s, and this procedure was repeated for 5 times.
• The highest EMG activity was considered as the maximum clenching EMG activity.
• Muscle activity was recorded during chewing equally sized pieces of carrot as hard food and banana as soft food.
• Foods were positioned at the first molar region of the preferred chewing side.
• The mean value of the EMG activity of each muscle was calculated from the root mean square amplitude in microvolts.
• Data from the two groups were collected, tabulated, and statistically analyzed.

**Patient satisfaction measures**

- Patients’ satisfaction with their prosthesis was assessed with the aid of special questionnaire and a visual analog scale (VAS).
- VAS described by Grandmont (1994).[10]
- The two ends (anchors) in a line about 10 cm represent the best and worst, respectively.
- Patients draw the location between two anchors to represent their feeling for every question. The distances of the location to anchors could be measured and quantified. After quantification, scores can be used to represent patient’s satisfaction.

**Results**

The results of the present study had revealed that there is no statistically significant difference in the massetter and temporalis muscles activity during clenching in both studied groups. On the other hand, during chewing soft and hard food, there was statistically significant difference between the studied groups for the massetter and temporalis muscles activity as summarized in Tables 1 and 2.

Regarding patient satisfaction, the results of this study revealed improvements in both groups. Ability to speak, the level of comfort, stability of the dentures, perception of the chewing ability, and function showed similar improvement in both groups pre- and post-implant placement. Moreover, there was no apparent distinction between the two groups regarding general satisfaction, cleaning, esthetic, and oral conditions.

**Discussion**

The present study had found that MI-retained mandibular overdentures achieved favorable results according to patient perceptions. This finding could be explained as the MIs improve the stability of the lower denture and consequently the muscle effort, potential, and strength. In agreements with our results, Heckmann et al.[11] reported that the dental implants improved the functional state of the masticatory apparatus and aided in the establishment of better neuromuscular coordination toward values of healthy dentate by improving the support, stability, and retention of the prosthesis. In this case, muscle activity was totally devoted to and directed...
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Difference between both types of the attachments.

The statistically significant increase in the muscle activity of both the masseter and anterior temporalis muscles when using different implant supported overdenture designs may be due to the fact that the functional activities of the stomatognathic apparatus require a stable tooth contact between the opposing dental arches. Hence, implant-supported overdentures provide a sufficient number of dental contacts which provide a stable reference for the contraction of the masticatory muscles during static “clenching” and dynamic “chewing soft and hard food” activities.\[14\]

The results of the present study showed that the masseter muscle employs higher muscle activity when compared to the temporalis muscle. These findings 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.\[15\]

In accordance with our finding, Shaarawy and Aboelross\[16\] compared standard implant distribution, group 1: Implants placed in interforaminal and molar areas, group 2: Implants placed in interforaminal area only, and on the EMG of mandibular overdenture, the results revealed a significant difference between the two groups after 3 months during chewing hard food for both muscles, whereby group 1 showed higher values. This may be because inserting the implants further apart by shifting them more posteriorly in group 2 may have resulted in better load distribution over a larger area, allowing for a wider area for chewing and hence better denture stability. Moreover, it renders the overdentures mostly implant supported, with no posterior soft-tissue contribution in support. All such factors eliminate the need for high muscle activity for food mastication.

A recent systematic review by Kim et al.\[17\] indicated that the treatment effect with mandibular implant overdenture is not related to attachment system. Cheng et al.\[18\] studied the masticatory efficiency of implant overdentures retained by locator and magnet attachments, and the results showed no difference between both types of the attachments.

References
