Conventional Versus Implant-Retained Overlay Dentures: A Pilot Study of Masseter and Anterior Temporalis Electromyography

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Implant-supported overlay dentures (ISODs) have been widely accepted among patients using conventional removable complete dentures (CRCDs). The present study aimed to comparatively study conventional and ISODs in terms of function and coordination of masticatory muscles using electromyograms. Included were 10 patients with ISODs (each with 2 implants in the intercanine area). The mean wave range (MWR) and frequency (MWF) of masseter and temporalis were recorded with (ISOD) and without (CRCD) ball attachments while maximum clenching on cotton rolls (cotton roll clenching), maximum intercuspal clenching (clenching), and unilateral gum chewing (chewing) using electromyography. Data were analyzed in SPAW using *t*-paired for matched groups and independent-sample *t* tests for unmatched ones. The MWF differences were not statistically significant with or without attachments ($P > .05$). Without attachments in place, the MWF of both masseter and temporalis muscles significantly decreased when patients clenched on cotton rolls ($P = .01$ and .02, respectively) and when chewing unilaterally (both $P = .01$). With attachments present, the right and left temporalis muscles did not show identical mean wave ranges while chewing ($P = .01$). Without attachments, this disharmony was seen in the left and right masseter muscles ($P = .03$). The MWR of masseter was higher in men while chewing with attachments ($P = .02$). Without attachments, the MWR of temporalis was higher in women while cotton roll clenching ($P = .03$) and chewing ($P = .02$). These findings are seemingly in favor of improved masticatory function and coordination in edentulous patients with the application of ISODs.

Key Words: dental implants, electromyography, implant-supported overlay dentures, masseter muscle, temporal muscle

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INTRODUCTION

The problems with retention and resistance of conventional removable complete dentures (CRCDs) have caused many patients not to be satisfied with their oral functions. Implant-supported overlay dentures (ISODs) are seemingly proper treatment alternatives for this group, who have

expressed higher satisfaction with the use of ISODs.[1–5] Also, a superior functionality has been reported through objective methods.[4–12] Maximum biting force in patients with ISOD is 60 to 200 times higher than that of patients with CRCDs.[9,10] The number of chewing cycles reduces significantly with the application of ISODs, which well depicts the improvement of mastication efficacy. Meanwhile, the type of the prostheses (fixed vs removable) and the number of supporting fixtures do not seem to influence the treatment outcomes significantly.[4]

The function of masticatory muscles and their neuromuscular harmony during mastication have been assessed in the literature.[11–15] However, to the best of our knowledge, CRCDs and ISODs have been often compared in 2 different groups of patients.[3,4,8–10,13] The present study aimed to comparatively assess the electromyographic (EMG) activity of the same patients with and without implant support.

Materials and Methods

Overview

This within-patient clinical trial was conducted in our Department of Oral and Maxillofacial Prosthodontics and Implants from January to August 2010. The study was peer-reviewed and approved by our local board of ethics and research methodology. Informed consents were obtained in advance from all patients.

Patients

Included were 10 patients (5 male and 5 female) with mandibular ISODs and maxillary CRCDs. The mandibular implants were placed in the anterior region of the maxilla between the 2 mental foramina at least 6 months prior to the study. All prostheses were fabricated at least 3 months in advance of the study (conventional loading) by 2 prosthodontists in our center and a private office. Clinical examinations by a prosthodontist were the basis for the patient selection. Inclusion criteria included the following:

- Fixtures should have been fully submerged so that there would be no contact with the interior surface of the denture
- Proper denture acrylic extensions should have been present; the presence of sore oral epithelium in contact with the overlay denture and uncomfortable mastication were considered as evidence to the contrary
- The presence of proper vertical dimension (VD) prior to and after the removal of the attachments

Exclusion criteria included the following:

- The presence of temporomandibular disorders, including clicking, limited mouth opening, and so forth
- The presense of some systemic conditions and disease such as osteoporosis or any kind of myopathy and muscular dysfunction
- The presense of any parafunctional activities (bruxism, clenching, etc)
- The presence of muscle tenderness

Electromyography

As there were no EMG devices in our dental research center, we used some devices in the medical office that were used for diagnostic purposes with needle electrodes, which are almost invasive. Therefore, we changed those electrodes to the superficial bipolar ones. Besides of that and based on our study's goals, we calibrated those apparatuses again.

The EMG activity of the right and left masseter and temporalis muscles was recorded in a private office. Bipolar superficial electrodes with a fixed distance of 3 cm were used. The EMG of the muscles was recorded using Phasis II (EsaOte, Florence, Italy):

1. With attachments in place
2. After the removal of the attachments

During:

1. Maximum bite force on the cotton roll (cotton roll clenching)
2. Maximum intercuspation (MIC; clenching)

Six examinations were then performed on each muscle, which counted for a total of 24 examinations for each patient. After recording EMGs in the first examination session, attachments were removed and measurements of "without attachments" type were performed after a week. Following the completion of the second examination, the attachments were reinstalled.

For each measurement, the active pole of the electrode was placed on the body of the muscles,

parallel to the muscular fibers. Mandibular angle and frontal bone were used as grounds for masseter and temporalis muscles, respectively.[7] During the myographic measurements, patients were asked to sit on a chair and look straight to the front. No head support was used. Prior to the examinations, the scalp was cleaned by alcohol using a cotton roll to reduce the resistance of the skin and electrical interferences and to gain better conductivity to the recording electrode.[7]

To record the EMG, patients were asked to bite with maximum force on a cotton roll for 3 minutes. They were asked to maintain a steady constant force during the examination. To ensure the consistence of the bite force, patients were provided with audiovisual feedback: they were able to monitor their bite force changes on a screen in front of them. The bite force was displayed in the form of waves. Also, the patients could hear a tune based on the applied pressure. The myographic activity was then recorded in the form of average wave range (in mV) and average frequency (Hz). After a couple of minutes of muscular rest, the patients were asked to clench for 5 minutes in MIC. The same procedure was followed to record EMG. After a couple of minutes of muscular rest, every patient was given a piece of chewing gum (Wrigley PK Germany by Wrigley Company Ltd, Nairobi, Kenya). After 10 seconds of chewing to soften the chewing gum, the patients were asked to chew only unilaterally for 15 seconds, and the same procedure was applied to record EMG. The waves were recorded with low filter (20 Hz) and high filter (10 KHz) with a resolution of 200 μV and a wavelength of 200 ms/div.

Statistics

The data were statistically analyzed by paired *t* test for matched-group comparisons and independent *t* test for unmatched ones using Predictive Analytic Software (PASW; SPSS, Chicago, Ill). The number of patients was calculated so that a 5-mV difference will be statistically significant with a confidence interval of 0.80 and an $\alpha = .05$.[3]

Results

Right and left masseter and temporalis muscles of 10 patients (5 females and 5 males) aged 43 to 74 years (mean age = 62 years) with mandibular ISODs and maxillary CRCDs were electromyographically studied with regard to 3 different jaw functions.

Mean wave range

Effect of Attachments

No statistically significant differences were found between clenching and chewing values before attachment removal and those afterward in either masseter or temporalis muscles. A statistically significant decrease, however, was detected for the cotton roll clenching values without attachments in both masseter and temporalis muscles ($P = .02$ both; Figures 1 and 2).

Masseter vs Temporalis

No statistically significant differences were found between masseter and temporalis muscles in terms of mean wave range (MWR) values in cotton roll clenching, clenching, or chewing with or without attachments in place.

Muscular Harmony

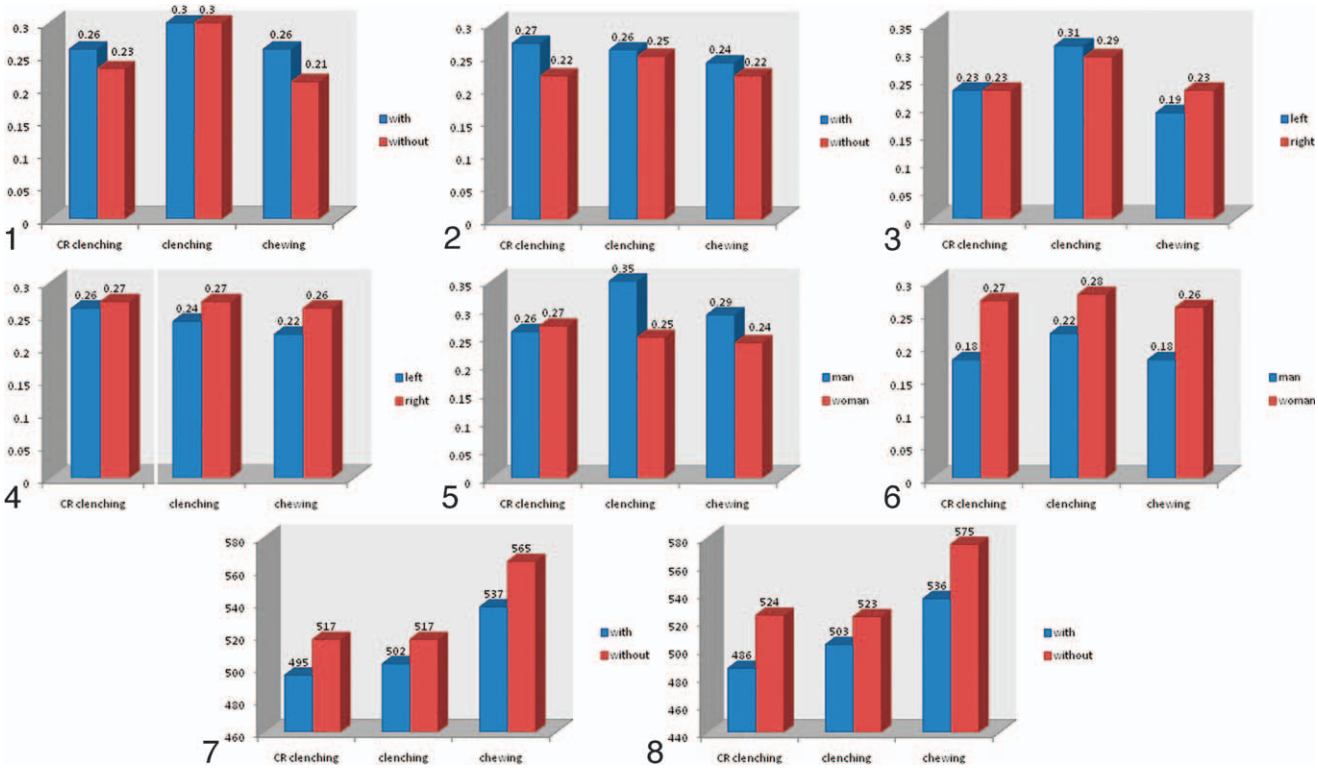
For masseter, no statistically significant differences were found between the MWR values of the right and left masseter muscles with attachments in place. Without attachments in place, however, the MWR values of the right and left masseter muscles were not in harmony while chewing ($P = .03$; Figure 3).

The right and left temporalis muscles were not significantly different in terms of MWR values prior to attachment removal, except for chewing ($P = .01$; Figure 4). Also, no statistically significant differences were found between the MWR values of right and left temporalis muscles without attachments.

Gender

The MWR for masseter was significantly higher in men than in women while clenching with attachments ($P = .02$). However, no statistically significant difference was seen for cotton roll clenching and chewing (Figure 5). After attachment removal, no statistically significant differences were found between genders for cotton roll clenching, clenching, or chewing.

The MWR for temporalis was not statistically different in men and women prior to attachment removal. In women, however, the cotton roll clenching and chewing were associated with statistically higher MWR values compared with



Figures 1–8. Figure 1. Comparative illustration of the mean wave range values of the masseter muscle during 3 masticatory functions, namely, clenching on cotton roll, clenching in maximum intercuspation, and gum chewing with and without attachments under the mandibular implant-supported overlay dentures. Statistically significant difference was found only in cotton roll clenching. **Figure 2.** Comparative illustration of the mean wave range values of the temporalis muscle in 3 masticatory functions, namely, clenching on cotton roll, clenching in maximum intercuspation, and gum chewing with and without attachments under the mandibular implant-supported overlay dentures. Statistically significant difference was found only in cotton roll clenching. **Figure 3.** Comparative illustration of the mean wave range values of the right and left masseter muscles during 3 masticatory functions, namely, clenching on cotton roll, clenching in maximum intercuspation, and gum chewing without the attachments of the mandibular implant-retained overlay dentures in place. During chewing, right masseter muscles were associated with significantly higher ranges compared with those of the left. **Figure 4.** Comparative illustration of the mean wave range values of the right and left temporalis muscles during 3 masticatory functions, namely, clenching on cotton roll, clenching in maximum intercuspation, and gum chewing with attachments of the mandibular implant-retained overlay dentures in place. During chewing, right temporalis muscles were associated with significantly higher ranges compared with those of the left. **Figure 5.** Comparative illustration of the mean wave range values of the masseter muscles of men and women during 3 masticatory functions, namely, clenching on cotton roll, clenching in maximum intercuspation, and gum chewing with the attachments of the mandibular implant-retained overlay dentures in place. Men showed significantly higher values than women while clenching. **Figure 6.** Comparative illustration of the mean wave range values of the temporalis muscles during 3 masticatory functions, namely, clenching on cotton roll, clenching in maximum intercuspation, and gum chewing without the attachments of the mandibular implant-retained overlay dentures in place. Women showed significantly higher values than men while clenching on cotton roll and gum chewing. **Figure 7.** Comparative illustration of the mean wave frequency values of the masseter muscle in 3 masticatory functions, namely, clenching on cotton roll, clenching in maximum intercuspation, and gum chewing with and without attachments under the mandibular implant-supported overlay dentures. Statistically significant differences were found in cotton roll clenching and chewing. **Figure 8.** Comparative illustration of the mean wave frequency values of the temporalis muscle in 3 masticatory functions, namely, clenching on cotton roll, clenching in maximum intercuspation, and gum chewing with and without attachments under the mandibular implant-supported overlay dentures. Statistically significant differences were found in cotton roll clenching and chewing.

those of women without attachments ($P = .03$ and .02, respectively; Figure 6).

Mean wave frequency

Effect of Attachments

Figure 7 represents the mean wave frequency (MWF) values for the masseter muscle prior to and after attachment removal. A statistically significant increase was found in MWF values while cotton roll clenching and chewing after attachments were removed ($P = .01$ both). No statistically significant difference, however, was detected for clenching.

Figure 8 represents the MWF values for the temporalis muscle prior to and after attachment removal. Cotton roll clenching ($P = .02$) and chewing ($P = .01$) were associated with significantly higher MWF values without attachments in place.

Masseter vs Temporalis

No statistically significant differences were found between masseter and temporalis muscles in terms of MWF values in cotton roll clenching, clenching, or chewing with or without attachments in place.

Muscular Harmony

No statistically significant differences were found between the MWF values of right and left masseter or temporalis muscles prior to and after the attachment removal.

Gender

No statistically significant differences were seen between genders in MWF values of the masseter or temporalis muscles in cotton roll clenching, clenching, or chewing with and without attachments.

Discussion

In the study by van der Bilt et al,[4] the MWR of the masseter and temporalis muscles during clenching on MIC with newly fabricated CRCDs was significantly less than that of newly fabricated ISODs ($P < .01$). Also, the MWR of both muscles during mastication with newly fabricated CRCDs was significantly less than that of newly fabricated ISODs ($P < .01$ masseter and $P < .05$ temporal). Consistent with the findings of van der Bilt et al,[4] the MWR of the masseter and temporalis muscles during clenching on the MIC was decreased in the present study after removing the attachments ($P < .02$). In addition, the MWR after removing the attachments decreased during chewing. This decrease, however, was marginally significant only in temporal muscle ($P = .05$).

Evidently, the activity of the masticatory muscles decreases after removing the attachments. This is thought to be attributed to the decreased retention and resistance of the mandibular denture and patients' compatibility with the new conditions.

In the study by van der Bilt et al,[4] the temporalis muscle showed significantly lower activity during maximum bite force on the CRCD compared with the masseter muscle. The activity of the muscles was, however, similar when patients received ISOD. In the present study, no significant difference was noticed between the activity of masseter and temporalis muscles either before or after removing the attachments. In dentate patients, the activity of these two muscles is not significantly different in MIC. van der Bilt et al[4] suggested that the direction of maximum static bite force is similar in patients with ISODs and dentate patients. On the other hand, this force is deviated in patients with CRCDs.

In the present study, the vertical dimension of occlusion (VDO), vertical dimension of rest (VDR), and MIC did not undergo any changes. The direction of the forces and consequently the muscle activities were similar. This is likely to be the result of the application of the same dentures for both ISOD and CRCD assessments. The VDR and VDO were then constant through the course of study.

In the study by van der Bilt et al,[4] a significant difference was found in the muscular activity of masseter and temporalis muscles between the newly fabricated denture and overlay denture both in chewing soft food (breakfast cake) and hard food (optocal; $P = .002$ for masseter and $P = .001$ for temporal). Karkazis et al[7]also reported that the contraction range of the masseter muscle in patients with ISODs is significantly higher than that of patients with CRCDs.

In the present study, both muscles showed higher levels of activity in the presence of ISODs, but the difference was significant only for the temporalis muscle ($P = .05$). This suggests that in the presence of an ISOD, the temporalis muscle is used more than the masseter muscle. It may then be concluded that excursive movements are more prominent in patients with ISODs, which is supported by the findings of van der Bilt et al.[4]

Ferrario and Sforza[8] reported no statistically significant differences in the wave range of right and left masticatory muscles in dentate patients. This finding suggests a symmetrical activity in the muscles of both sides. Ferrario et al[3] found a higher symmetry in the activity of the temporalis muscle in dentate patients compared with that of patients with ISODs. No statistically significant differences were found for masseter muscles. In the present study, the activity of the right and left masseter muscles was not statistically significant before and after removing the attachments ($P = .6$), which indicates symmetry. On the other hand, the right and left temporalis muscles showed statistically significant differences indicative of asymmetry ($P = .01$). The findings of the present study are consistent with the findings of Ferrario et al.[3] Of course, they studied the maximum bite force in MIC clenching, for which the right and left muscles were not statistically different and showed symmetrical activity in the present study.

No significant differences were found in the activity of right and left temporal and masseter muscles when maximum static force was applied without attachments. This meant the symmetrical activity was present after removing the attachments. While chewing, however, significant differences were found in the activity of masseter muscles ($P = .03$), meaning the symmetrical activity was lost after removing the attachments. Oppositely, asymmetrical activity of the temporalis muscles before removing the attachments was corrected after removing the attachments. No statistically significant difference was then found between the muscles of the 2 sides. No other studies have reported the differences of the bilateral masticatory muscles in patients wearing CRCDs.

The MWF for both muscles under both the static and dynamic forces significantly increased after removing the attachment. Since the EMG wave frequency shows the number of potentials of action by time (the rate of contraction wave production), it can be concluded that attachment removal is associated with decreased contraction efficiency yet increased contraction rate. Again, no other studies have investigated the frequency alterations of the edentulous patients.

The MWR of masseter muscle under the MIC force with the attachments in place was significantly higher in men compared with women. In other conditions, however, there were no significantly different changes found between the 2 genders.

The wave range of temporal muscle in MIC force on cotton roll and chewing without attachment was significantly higher in women ($P = .03$ and $P = .02$, respectively). This shows a higher level of function in the temporal muscle of the women after attachment removal.

The MWF of masseter muscle, either with the attachment in place or after attachment removal, was not different between men and women. However, the MWF of temporal muscle with the attachments in place under the maximum bite force on the cotton roll and also after attachment removal was significantly higher in men ($P = .05$). This shows that with attachment removal, the contraction force of the temporal muscle decreases but the contraction rate increases, which is consistent with previous findings on the relation between range and frequency.

Since the EMG device is not as popular in dentistry as in medical research, it was a difficult task to find the same patients and convince them to participate in this recall session. In addition, there were some limitations in conducting this research. The variety in the type of applied implants as well as the fact that different operators performed implants and dentures may have had some effects on the outcome. Also, it was not clear that how long before the surgery patients were edentulous or using any kind of dentures.

Recommendations for future studies

- For better comparison of the activity of the masticatory muscles, we recommend using a fixed EMG device to facilitate adjustments and allow comparison of the findings.
- It is better to measure the EMG activity of the muscles prior to surgery and implantation and compare them to the same values after implant treatment.
- The activity of each muscle should be recorded simultaneously for both working and nonworking sides in order to track the masticatory pattern changes after implant treatment.
- Equip the EMG devices with proper software to allow a more comprehensive assessment of the muscles' activity overlap and their activity symmetry.

- It is also recommended to have more patients (larger sample size) in order to have more reliable conclusions in future studies.

Conclusions

Considering the limitations of the present study, the following can be concluded:

- The contraction force of the masseter and temporal muscles decreases by attachment removal.
- The contraction rate of the masseter and temporal muscles increases with attachment removal.
- Coordination and symmetry of action are seen in the masseter activity bilaterally with attachment removal both under static and dynamic forces.
- Coordination and symmetry are seen in the activity of masseter muscle bilaterally with attachment removal only under static forces.
- Asymmetrical activity is seen in the temporal muscle with the attachment in place and under dynamic forces. After attachment removal, however, symmetrical activity is expected both under static and dynamic forces.
- The contraction force of the masseter muscle is higher in men compared with women under static forces and with attachments in place.
- The contraction rate is similar in men and women under static and dynamic forces.
- The contraction force of the temporal muscle with the attachments in place and under dynamic forces and also after attachment removal and under both static and dynamic forces is higher in women.
- The contraction rate of the temporal muscle with the attachments in place and under static forces and also after attachment removal and under the dynamic forces is higher in men.

Abbreviations

CRCD: conventional removable complete dentures
EMG: electromyography
ISOD: implant-supported overlay dentures
MIC: maximum intercuspation
MWF: mean wave frequency
MWR: mean wave range
VDO: vertical dimension of occlusion
VDR: vertical dimension of rest

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