The influence of silicone remover on the tensile bond strength of resilient denture liner to an acrylic denture base resin

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Purpose: The purpose of this study was to determine the influence of silicone remover on tensile bond strength of eight silicone-resilient denture liners to a denture base resin. Durability of bond strength of resilient denture liner to denture base resin was also examined by thermal cycling test.
Materials and Methods: Eight commercial silicone resilient denture liners were used. The specimens were exposed to thermal cycles. Approximately 2 mL of silicone remover was applied with the brush between the resilient denture liner and the denture base resin at 0 cycle. The test specimens were placed under tension, until failure, in a materials testing machine.
Results: A significant difference was found between different silicone resilient denture liners for tensile bond strength in the application, and no application of silicone remover, at 0 cycle ($p<0.05$). When silicone remover was applied, the tensile bond strength of all silicone resilient denture liners to the denture base resin decreased significantly ($p<0.05$). The bond strength of all resilient denture liners tested exhibited at higher than 0.46 MPa.
Conclusion: The following conclusions were drawn: 1) Significant differences were found among the tensile bond strengths between various resilient denture liners and denture base resin. 2) The influence of thermal cycles exerted on bond strength between resilient denture liners and denture base resin varied according to the resilient denture liner used. 3) Silicone removal material was found to be effective in the removal of silicone resilient denture liners from the denture base resin. **(Int Chin J Dent 2006; 6: 39-44.)**

Key Words: resilient denture liner, silicone remover, tensile bond strength, thermal cycling.

Introduction

Resilient denture liner is used for a patient who has excessive absorption of the alveolar bone, and lesion of the alveolar mucousa due to long-term use of complete denture.[1] Most resilient denture liners were made with silicone, acrylic resin, isoprene or polyolefin.[2,3] Silicone resilient denture liners have the advantage of being inherently soft over a long period.[4,5] However, some silicone resilient denture liners have inadequate bonding to the denture base resin.[3,6,7] One of the serious problems is the failure of adhesion between the resilient denture liner and the denture base resin. The loss of bonding of the resilient denture liner to the denture base resin result in lining failure.[8-10] Khan et al.[9] reported that 10 pounds per inch (0.45 MPa) would be satisfactory for clinical use of resilient denture liner materials.

Sometimes, dentists fail to take an accurate denture lining because of air bubbles. And some problems associated with long-term use of resilient denture liners include staining, porosity, and loss of elasticity. In these cases, it is necessary to remove the failed resilient denture liners quickly and completely. Recently, silicone removing agent has been developed. Several tests have been used to assess the bond strength of resilient denture liners. Wright[11] estimated the bond strength of nine resilient denture liners using a peeling test. Kulak-Ozkan et al.[7] assessed the bond strength of six silicone based resilient denture liners using a tensile test. Al-Athel and Jagger[12] measured the bonding properties of silicone resilient denture liner using tensile, shear and peeling tests. Although the bonding of different types of resilient denture liner has been investigated,[6,9,10,13-17] conclusive evidence about the influence of silicone remover on the bond strength of silicone resilient denture liners to a denture base resin can not be found.

The purpose of this study was to determine the influence of silicone remover on tensile bond strength of eight silicone resilient denture liners to a denture base resin, and to confirm whether or not these was adequate bond strength of these resilient denture liners to the denture base resin. Furthermore, the durability of the bonding strength of resilient denture liner to denture base resin was examined by thermal cycling test.

Materials and Methods

Table 1 gives details of the eight commercial silicone resilient denture liners used in the present study. Seven room-temperature vulcanized materials and one high-temperature vulcanized material were used. Denture base acrylic resin specimens (Acron, powder 0212241, liquid 310842, GC Corp., Tokyo, Japan) were polymerized according to the manufacturer's recommended procedures to the rectangular blocks (35×10×10 mm). The section surfaces of tensile test specimens were abraded with 400 grit waterproof abrasive paper, and were rinsed with tap water for 15 s, and were allowed to air dry for at least 5 minutes. The adhesive agents of each material were applied to tensile test section surfaces of resin blocks.

Table 1. Materials used in this study.

Material	Abbreviation	Type	Manufacturer	Lot number
Molloplast-B	MB	HTV	Detax GmbH & Co., Ettlingen, Germany	991265
Ufi Gel C	UGC	RTV	Voco, Cuxhaven, Germany	97065
Sofreliner Tough	SRT	RTV	Tokuyama Dental Corp., Tokyo, Japan	VSD11210
Sofreliner Super Soft	SRS	RTV	Tokuyama Dental Corp., Tokyo, Japan	104
GC Reline Ultra Soft	GRU	RTV	GC Corp., Tokyo, Japan	0303251
Mollosil Plus	MP	RTV	Detax GmbH & Co., Ettlingen, Germany	000101
Permafix	PF	RTV	Kohler., Neuhausen, Germany	000502
Evathouch Soft	ETS	RTV	Neo Dental Chemical Products Co., Tokyo, Japan	LG01

HTV, High temperature vulcanized silicone; RTV, Room temperature vulcanized silicone.

Two denture base resin blocks were placed back into the metal mold with a 2 mm-thick spacer, and the resilient denture liners were then packed into the space (Fig. 1), and vulcanized according to the manufacturer's recommended procedures. Five specimens were prepared for each material and experiment. After curing, the specimens were exposed to thermal cycles between 4°C and 60°C water for 1 minute (0, 1,250, 2,500, 5,000 and 10,000 cycles). Ten specimens were prepared for 0 cycle. And it was divided into two groups of application silicone removing agent group (five specimens) and without silicone removing agent group (five specimens). Approximately 2 mL of silicone removing agent (Siliconeremover, 006, Tokuyama Dental Co., Tokyo, Japan) was applied with the brush between the resilient denture liner and the denture base resin at 0 cycle. The specimens were placed under tension, until failure, in a mechanical testing machine (Model 5565, Instron Corp., Canton, USA) using a crosshead speed of 20 mm/minute. The load (N) at which failure occurred was recorded together with the type of failure. The tensile bond strengths were calculated as follows: Tensile bond strength (MPa) = Load (N)/Cross-sectional area (mm^2). Means and standard deviations of five specimens were determined for all materials. The type of failure was assessed visually, and was recorded as being cohesive, adhesive, or mixed, depending on whether the fracture surface was in the resilient denture liner only, at the denture base resin-resilient denture liner interface only, or in both.

Results were compared using one-way analysis of variance testing (ANOVA) and two-way ANOVA. The difference in these values among the materials of bond strength were tested with Student-Newman-Keuls multiple comparison tests and t-test. All data were analyzed at a 0.05 level of significance.

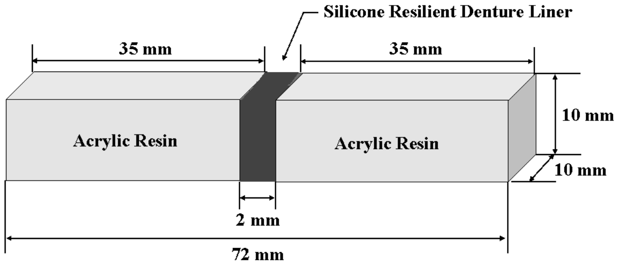

Fig. 1. Test specimen.

Results

The mean and standard deviation values of tensile bond strength without silicone remover at 0 cycle are shown in Fig. 2. A significant difference ($p<0.05$, one-way ANOVA) was found between different silicone resilient denture liners for tensile bond strengths at 0 cycle. Results of Student-Newman-Keuls multiple comparison tests showed no significant difference among the SRT, MB, and UGC, or among the GRU, PF and MP, or between SRS and ETS specimens of tensile bond strength at 0 cycle ($p>0.05$). The SRT (2.1 MPa), MB (2.0 MPa), and UGC (2.0 MPa) specimens exhibited higher values of tensile bond strength than other materials. The SRS and ETS specimens exhibited lower values of tensile bond strength between resilient denture liners and denture base acrylic resin than other materials.

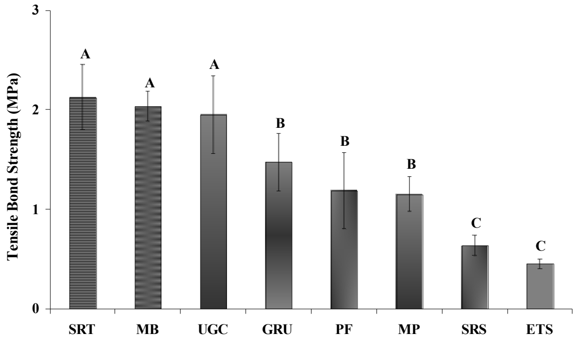

Fig. 2.

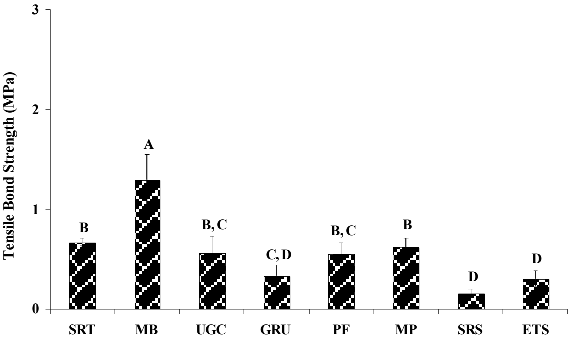

Fig. 3.

Tensile bond strength at 0 thermal cycle. Fig. 2 (left) shows the results without application of the silicone remover, whereas Fig. 3 (right) shows the results after application of the silicone remover. Identical letters indicate no significant difference.

The mean and standard deviation values of tensile bond strength in the application silicone remover at 0 cycle are shown in Fig. 3. A significant difference ($p<0.05$, one-way ANOVA) was found between different silicone resilient denture liners for tensile bond strength at 0 cycle. Student-Newman-Keuls multiple comparison tests showed that the MB specimen (1.3 MPa) exhibited higher values of tensile bond strength than other materials. The SRS and ETS specimens exhibited lower values of tensile bond strength between resilient denture liners and denture base acrylic resin than other materials. When the silicone remover was applied between the denture base resin and resilient denture liner, the tensile bond strength of all silicone resilient denture liners to the denture base resin decreased significantly ($p<0.005$, ANOVA and t-test).

The influence of thermal cycling on tensile bond strength is shown in Fig. 4. Significant differences were found as the tensile bond strength between the resilient denture liners at 1,250, 2,500, 5,000, and 10,000 cycles ($p<0.05$, ANOVA), except for SRT and MB. The change of tensile bond strength values from 0 cycle to 10,000 cycles are; from 2.1 to 2.4 MPa for SRT ($p=0.744$), from 2.0 to 1.7 MPa for MB ($p=0.115$), from 1.95 to 0.85 MPa for UGC ($p<0.05$), from 1.5 to 1.2 MPa for GRU ($p<0.05$), from 1.2 to 1.7 MPa for PF ($p<0.05$), from 1.2

to 1.4 MPa for MP ($p<0.05$), from 0.6 to 1.1 MPa for SRS ($p<0.05$), and from 0.5 to 0.6 MPa for ETS ($p<0.05$).

At the UGC, PF, and SRS, all specimens showed adhesive failures; the SRT, MB, GRU, and MP specimens showed most adhesive failures at 0 cycle. Most of the specimens showed adhesive failures except ETS with an increase in thermal cycling. The failure mode of all resilient denture liners was adhesive, when the silicone remover was applied at 0 cycle.

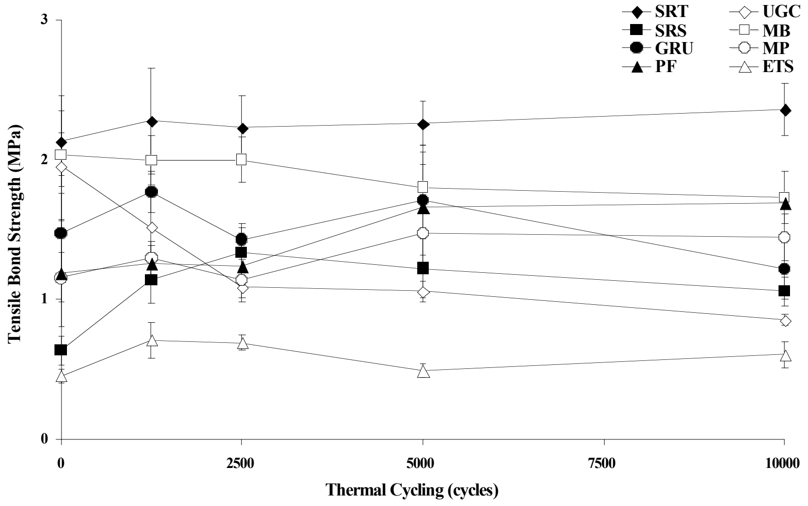

Fig. 4.
The influence of thermal cycling on tensile bond strength.

Discussion

Resilient denture liners have been a valuable asset for prosthesis clinically, because of their viscoelastic properties. They have been used when the oral mucosa exhibits a reduced tolerance to loads applied by dentures.[1] Sufficient bond strength between the resilient denture liner and the acrylic denture base resin is required to avoid interfacial separation of the prosthesis. This study measured the tensile bond strength between eight commercial silicone resilient denture liners to a denture base resin, and the influence of silicone remover on tensile bond strength. In addition, the influence that thermal cycling exerted on bond strength between resilient denture liners and denture base resin was examined.

The peel test[6,11,18] shear test[12,13] and tensile test[7,9,10,19] have been used to measure the bond strength between resilient denture liner and denture base resin. Although the peel test closely simulates the force applied at the interface between the resilient denture liner and the denture base, direct gripping of the resilient denture liner in the peel test may damage the sample integrity at the gripped region. The force may not be applied at the interface between both materials directly, because the applied force may depend on the properties of the resilient denture liner.

The tensile test did not simulate the clinical forces that may induce separation between the resilient denture liner and the denture base resin; however, the force was applied to the bonding area of both materials. This test was effective in ranking the materials, and in evaluating the failure mode. Then, the tensile bond test was used in this study. The highest tensile bond strength between resilient denture liners and denture base acrylic resin was seen with SRT, MB, and UGC specimens in the no application silicone remover at 0 cycle. Because MB is a high temperature vulcanized material, this may be the reason that high temperatures promoted the vulcanized reaction, and established good bonding eventually. SRT and UGC materials may be the reason for improvement of the adhesive agent, and to be the cause for high bond strength. The SRS and ETS specimens exhibited lower values of tensile bond strength between resilient denture liners and denture base acrylic resin. ETS showed an even more significantly lower value of bond strength, because the ETS polymerizes with condensation reaction. However, it polymerizes with other silicone resilient denture liners with the addition reaction. Therefore, the tear strength of ETS samples is small. This may be reflected in the bond strength of the material.

The results of this study indicate that the force for failure is higher than 0.46 MPa for all resilient denture liners tested. It has been reported that 10 pounds per inch (0.45 MPa) would be satisfactory for clinical use of resilient denture liner materials.[9,20,21] Considering this criterion, all resilient denture liners tested had satisfactory bond strength to denture base resin.

When the silicone remover was applied, the tensile bond strength of all silicone resilient denture liners to the denture base resin decreased significantly ($p<0.05$, ANOVA). The failure mode of all resilient denture liners was adhesive, when the silicone remover was applied. The component of adhesive agent for silicone resilient denture liners is silicone polymer in solvent or γ-methacryloxypropyl trimethoxysilane.[22] Tensile bond strength of silicone resilient denture liners to a denture base resin decreased significantly by using silicone remover. This may be the cause for why the silicone remover dissolves the component of the adhesive agent.

The tensile bond strength of resilient denture liners to the denture base resin increased significantly with an increase in thermal cycles ($p<0.05$, ANOVA), except for UGC, MB, and SRT specimens. This may account for the finding that at high temperatures, thermal cycles promoted the vulcanized reaction, and bond strength between resilient denture liner and denture base resin increased eventually. The tensile bond strength of UGC and MB specimens to the denture base resin decreased significantly with increasing thermal cycles. This may explain the distinct difference in behaviour for water sorption and desorption between denture base resin and resilient denture liners to cause the interfacial stress concentration.[23] The tensile bond strength of SRT samples to the denture base resin was shown to be a stable value with increase thermal cycling. The difference of water sorption and desorption between resin and liners may be little. And, improvement of the adhesive agent may have an influence on bond strength.

For the UGC, PF, and SRS, all specimens showed adhesive failures. The SRT, MB, GRU, and MP specimens showed adhesive failures at 0 cycle, which implies that the tear strength of the resilient denture liners was greater than bond strength to the denture base resin. At 0 cycle, the ETS specimen showed cohesive failures. This indicates that the tear strength of the resilient denture liners is weaker than the bond strength to denture base resin. Most specimens showed adhesive failures except ETS specimen with an increase in thermal cycling. The high temperatures of thermal cycles may have promoted the vulcanized reaction, and bond strength to denture base resin grew greater than tear strength of the resilient denture liners.

CONCLUSION

Within the limitations of the present study, the following conclusions were drawn:

1. The use of different materials showed significant differences in tensile bond strength between the denture base resin and resilient denture liners.
2. The influence of thermal cycles on bond strength between resilient denture liners and denture base resin varied according to the resilient denture liners used.
3. Silicone removal material was found to be effective in removal silicone resilient denture liners from the denture base resin.
4. The bond strength of all resilient denture liners tested exhibited at higher than 0.46 MPa.

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