Shear bond strength of three silicone lining materials bonded to heat-cured denture resin

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Abstract This research compared the adhesive strength of three resilient denture lining materials cured with two different curing modes: autopolymerized (Mollosil plus, GC Reline Soft), and conventional laboratory processing (Molloplast-B); bonded to heat-cured acrylic resin. The findings showed that all the lining materials were acceptable for clinical use; there were no statistically significant differences among the bond strengths of the studied silicone materials. However, the bond strength became higher when Molloplast-B was applied to unpolymerized polymethyl methacrylate PMMA and processed together than it was applied to polymerized PMMA.

1. Introduction

Soft denture lining materials have been used in dentistry for more than a century; the earliest soft liner was the soft natural rubber and it was applied by Twichell in 1869 [16]. One of the first synthetic resins developed in 1945 as a soft liner was a plasticized polyvinyl resin [12], followed by the introduction of silicones in 1958 [5].

Soft denture liners provide an even distribution of the functional load on the denture-bearing area and avoid load stress concentrations [16]; and they are widely used as a cushion on the intaglio surface of dentures in the management of traumatized oral mucosa, ridge atrophy, bony undercuts, bruxism, xerostomia, edentulous arches opposing natural dentition, congenital oral defects requiring obturation, and for improving the retention of the dentures by engaging undercuts [16,6,7, and, 20]. However, these materials have several problems associated with their use. One of the more serious problems with soft denture liners is the failure of adhesion between the soft denture liner and the denture base [3,18].

In spite of the similar bond mechanisms, the clinical practice reveals that the bond failure of cold-cured silicone-based lining material to acrylic denture base is more likely to occur than the bond failure of heat-cured denture base. On the other hand, some studies [2,8] and, [4] illustrated that bond strength became higher when Molloplast-B was applied to unpolymerized polymethyl methacrylate (PMMA) and processed together than it was applied to polymerized PMMA; others [9] confirmed the reverse. Bonding of resilient lining materials to PMMA denture base material has been evaluated by several investigators using tensile, peeling, and shearing tests [14,8,10,19] and, [17]. The purpose of this study was to compare the shear bond strength

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of three silicone soft denture liners (Mollosil plus, GC Reline Soft, Molloplast-B); and to compare the measured bond strengths of Molloplast-B to those obtained by packing this material against PMMA denture base acrylic resin dough.

2. Materials and methods

The resilient denture lining materials involved in this study represent two different curing modes: autopolymerization [Mollosil plus (DETA, Ettlingen-Germany), GC Reline Soft (GC Corporation, Tokyo, Japan)], and conventional laboratory processing [Molloplast-B (DETA, Ettlingen-Germany)], and the denture base material was heat-curing acrylic resin [RODEX, Mulazzano (LO), Italy].

Shear adhesive strength was evaluated using a simple overlap-joint model. Shear specimens consisted of soft denture lining material with dimensions of (10 × 10 × 3) mm. The denture lining materials were bonded to two plates of acrylic resin, each (50 × 10 × 3) mm, (Fig. 1).

RODEX PMMA denture base material was packed into performed molds (50 × 50 × 3) mm to make the acrylic resin plates (Fig. 2).

The acrylic resin plates were then invested in Silicone Putty (Zetaplus, Zhermak, Italy), together with glass spacers (10 × 10 × 3) mm to provide space for the soft lining materials after their removal (Fig. 3). Silicone primer was applied to the acrylic bond surface, and the manufacturer’s instructions were followed for packing and curing the liners.

The number of shearing specimens was five for each soft lining material in addition to additional five specimens which were fabricated by processing Molloplast-B against unpolymerized PMMA. The additional Molloplast-B specimens were prepared by investing two wax plates, each (50 × 10 × 3) mm, bonded to a Teflon plate with dimensions of (30 × 10 × 3) mm (spacer) in 50:50 stone and plaster mix. The acrylic resin dough was packed into the space which resulted during wax plate removal, then the Teflon spacers were removed to provide space for Molloplast-B.

The samples were tested by using the universal testing machine (DY-34 Adamel Lhomargy, France) (Fig. 4). Samples were tested at a crosshead speed of 40 mm per minute until

Figure 1  Shear specimen.

Figure 2  The copper mold.

Figure 3  Silicone mold.

Figure 4  Universal testing machine.

Figure 5  Shearing test.
the liner material was separated from the acrylic plates (Fig. 5). The maximum force indicating the point of failure by separation was recorded. Surfaces of bond failure were evaluated by using an explorer for determining the type of failure (cohesive or adhesive). Mean values of stress needed for the separation were compared for statistically significant differences at the 95% confidence level by using ANOVA.

3. Results

The means of bonding strength measurements of the three resilient liners and the type of failure are shown in Table 1. A two-way analysis of variance was used to analyze the results. Statistical analysis is summarized in Table 2.

4. Discussion

Shear test specimens of this study were based on the simple lab design described by Al-Athel and Jagger [1]. Evaluation of bond strength was carried out with shear bond tests, because the forces that the lining material is clinically exposed to are more closely related to shear and tear tests [13].

The results of this study indicated that the force for failure was higher than 0.59 MPa for all three materials tested. It has been reported that 0.45 MPa (4.5 kg/cm²) would be satisfactory for clinical use of the resilient lining materials [8]. Considering this only criterion, all three materials were acceptable for clinical use. Statistical analysis did not reveal significant differences between the bond strength of the laboratory processed material and of the autopolymerized materials. The adhesion of silicone-based soft lining materials (heat and cold cured) to processed acrylic resin depends upon the use of a volatile solvent which softens the denture base surface. Once the solvent evaporates, the silicone molecules penetrate into the PMMA matrix, achieving mechanical union during the curing stage of processing [11]. For Molloplast-B, this study demonstrated a significant increase in bond strength when the soft lining material was processed against unpolymerized PMMA. This finding suggests the possibility of formation of an intimate contact with a diffuse boundary, and this was confirmed by the SEM results [2]. The results of this study agree with those of [8] that studied the adhesion of Molloplast-B soft lining material and revealed that the bond strength improves by applying Molloplast-B to the dough stage of the PMMA base and curing the two together. However, it disagrees with the study of Kawano et al. [9] who demonstrated that the bond strength is increased by applying Molloplast-B to polymerized PMMA.

The clinical observations show that the adhesive properties of heat-cured silicone-based lining material to acrylic denture base are better than those of cold-cured silicone-based lining material. These observations disagree with the results of this study (no differences were recorded). The difference noticed clinically between the adhesive properties of heat-cured silicone-based lining material and cold-cured silicone-based lining material may be resulted from the different conditions of application, or may be related to the kind of denture base polymer [15].

The type of failure observed in shear specimens tested were cohesive failures, except for GC Reline Soft (43%). This result indicates that the strength of GC Reline Soft is nearly equal to its bond strength.

5. Conclusions

Within the limits of this study, the following conclusions were made:

- The findings revealed that all of the lining materials were acceptable for clinical use.
- The results showed that there were no statistically significant differences among the studied silicone materials.
- Bond strengths improved by processing Molloplast-B against unpolymerized PMMA.

References