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Effect of different surface treatments on tensile bond strength of silicone-based soft denture liner

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Abstract
Failure of the bond between the acrylic resin and resilient liner material is commonly encountered in clinical practice. The purpose of this study was to investigate the effect of different surface treatments (monomer MMA, Er: YAG laser) on tensile bond strength of silicone-based soft denture liner. Polymethyl methacrylate test specimens were fabricated and each received one of three surface treatments: untreated (control), MMA monomer treatment, Er:YAG laser irradiated with three different intensity. The resilient liner specimens (n=50) were processed between two polymethyl methacrylate (PMMA) blocks. Bonding strength of the liners to PMMA were compared by tensile test with the use of a universal testing machine at a crosshead speed of 5 mm/min. T-student test was used to analyze the data (α=0.05). Altering the polymethyl methacrylate surface by Er:YAG laser (300mJ) significantly increased the bond strengths in polymethyl methacrylate/silicone specimens.

Keywords: Er:YAG laser, tensile bond strength, soft denture liner

Introduction
Denture lining materials have become important in dental prosthetic treatment. They are applied to the intaglio surface of dentures to achieve more equal force distribution, reduce localized pressure, and improve denture retention by engaging undercuts [1]. Denture liners have been shown to increase a patient's level of comfort during mastication [2]. They provide comfort for patients who cannot tolerate occlusal pressures or who present alveolar ridge resorption, chronic soreness, and knife-edge ridges [3]. The favorable properties of denture liners are long-term resiliency and good adhesion to denture base materials [4]. Several problems are associated with the use of resilient denture liners, including bond failure between the liner and denture base, colonization by Candida albicans, porosity, poor tear strength, and loss of softness [1, 4]. Heat-cured silicone lining materials can last for 3 to 6 years [5]. A common clinical occurrence and major problem is the lack of durable bond to the denture [1-8]. Sufficient bond strength between the soft lining material and acrylic resin denture base is required to avoid interfacial separation at the denture borders [3]. Adhesive failure between the lining material and denture base can create an environment for potential bacterial growth and accelerated breakdown of the soft lining material [3, 6, 7]. Therefore, the measurement of bond strength is very important.

Numerous materials have been used as resilient liners since the introduction of velum rubber. Many have been used with varying levels of success, but limitations exist in the areas of cleanability, hardness, volumetric change due to water absorption, and abrasion resistance [2].

Recently, lasers have been shown to provide a relatively safe and easy means of altering the surface of materials. Although lasers have not been used to roughen PMMA surfaces before application of a resilient liner, they have been used to etch metals before application of porcelain [2]. Lasers have also been used for processing dental materials, especially for fusing the materials on or into tooth surfaces [9].

Bonding properties of resilient lining materials have been evaluated by several investigators using tensile, tensile and tear, and shear and peeling tests [8].

The purpose of this study was to investigate the effect of different surface treatments on the interfacial bonding of PMMA and resilient liners by tensile testing.

Materials and Methods

The soft liner used in this study was a silicone-based material (UfiGel P Voco, Germany) (Fig. 1) and the denture base material was a heat-cured polymerized acrylic resin. A dumbbell-shaped brass patterns were prepared with a, 75 mm in length, 12 mm in diameter at the thickest section, and 7 mm at the thinnest section. The heat-cured specimens were prepared in the molds in denture flasks and cured in a manner similar to that used in conventional denture construction. The heat-polymerized acrylic resin was processed according to the manufacturer's instructions. After the acrylic specimens were removed, finishing was performed. Then, 3 mm of the material was cut from the thin midsection using a water-cooled diamond-edged saw (Fig. 2). Eventually, a total of 50 test specimens were prepared. Specimens were then randomly assigned to five groups (n=10), according to the surface treatments applied. The bonding surface of the specimens received surface treatments, as follows:

Fig 1: Autopolymerizing silicone based denture liner-Ufigel P

Fig 2: Specimen preparation. **a** Dumbbell-shaped acrylic resin block. **b** 3 mm of material removed from thin mid-section. **c** After application of soft denture line

Group A-untreated (control): No treatment was applied to the acrylic resin specimen surfaces, this group served as a control.
Group M-MMA monomer treatment for 180 s.
Group L-Er:YAG laser irradiated: Bonding surfaces of specimens were irradiated by Er:YAG laser (KaVo KEY Laser 3 1243/Germany).

- **Group L1:** It is the group exposed to first degree laser irradiate / 1 /, where the test surface is fully exposed to a laser irradiate pulse at 10 Hz, 100MJ to create deep holes on the test surface.
- **Group L2:** It is the group exposed to second degree laser irradiate / 2 /, where the test surface is fully exposed to a laser irradiate pulse at 10 Hz, 200MJ to create deep holes on the test surface.
- **Group L3:** It is the group exposed to third degree laser irradiate / 2 /, where the test surface is fully exposed to a laser irradiate pulse at 10 Hz, 300MJ to create deep holes on the test surface. (Fig. 3)

After surface preparations, The specimens shall be placed in a rubber mold in order to secure a sufficient distance to apply the soft lining material. The acrylic specimens surface is cleaned and wiped with a cotton tip wet with alcohol and allowed to dry, and then apply the adhesive that followed with the material using the brush cover supplied with the adhesive and wipe over the entire specimens surface to which the soft lining material will be applied and left for a minute. After applying the adhesive, the soft lining material is mixed by mixing two equal lengths of the base (red) and the accelerator (blue) for 30 seconds to obtain a uniform consistency and then applied to the test surface of the specimens in the remaining space of removing the wax disk using a thin tip followed with the material.

The soft lined material is left for 5 minutes until hardening. After hardening, the acrylic specimens are removed from the rubber mold, and the extra material is removed using a sharp scalpel after 10 minutes since application of the material.

The soft lining material is polished using a Glaze, where a drop of the base is mixed with a drop of accelerator and brushed on the soft lining and the acrylic edges and left for 10 minutes to dry at room temperature, and then specimens were stored in distilled water at a temperature of 37 °C for a week.

All specimens were placed under tension until failure in a Universal Testing Machine at a crosshead speed of 5 mm/min. The maximum tensile stress before failure was recorded for each specimen. Failure strength was recorded in Newtons.

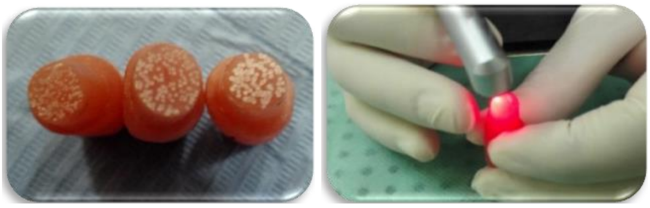

Fig 3: Appling laser irradiation on the bonding surface of the specimens

Results

Statistical results for tensile bond strength measurements of the groups are summarized in Table 1. The highest mean force value was observed in group L3 specimens while the lowest tensile bond strength observed in group A. We also note that there are statistically significant differences between group M and group L ($p<0.05$), where group L appears to have the highest values. As for the comparison between the laser groups, the group of L3 showed the highest value with statistically significant differences (p<0.05). The Er:YAG laser application resulted in irregularities and lots of small pits on the surface of the denture base resin. Therefore, soft lining materials can penetrate into the irregularities or pits produced by the Er: YAG laser and increase the strength of the bond.

Table 1: Mean tensile bond strength and SD of each group

Groups	Mean (N)	SD
Group A	32.06	1.20
Group M	37.66	0.92
Group L1	46.88	0.69
Group L2	48.80	0.76
Group L3	54.68	1.21

Discussion

The failure of adhesion between a silicone based resilient liner and an acrylic denture base material is a significant clinical problem. Adhesive failure between the liner and the denture base resin creates a potential interface for microleakage leading to an environment for potential bacterial growth and accelerated breakdown of soft liner resulting in deteriorating prosthesis [2, 10].

To achieve better bonding between denture lining materials and denture base resin, several experimental procedures have been conducted such as mechanical surface preparation i.e., roughening of denture base resin, effect of polymerization stage at which resilient liner is packed against the acrylic resin and chemical surface treatment of denture base resin [10, 12].

The results of the present study support rejection of the hypothesis because altering the polymethyl methacrylate surface by Er:YAG laser significantly increased the bond strengths in polymethyl methacrylate/silicone specimens, in addition, the application of different chemical etchants on denture base resin increased the bond strength of silicone based lining material, UfiGel P, to denture base resin, compared to the control group. However, applying monomer MMA before applying soft lining material had a less effect on the bond strength than the application of Er:YAG laser.

In general, debonding of the resilient denture lining materials is a common problem [4]. To solve this perplexing problem, researchers have considered altering the PMMA surface before applying a resilient material [2]. On the other hand, hardness of denture base resin is not equal to that of titanium. Whereas, Lasing have been used to alter the surface of the PMMA with the intention of providing increased surface area and mechanical locks. Another possibility may be that the size of irregularities created by the laser medium may be insufficient to allow flow of the resilient lining material into them [2].

On the other hand, only a few studies have been conducted on laser treatment of acrylic resin surfaces. Usumez *et al.* [12] reported that lasing of the PMMA before resilient-material application resulted in higher mean tensile bond strengths than those of control specimens, but these increases were not statistically significant. In the other hand, Akin *et al.* [13] reported that Er:YAG laser surface treatment increased tensile bond strength between resilient soft-liner and denture base. In the present study, surface treatments with Er:YAG laser (300mJ) were found to be effective for increasing the bond strength and resulted in high mean tensile bond strengths than those of control specimens, and these increases were statistically significant. These results were not in accordance with Usumez *et al.* [12]. However, these results were in agreement with Akin *et al.* [13]. This finding is understandable and can be explained by the high energy of the Er:YAG laser. The impact of high energy causes instant vaporization of water with a massive volumetric expansion. This expansion causes the surrounding material to ablate [16], increasing the surface area. Therefore, soft-lining materials penetrate into the irregularities or pits produced by the Er:YAG laser and increase the strength of the bond.

Sarac *et al.* [14] reported that wetting the denture base resin with 180 s of MMA monomer was an effective method for reducing microleakage between lining material and denture base resin when using silicone based lining materials. In addition, in a study of Gupta [15] in which he stated that Surface treatment of denture base resin with chemical etchants increased the tensile bond strength of silicone based liner to denture base resin and the increase in tensile bond strength value was highest with specimens subjected to 180 s of MMA surface treatment and lowest with control group specimens. The findings of this study were in agreement with the study of Sarac *et al.* [14] and Gupta [15].

Summary and Conclusions

Within the limitations of this study,

1. Er:YAG laser surface treatment increased tensile bond strength between resilient soft-liner and denture base.
2. Surface treatment of denture base resin with chemical etchants increased the tensile bond strength of silicone based liner to denture base resin.

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