

The Effect of Thermocycling on Tensile Bond Strength of Two Soft Liners

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Abstract

Objective: Failure of soft liners depends mostly on separation from the denture base resin; therefore measurement of the bond strength is very important. The purpose of this study was to compare the tensile bond strength of two soft liners (Acropars, Molloplast-B) to denture base resin before and after thermocycling.

Materials and Methods: Twenty specimens from each of the two different soft liners were processed according to the manufacturer's instructions between two polymethyl methacrylate (PMMA) sheets. Ten specimens in each group were maintained in 37 °C water for 24 hours and 10 were thermocycled (5000 cycles) among baths of 5° and 55°C. The tensile bond strength was measured using a universal testing machine at a crosshead speed of 5 mm/min. Mode of failure was determined with SEM (magnification ×30). Two-way ANOVA was used to analyze the data.

Results: The mean and standard deviation of tensile bond strength of Acropars and Molloplast-B before thermocycling were 6.59±1.85 and 1.51±0.22 MPa, respectively and 5.89±1.52 and 1.37±0.18 MPa, respectively after thermocycling. There was no significant difference before and after thermocycling. Mode of failure in Acropars and Molloplast-B were adhesive and cohesive, respectively.

Conclusion: The bond strength of Acropars was significantly higher than Molloplast-B (P<0.05).

Key Words: Denture Liners; Tensile Strength; Acrylic Resins; Prosthodontics

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INTRODUCTION

Soft liners are made from silicon or acrylic-based material, both of which may be heat-cure or self-cure [1-3]. They have wide application due to cure inflamed mucosa [4, 5],

functional force distribution on denture base [6, 7], further retention, denture's compliance improvement [8] and helping patients tolerate hard denture bases [2, 9]. The favorable properties of them include high bond strength to

denture base, dimensional stability, prolonged elasticity, minimal water absorption, color stability, easy application, biocompatibility, sweet smell and low cost [2, 3] and their disadvantages are loss of softness, candida albicans colonization, porosity and poor tear strength [10].

One of the main problems of these materials is separation from denture base resins in which a potential area for bacterial growth and plaque accumulation are provided. Two-layer dentures can be successful if the bond between the two materials are acceptable [7, 10]. For this purpose, 0.44 Mpa is the minimum amount of bond strength that is required. Parameters that may affect the bond strength between soft liners and denture bases include aging in water, thermal cycling, primer application and the nature of denture base resin [11].

During eating and drinking the dentures are exposed to thermal cycles; so measuring the bond strength after thermocycling can provide more information about the aging process.

In prior studies, the effect of thermocycling on different types of soft liners and their properties such as bond strength to denture base resins have been investigated. There is a lot of controversy over the effect of thermocycling on the bond strength of soft liners; therefore, the bond strength may be increased, decreased or not affected [11-15]. In a study conducted by Kulak et al. about 6 silicon liners, the bond strength decreased significantly after thermocycling except for Ufigel C and Mollosil [11]. In addition, in a study carried out by Pinto et al. thermocycling decreased the bond strength of Molloplast-B and Pro Tech and did not change Flexor and Permasoft.[12] In another study performed by Pinto et al., after thermocycling the bond strength of soft liner was not affected significantly, but in Permasoft it increased [12].

The aim of this study was to evaluate the bond strength of Acropars acrylic liner before and after thermocycling and comparing it with Molloplast-B silicone liner.

MATERIALS AND METHODS

In this experimental study, 40 samples of Acropars (Marlic Co. Iran) and Molloplast-B (Detax-GmbH & Co. KG, Ettlingen, Germany) were evaluated (20 samples for each soft liner).

In order to unify the specimens, two brass spacers with $3 \times 10 \times 70$ and $3 \times 10 \times 10$ mm dimensions were designed. The specimens were prepared as follows:

First, the muffle was fully applied with vaseline and plaster was poured in the lower section of the muffle. Then a large spacer was placed in the center of the muffle so that half of that was in the plaster and half out of the plaster in order to place in the upper section of the muffle. After pouring the plaster into the upper half, the muffle was pressed for 20 minutes. Two halves of the muffle were separated and the large spacer was removed. The small spacer was placed in the middle of the large space. Acrylic polymethyl methacrylate (PMMA) (Melliodent, HeraeusKulzer, Berkshire, UK) were mixed according to the manufacturer's instructions and packed into two sides of the small spacer in doughy stage. Acrylic curing process was performed according to the manufacturer's instructions.

Acropars and molloplast-B soft liners were processed between two blocks of PMMA according to the manufacturer's instructions. After accomplishment of the procedure the samples were removed and polished. 20 samples of each soft liner were prepared.

Ten specimens in each group as the control group were stored in aqueous incubation at 37°C for 24 hours and 10 were thermocycled (5000 cycles) among 5° and 55°C water baths. 2 cm on either side of the samples were placed in the fixture and tensile force was applied using a universal testing machine (ZwickRoll, Z50, Germany) at 5 mm/min speed.

The maximum tensile bond strength of the specimens was calculated in MPa. Mode of failure was determined with a scanning electron microscope (SEM) (CamScan MV2300,

Oxford, England) at magnification $\times 30$. Based on the failure location, the failure modes were categorized as follows:

- (1) Cohesive: failure in acrylic resin or soft liner itself
- (2) Adhesive: failure in interfacial surface of acrylic resin and soft liner
- (3) Mixed: failure in both materials

SPSS 16 software was used for statistical analysis. Two-way ANOVA was used to analyze the data.

RESULTS

The mean and standard deviation of the tensile bond strength for Acropars and Molloplast-B were 6.59 ± 1.85 and 1.51 ± 0.22 MPa, respectively before thermocycling and 5.89 ± 1.52 and 1.37 ± 0.18 MPa, respectively after thermocycling. Thermocycling did not have a significant effect on the tensile bond strength of both soft liners and interaction between the samples was not significant. Two soft liners had significant difference in bond strength so that Acropars bond strength was significantly higher than Molloplast-B ($p < 0.05$).

The mode of failure in Acropars was adhesive and frequently cohesive in Molloplast-B (Table 1).

DISCUSSION

Deboning of soft liners is a usual problem in clinical service. After separation, the joint area becomes unsanitary and non-functional [12].

After thermocycling, the bond strength of Molloplast-B and Acropars reduced insignificantly; so it was in a clinically acceptable range. This indicates that these soft liners maintain their adhesion to the denture bases over time and due to the aging process and can be useful in clinic. The effect of thermocycling on bond strength reduction is because of water immersion [13]. After immersion in water, two processes occur: plasticizer release and water absorption [11]. Water may penetrate directly in the bond interface and may lead to swelling and stress production between the denture base and the soft liner [12]. When the swelling occurs, the stress produced at the bonding surface and the viscoelastic properties of the soft liners change. The material becomes hard and transmits external forces to the bond surfaces [11], so the bond strength is reduced. The filler content of Molloplast-B absorbs water and may cause bond strength reduction and cohesive failure [11].

In a study conducted by Kulak-Ozkan et al., the Molloplast B bond strength decreased after thermocycling significantly although it was clinically acceptable [11]. This is somewhat similar to our results with this difference that in the present study, reduction of bond strength was not significant. The present study is similar to the study conducted by Pinto et al. [14] about silicon liners (soft liner) and is in conflict about acrylic liner (Permasoft). Pinto et al. [12] reported that thermocycling

Table 1. Mode of Failure in Soft Liners Before and After Thermocycling

Soft Liners	Adhesive	Cohesive	Mixed
Acropars before thermocycling	2	2	6
Acropars after thermocycling	7	2	1
Molloplast B before thermocycling	1	5	4
Molloplast B after thermocycling	0	5	5

reduced Molloplast B bond strength insignificantly, which is quite consistent with the present study. This contradiction is due to the acrylic resin type that is effective in bond strength [15, 16] and the number of cycles (in our study 5000 cycles and in the study by Pinto et al. 4000 cycles). In several studies about the effect of accelerated aging by thermocycling on the bond strength of soft liners [11, 12, 14, 17, 18], the results were different. This could be due to the acrylic resin and the soft lining material type, sample shape, number of cycles, thermocycling temperature, type of test and speed of force application. This study showed that the bond strength of Acropars was significantly higher than Molloplast-B. The bond strength of soft liners depends on their chemical composition [12]. Acropars chemical composition is similar to PMMA. PMMA and acrylic soft liners exist as powder/liquid. The powder is methacrylate polymer and the liquid is methacrylate monomer. Due to similarity in the chemical composition, a chemical bond is formed between PMMA and acrylic liners so bonding agents are not required [13, 15].

Molloplast-B is a polydimethyl siloxan. When cross-linking occurred a rubber with appropriate properties is formed. The elasticity of the soft liner is controlled by the amount of cross-linking. Chemical adhesion between silicone base liners and the denture base is absent or very low; so the bond improves with application of silicone polymer (methyl siloxan), or using alkaline silane bonding agent [11].

In this study, primer was used to enhance the bond of denture base to Molloplast-B liner.

The minimum acceptable bond strength for clinical application of soft liner is 0.44 MPa [11]; thus, both of the soft liners have sufficient bond strength in clinical application. In various studies [7, 15, 19-22], the bond strength of Molloplast-B has been lower than heat-cure acrylic liners, which is consistent with the results of the present study, although EL_ Hadary has reported that silicone liners have a higher bond strength than acrylic liners

[23]. This contradiction is because of differences in materials and methods. In this study, the bond strength of Molloplast-B (1.51MPa) is in a similar range of other studies (1.07, 1.37, 0.93, 0.63 MPa) [11, 12, 24, 25], although minor differences in the results of various studies are seen that is due to the difference in sample size and shape, speed of force application and material type. Similar to the study carried out by Kulak et al., [11] the fracture type in Molloplast-B was mostly cohesive, although in the Acropars group it was adhesive. Cohesive failure showed that the tensile strength of the liner is weaker than its bond strength to the denture base and adhesive failure showed that the bond strength between the liner and PMMA is lower than the bond strength of liner molecules. In Molloplast-B specimens, the mode of failure before and after thermocycling did not change; but the failure of Acropars samples before thermocycling was often mixed and after thermocycling it was often adhesive and this represents that thermocycling may have had an effect on the bond interface and mode of failure. The results of this study are compatible with some studies in this field [11, 19].

Comparison of the failure mode in different studies should be done with more attention; because mechanical tests, testing process and used acrylic resin are different. Proper tensile and tear strength, biocompatibility and color stability are all features that a soft liner should have. Selection of a special liner cannot be based on a specific feature and clinical conditions should be considered. It should be emphasized that although laboratory studies simulate clinical conditions, long-term clinical studies are needed to compare materials. The important note is that both evaluated soft liners can provide their main purpose of application if used appropriately. Factors such as processing methods, bonding agents and in vivo changes in the bond strength need more researches to predict which material can provide the best clinical services.

CONCLUSION

Considering the limitations of this study, the following results were obtained:

There was no significant difference in the bond strength of two soft liners to acrylic resin before and after thermocycling. The bond strength of Acropars was significantly higher than that of Molloplast-B. The mode of failure in Acropars and Molloplast-B was dominantly adhesive and cohesive, respectively. Thermocycling had affected the bond interface and the mode of failure of Acropars samples.

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