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Dentistry Section

# Electromyographic Evaluation of the Effect of Lined Dentures on Masticatory Muscle Activity in Edentulous Subjects

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## ABSTRACT

**Aim:** The purpose of this study was to examine changes in relative electromyographic (EMG) activities of temporal and masseter muscles after relining the dentures with silicone and acrylic-resin based denture liners.

**Materials and Methods:** Conventional complete dentures were fabricated for 20 edentulous patients. One month after completing adjustments of the dentures, electromyography of the masseter and temporalis muscle during maximum intercuspation was recorded. The dentures were then relined with a silicone denture liner and after an adaptation period of one month, were again subjected for electromyographic evaluation. Further, the dentures were relined with acrylic denture liner and subjected to electromyographic evaluation. Data was analysed using Statistical Package for Social Sciences (SPSS) version 15.0. Intergroup comparisons were done using ANOVA followed by post-hoc assessments using Tukey HSD test.

**Results:** Mean amplitude and duration with conventional dentures was found to be significantly lower as compared to silicone lined and acrylic lined dentures for all the comparisons. Statistically, no significant difference between silicone lined and acrylic lined dentures was observed for any of the comparisons.

**Conclusion:** Within the limitations of this experimental design, it was concluded that relining significantly increases electromyographic activity of the masseter and temporalis muscles. Thus, resulting in an improved biting force, chewing efficiency and masticatory performance. There were no significant differences between silicone and acrylic based denture liners for both electromyographic variables.

**Keywords:** Electromyography, Masseter muscle and temporalis muscle, Silicone and acrylic denture liners

## INTRODUCTION

As the life span of an individual has progressively prolonged, the duration of denture wearing is increasing more and more [1]. Some complete denture wearers find mastication difficult because of presence of atrophic alveolar ridges. Consequently, in the future, dentists may encounter such patients more frequently.

In the case of an extremely resorbed residual ridge, the denture-bearing area is reduced and the overlying mucosa decreases in thickness and lacks elasticity [2]. As a result, the residual ridge is unable to adequately support the occlusal force. The difficulties encountered by such patients while masticating are overcome with the use of either implants or resilient liners. Although implants are highly effective [3] they are not a viable solution for all edentulous patients because of medical, psychological, and financial constraints. In such a situation, a soft denture liner may be used to compensate for the lost thickness and viscoelasticity of the mucosa [4,5]. The pain is relieved by reducing the impact force during mastication because of the cushioning effect of the soft liner [6,7].

The relined denture bases reduce the load on the supporting tissues as they enable energy to be absorbed as they replace the missing oral mucosa. Thus, the load is evenly distributed over the entire denture bearing area, preventing localized areas of stress concentration [8]. Majority of the patients preferred dentures with resilient denture liners as found in a cross over trial [9]. Several studies have reported that these materials improve denture stability, patient comfort and absorb impacts and distribution of masticatory load, thus enhance functional activities [10-12].

Soft liners have been a valuable assist for dentists because of their visco-elastic properties. The material must compress and distribute the stresses on the denture bearing tissues when a load is applied and recover when it is released, and must maintain the desired resiliency over time [13,14].

Denture liners are classified as hard or soft, acrylic resin based or silicone based, and chemically or thermally polymerized and is indicated for temporary and permanent use. These liners have different mechanical properties; therefore, they have different clinical effects. Due to this variety of classifications, dentists have difficulty choosing the ideal material for particular clinical case.

The impact of denture relining on stomatognathic system should be assessed in addition to the concerns regarding patient satisfaction [15,16]. Surface electromyography of masticatory muscles can be an excellent method of measuring muscular activity, stability and comfort during static and dynamic tasks [17,18].

Electromyography (EMG) is defined as the graphic recording of the electrical potential of muscle. It forms the only tool to assess the muscle activity of the stomatognathic system since its first concerted use in dentistry by Robert moyers in 1949. Over years clinicians and researchers have tried electromyographic activity to detect the chewing abilities in denture wearers.

There have been several reports regarding the physical properties and contamination of soft liners [5,19,20]. There have been few studies on the effects of soft denture liners on masticatory function [6]. However, none of the reports has satisfactorily clarified how masticatory performance and muscle activities are affected by the use of these soft materials. Furthermore, none of the previous studies compared the effect of silicone and acrylic based denture liners on muscle function. The purpose of this study was to examine changes in relative EMG activities of temporal and masseter muscles after relining the dentures with silicone and acrylic based denture liners.

## MATERIALS AND METHODS

This clinical study was conducted (between November 2013 till September 2014) in the Department of Prosthodontics at Saraswati Dental College and Hospital, Lucknow, India. Edentulous patients, who volunteered to participate in this study, were selected. All patients provided written informed consent prior to participation. The study protocol was reviewed and approved by the institutional human ethics committee.

### Patient Selection

The study enrolled 20 edentulous patients (12 men and 8 women) between the age group of 40- 80 years, with no evident signs and symptoms of stomatognathic system disorder. The patients had been wearing dentures for 5 years or more and had no abnormal habits such as clenching, bruxism and tongue thrust and was ready to co-operate through the study. Medical and dental history of the patient with full mouth examination (visual and digital examination) and panoramic radiographic examination were done. Presence of any bony lesions of the jaws or any impacted tooth or root was ruled out. Patients with neurological diseases, lack of motor coordination or cognitive difficulties, allergies to methacrylate or silicone were excluded.

### Fabrication of New Dentures Treatment Protocol

Stock edentulous trays (DentcraftSto-K TRAY; Yoshida, Tokyo, Japan) and irreversible hydrocolloid impression material (zelgan; Dentsply, India) were used for making the preliminary impressions. Border moulding procedures were carried out using custom trays fabricated on study casts and stick modeling compound (DPI Pinnacle Tracing Sticks; The Bombay Burmah Trading Corporation Ltd., India). Zinc oxide eugenol impression paste (DPI Impression Paste; The Bombay Burmah Trading Corporation Ltd., India) was used for making final impressions.

The jaw relation was recorded using occlusal rims and an inter-occlusal registration paste (superbite; Harry J. Bosworth Co., Skokie, IL). Try-in was done and patient's feedback and acceptance of the trail dentures were obtained. Complete dentures (conventional dentures) were fabricated using heat polymerized acrylic resin (Trevalon; Dentsply India Pvt. Ltd., India). The dentures were inserted after processing. A thorough clinical examination of the denture for proper extension, adequate retention and stability and occlusion in maximum intercuspation was done. If premature contacts were observed on the path of closure, occlusal adjustments were made by using articulating paper (Horseshoe/Full Arch, red/blue articulating film; Ardent, Inc., Ossining, NY, USA). When necessary, the dentures were remounted with semi-adjustable articulators (HANAU™ Wide-Vue Articulator, Whip Mix Corp., USA) for occlusal equilibration during the adjustment period. One month after completing the appropriate adjustments, the patients were satisfied and free of any discomfort with the dentures. Thereafter, EMG recordings were made [Table/Fig-1].

### Electromyographic Recording with Conventional Acrylic Dentures

The masseter and anterior temporalis muscles on both sides were thoroughly examined. Before electrode placement, the skin was cleaned with ethanol to reduce impedance. Disposable, pre-gelled, silver/ silver chloride bipolar surface electrodes (diameter 10 mm, inter-electrode distance 21+1 mm, as suggested by Farina et al., [21], (FLAB*) were used. While a ground electrode was attached to the right wrist.

Bipolar surface electrodes were positioned on the muscular bellies of masseter and temporalis parallel to the muscle fibers. The electrodes on the anterior temporalis were placed vertically along the anterior margin of the muscle. On the masseter muscles, the electrodes were parallel to muscular fibres, with the upper pole of the electrode at the intersection between the tragus-labial commissure and the exocanthion-gonion lines [22].

During procedure, the patient sat with their head unsupported and asked to maintain a natural erect position with Frankfort horizontal plane nearly parallel to ground. During test performance, the subjects were verbally encouraged to perform at their best. The patient was instructed to bite forcefully in maximum intercuspation. Three bite force recordings were made at 30 second intervals for each muscle testing. A computerized system was used for recording and analysis of electromyograhic data. Each of the three recordings was analysed for peak amplitude and duration of the longest wave and was subjected to statistical analysis. Following completion of EMG recordings, the maxillary and mandibular dentures were relined with silicone based denture liner.

### Relining the Dentures Using Silicone-based Denture Liners

The maxillary and mandibular dentures were relined with a silicone-based denture liner (Mollosil plus; Detax, Ettlingen, Germany) using direct relining technique, as recommended by the manufacturer. The maxillary and mandibular dentures were relined separately using intercuspal position as guide. Borders and tissue surface of the denture were trimmed by 1.5-2 mm except in the region of canine and first molar to act as vertical stops ensuring proper placement of dentures.

Once trimmed, the degreasing was done by means of pure medical alcohol and allowed to dry. Later primer liquid supplied by the manufacturer was applied uniformly and dried for 2 minutes. Relining material was applied directly from the cartridge on to the prepared denture base, uniformly maintaining a thickness of 2mm over the tissue surface and borders. It was then placed in patient's mouth and functional molding was accomplished. Patient was asked to bite in centric occlusion till material sets completely. Excess material was removed using sharp scalpel and fine scissors.

### Electromyographic Recording with Silicone Lined Dentures

After an adaptation period of 1 month the EMG recordings were made with the silicone lined dentures as was described above.

### Relining the dentures using acrylic resin-based denture liners

The silicone lined dentures were again relined with acrylic resin-based denture liner (Permasoft; Dentsply Ltd., Delhi, India) using direct lining method, the technique previously described, following manufacturers instruction.

### Electromyographic recording with acrylic lined dentures

After an adaptation period of 1 month the EMG recordings were made with acrylic lined dentures as described above.

## STATISTICAL ANALYSIS

For each parameter, a total of three readings were taken. For comparison purposes the average of three readings was used. Data was analysed using Statistical Package for Social Sciences (SPSS) version 15.0. The distributions were checked for normality and were found to be normal, hence a parametric evaluation plan was followed. Intergroup comparisons were done using ANOVA followed by post-hoc assessments using Tukey HSD test. Confidence level of the study was kept at 95%, hence a p-value less than 0.05 indicated a statistically significant association.

## RESULTS

It was observed from statistical analysis that, for all the comparisons, intergroup differences were found to be significant statistically ($p<0.05$) [Table/Fig-2-4].

[Table/Fig-2] shows masseter muscle activity with mean amplitude 152.22 with conventional denture, 267.11 after relining with silicone-based denture liner and 251.97 after relining with acrylic resin-based denture liner. Standard deviation was observed as 49.91, 100.80, and 96.62 respectively. P- Factor was noted as <0.001 for amplitude and duration, which was found to be highly significant [Table/Fig-2].

[Table/Fig-3] shows temporalis muscle activity with mean amplitude 102.94 with conventional denture, 187.86 after relining with silicone-based denture liner and 168.74 after relining with acrylic resin-based denture liner. Standard deviation was observed as 49.20,

| Insertion of new denture | EMG evaluation with conventional dentures | Relining with silicone-based denture liner | EMG evaluation with silicone lined dentures | Relining with acrylic resin-based denture liner | EMG evaluation with acrylic lined dentures |
|---|---|---|---|---|---|
| ↓<br>Adjustment phase (1-2 wk)<br>↓<br>Adaptation phase (1 mo) | → | Chair side relining with silicone-based denture liner.<br>↓<br>Adjustment phase (1-2wk)<br>↓<br>Adaptation phase (1 mo) | → | Chair side relining with acrylic resin-based denture liner<br>↓<br>Adjustment phase (1-2 wk)<br>↓<br>→Adaptation phase (1 mo) | |

**[Table/Fig-1]:** Testing protocol for conventional, silicone lined and acrylic lined dentures

| S.N | Variable | Conventional (a) Mean±SD | Silicone Lined (b) Mean±SD | Acrylic Lined (c) Mean±SD | Significance of difference (ANOVA) F | p |
|---|---|---|---|---|---|---|
| Masseter Muscle (Both sides) (n=40 each) | | | | | | |
| 1. | Amplitude | 152.22[b,c]±49.91 | 267.11[a]±100.80 | 251.97[a]±96.62 | 21.267 | <0.001 |
| 2. | Duration | 6.76[b,c]±0.75 | 8.00[a]±1.11 | 7.72[a]±1.00 | 18.064 | <0.001 |

**[Table/Fig-2]:** Mean amplitude and duration of masseter muscle with conventional dentures, silicone lined dentures and acrylic lined dentures

| SN | Variable | Conventional (a) Mean±SD | Silicone Lined (b) Mean±SD | Acrylic Lined (c) Mean±SD | Significance of difference (ANOVA) F | p |
|---|---|---|---|---|---|---|
| Temporalis Muscle (Both sides) (n=40 each) | | | | | | |
| 1. | Amplitude | 102.94[b,c]±49.20 | 187.86[a]±97.83 | 168.74[a]±89.79 | 11.875 | <0.001 |
| 2. | Duration | 5.83[b,c]±0.80 | 7.65[a]±1.50 | 7.39[a]±1.35 | 24.790 | <0.001 |

**[Table/Fig-3]:** Mean amplitude and duration of temporalis muscle with conventional dentures, silicone lined dentures and acrylic lined dentures

| SN | Variable | Conventional (a) Mean±SD | Silicone Lined (b) Mean±SD | Acrylic Lined (c) Mean±SD | Significance of difference (ANOVA) F | p |
|---|---|---|---|---|---|---|
| OVERALL (Both sides + Both muscles) (n=80 each) | | | | | | |
| 1. | Amplitude | 127.58[b,c]±55.13 | 227.48[a]±106.45 | 210.36[a]±101.70 | 27.721 | <0.001 |
| 2. | Duration | 6.29[b,c]±0.90 | 7.82[a]±1.32 | 7.56[a]±1.19 | 40.208 | <0.001 |

**[Table/Fig-4]:** Mean amplitude and duration of masseter and temporalis muscle together with conventional dentures, silicone lined dentures and acrylic lined dentures
[a]-Mean difference significant as compared to Conventional Denture (TukeyHSD)
[b]-Mean difference significant as compared to Silicone lined denture (TukeyHSD)
[c]-Mean difference significant as compared to Acrylic lined denture (TukeyHSD)

97.83, and 89.79 respectively. P- Factor was noted as <0.001 for amplitude and duration, which was found to be highly significant.

Mean amplitude and duration with conventional dentures was found to be significantly lower as compared to silicone lined dentures and acrylic lined dentures for all the comparisons [Table/Fig-4]. Statistically, no significant difference between silicone lined and acrylic lined dentures was observed for any of the comparisons.

## DISCUSSION

It has long been recognized that any interpretation of electromyography is a measure of mechanical function of muscle both as magnitude and duration of muscle force. More the amplitude of wave more is the total contractile force in recruitment (maximum biting) [23]. Hence amplitude and duration per wave was used to assess the muscle function in maximum biting in intercuspal position. The electromyograms of masticatory muscles were analysed before and after relining the dentures with silicone and acrylic resin-based denture liners. This study showed significant improvement in EMG activity (amplitude & duration) after insertion of lined dentures. However, the difference was not significant when silicone and acrylic lined dentures were compared for both EMG variables (amplitude & duration). The results obtained are in conformity with the study conducted by Iwao Hayakawa [24]. His study reported that EMG activity and maximum occlusal force were improved by applying a resilient denture liner on a complete denture.

Emura et al., observed in his study that the lined denture significantly increases the maximum biting force because of even distribution of the occlusal force over the mucosa by these soft materials leading to an increased capacity for stress bearing by residual ridges [25]. He also reported that the number of occlusal contacts tend to increase when using lined dentures and suggested that the deformation of soft lining materials causes slight movement of the mandibular denture into most stable position. During mastication, the soft lining material may also improve occlusal balance by its deformation because of elasticity and consequently the masticatory performance could improve.

Helkimo et al., in an another study reported that there is significant correlation between maximum biting force and chewing efficiency [26]. It has also been reported that the increase in biting force improves masticatory performance [27].

According to Tartaglia et al., the symmetrical distribution of muscle activity during maximum intercuspation is largely determined by occlusion [25]. In present study, we assume that relining had no effect on occlusion. Muscle effort, potential and strength are significantly greater if dentures have good retention and stability [28]. Relining may have increased retention and stability of dentures, which gradually augmented strength and muscle effort and consequently increased electromyographic activity. In current study EMG activity was not recorded by dynamic testing of mastication of food. However, previous studies have reported an overall increase in EMG activity following insertion of lined dentures [29].

Zhang et al., reported increase in EMG and bite force during chewing after relining [30]. However, Hayakawa et al., found improvements in masticatory function, without differences in electromyographic activity, before and after relining [31]. In a randomized controlled trial,

Kimoto et al., reported that use of a silicone-based soft liner improved masticatory performance by changing the occlusion phase during chewing [10]; however, they found no change in electromyographic activity, which, according to the authors, might have been due to insufficient accuracy and sensitivity of the electromyographic evaluation to detect differences between conventional and relined dentures.

It should be acknowledged that there are limitations to this study, and the results may not be applicable to all edentulous patients. The follow-up period after relining and recording EMG activity was limited (30 days). The soft acrylic-based denture liner (permasoft) hardens with time due to gradual leaching out of plasticizers. Silicone-based denture liner (mollosil plus) also has certain drawbacks such as increased uptake and loss of chemical compounds through oral cavity [32] and poor adhesion to the denture base. These factors may not have been comprehended by the patients, due to short duration of follow-up. A longer follow-up might have conceded slightly different results. In addition to it, residual ridge resorption has been an important point of discussion when considering denture liners. Woelfel et al., reported bone loss caused by an improperly used denture liner [33]. Another study reported that the rate of ridge resorption with a resilient liner was significantly less than that of conventional dentures [34]. Unfortunately, the follow up period for this study was limited. Still relationship of the residual ridge resorption to the resilient denture liner remains an important area of interest for the clinicians.

## CONCLUSION

Relining significantly increased electromyographic activity of the masseter and temporal muscles and thus, improved biting force. Improved biting force should result in improved chewing efficiency and thus the masticatory performance. There were no significant differences between silicone and acrylic based denture liners for both electromyographic variables.

Further, an in-depth investigation of the indications and exceptions for silicone and acrylic based resilient denture liner is needed.

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