Comparative Study on Tensile bond Strength between Heat curing Denture base Resin and Reline Materials

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Abstract

Background/Objectives: The purpose of this study was to evaluate the effect of the chemical surface treatment on the tensile bond strength of heat curing denture base resin and reliners. Methods/Statistical Analysis: The resin used for producing the sample was heat curing resin, while for the liner, two types of self-curing resins, two types of hard liners and two types of soft liners were used. Denture base resin surface was treated with MMA 95% and TEGDMA 5%, MMA 95% and silane coupling agent 5%, heat curing resin monomer. After denture reliners were injected, tensile bond strength was measured. Findings: When analyzed by manufacturer, for repair resin, Lang had a higher tensile bond strength than Vertex SC in all experiment groups (p<0.05). For hard liner, Kooliner was higher than Rebase in all experiment groups (p<0.05). For soft liners, Dura base had a higher tensile bond strength than Coe-soft in all experiment groups (p<0.05). As such, it is assumed that the chemical treatment of surfaces between the denture base resin and each of the liners affects the tensile bond strength, and that MPS intermediates the adhesion between the organic and inorganic matter to increase the bonding. Therefore, chemical treatment of the surface using TEGDMA and MPS, as well as heat curing resin monomer is effective in improving the tensile bond strength. Among them, chemical surface treatment using MPS and heat curing resin monomer appeared to be the most effective. Improvements/Applications: After, in order to increase the bond strength between heat curing denture base resin and reliners, to have more kinds of silane coupling agent and liner for studies of chemical bonding is considered it should be continued.

Keywords: Denture Base Resin, Reliner, Silane Coupling Agent, Surface Treatment, TEGDMA, Tensile Bond Strength

1. Introduction

Many changes occur in the location and appearance of dentures until they settle into the patient, and during this process stress is focused on the supporting tissue. Moreover, the residual ridge in the lower direction of the denture continues to change, causing reduced retention of the denture and changes in vertical dimension over time. To address such issues, denture liners may be used. Therefore, the liner of the denture needs to bond well with the resin and remain stable to the various environmental factors in the oral cavity. Other requirements of the liner include bonding to the resin, small degree of expansion or contraction, high strength, stable color, low moisture absorption rate, resistance to abrasion, easy to clean with no taste or odor, and causing no irritation to the mucous membrane of the oral cavity. The material most frequently used is the self-curing material which is easy to use and doesn’t require many patient visits. But compared to the heat curing resin, the appropriateness and bonding is low. Preceding studies, too, note that stable binding is difficult between the material and the denture base, many studies have been conducted on how to improve such bonding. One of the leading methods to improve binding is to use mechanical or chemical treatment. The mechanical treatment promotes mechanical bonding and increases the surface area and intensity of bonding but makes the surface rough and porous, making it prone to
bacteria growth. There are also reports that it affects the accumulation of food remnants and causes discoloring or plaque\textsuperscript{14,15}. Chemical treatments use methyl-methacrylate, chloroform, methylene chloride or acetone to improve the bonding so that the repair material can be distributed evenly on the denture, changing the form and chemical characteristics of the denture\textsuperscript{16–19}. In studies on simple chemical treatments to improve bonding between denture liners and resin, some suggested the use of silane coupling agent to increase bonding between the inorganic surface and composite-molecules. But studies on the use of silane coupling agent is insufficient and it was reported that in most cases composite resin and the dental cement improved bonding\textsuperscript{20,21}.

While there are many studies on the bond strength between heat curing resin and liners, the studies have been limited to specific organic solvents or one type of experiment on bond strength. The use of silane coupling agent, too mostly focused on composite resin and dental cement, and there is insufficient comparative studies on various types of liners. As such, this study was to compare and evaluate the effect of MPS and TEGDMA and heat curing resin monomer on the tensile bond strength between denture base resin and reliners.

### 2. Materials and Methods

#### 2.1 Materials

The resin used for producing the sample was heat curing resin (Vertex RS, Dentimax, Netherlands), while for the liner, two types of self-curing resins (Vertex self curing, Dentimax, Netherlands; Lang self curing, Lang Dental, USA), two types of hard liners (Kooliner, GC Inc., USA; Rebase II, Tokuyama, Japan) and two types of soft liners (Dura base, Reliance Dental MFG, USA; COE-soft, GC Inc., USA) were used. For the surface treatment solution, Methylmethacrylate (Sigma-Aldrich, USA; MMA) was used as base to which two types of bridging binding agent, Triethyleneglycol Dimethacrylate (Sigma-Aldrich, USA; TEGDMA) and the commonly used coupling agent Methacryloxypropyltrimethoxysilane (Dami-polychem, Korea; MPS) was added. The heat-curing resin monomer single unit (Vertex RS, Dentimax, Netherlands) was also used for surface chemical treatment.

#### 2.2 Test Method

The sample for the study was produced referencing the international standard number 10139–2\textsuperscript{22}. Heat-curing resin (vertex RS) in square form with each side being 25 mm and thickness of 3 mm was mixed according to the manufacturer’s manual for 30 seconds at 12.9 g of powder/solution 5.7 g, which was then placed into a flask using molding with pressure. This flask was placed in a water tank whose temperature was gradually increased to 72°C. At this temperature it was kept for two hours and it was kept at 100°C for another hour. It was then taken out of the water tank and kept at room temperature for 30 minutes, then in flowing water for 15 minutes.

After this process, the sample which was removed from the flask was honed using SiC polishing paper number 200, 400, 600, 800, and 1200 in that order on both sides. Then using a low speed saw, it was cut to be made into a 25 mm x 25 mm square with a thickness of 3 mm. The manufactured sample was kept in water of 37°C for 28 days. Then a polyethylene collar which is a tube with an internal diameter of 10 mm and a thickness of 3 mm to which the liner would be inserted, was bonded to the resin. On the surface where the resin and the liner would be bonded, TEGDMA 5 wt%, MPS 5 wt%, and heat curing resin monomer were used for the respective surface treatments. The two types of repair self-curing resin (Vertex SC, Lang), two types of hard liner (Kooliner, Rebase II), and two types of soft liner (Dura base, Coe-soft) were then inserted into the collar to the point of slightly over-flowing for bonding at room temperature. The sample was then kept for 24 hours in distilled water of 37°C.

For each group, 10 samples were produced. To measure the tensile bond strength of the denture base resin and liner sample, the all-purpose tester (Z020) was used. The sample was fixed onto the gauge and had pressure be added at a test speed of crosshead speed being 10 mm/min. the maximum weight at the time where the resin and liner separate were measured and the form of separation was also observed. For statistical analysis, SPSS was used. For the experiment group and the control group, the flexural rigidity and tensile strength were measured and analyzed using one way ANOVA at a confidence level of 95 %. For a post verification, Tukey multiple range test, and the strength of the liners were analyzed using a t-test (α = 0.05).
2.3 Failure Modes

The separation form of the sample was categorized into three types. If the bonding point were broken into two pieces, it was categorized as A type of separation. If the break occurred starting at the corner of the bonding surface, it was categorized as B type of separation, and if only the liner was broken, it was categorized as focused separation type C.

3. Result

3.1 Test result

When analyzed by manufacturer, for repair resin, Lang had a higher tensile bond strength than Vertex SC in all experiment groups (p<0.05). For hard liner, Kooliner was higher than Rebase in all experiment groups (p<0.05). For soft liners, Dura base had a higher tensile bond strength than Coe-soft in all experiment groups (p<0.05). When looked at chemical treatment, in repair resin, Lang was ranked significantly higher for the group that had its surface treated than any other comparison group. For Vertex SC, the group that had the surface treated with MPS and heat curing resin monomer showed a significantly higher level than the controlled group or the group whose surface was treated with TEGDMA (p<0.05). For hard liners, in Kooliner, the group whose surface was treated with MPS ranked significantly higher than the group treated with other solutions. In Rebase, the group whose surface was treated with MPS and heat curing resin ranked significantly higher than the control group or the group whose surface was treated with TEGDMA (p<0.05). In soft liners, for Dura base, the group whose surface was treated ranked significantly higher than the control group (p<0.05). For Coe-soft, there were no significant differences across all groups (p>0.05).
The columns with the same letters were not significant different by one way ANOVA and Tukey multiple range test at $\alpha = 0.05$.

Control: No treatment, M+M: MMA 95 wt% + MPS 5 wt%, M+T: MMA 95 wt% + TEGDMA 5 wt%, Liquid: the monomer of heat-cured denture base resin. * Significantly different by t-test.

**Figure 5.** Tensile strengths between two repair resins and heat-cured denture base resin according to the chemical surface treatment.

The columns with the same letters were not significant different by one way ANOVA and Tukey multiple range test at $\alpha = 0.05$.

Control: No treatment, M+M: MMA 95 wt% + MPS 5 wt%, M+T: MMA 95 wt% + TEGDMA 5 wt%, Liquid: the monomer of heat-cured denture base resin. * Significantly different by t-test.

### 3.2 Failuremodes

The separation patterns of the sample are shown in the table. The repair resins Vertex SC and Lang, and the hard liners Kooliner and Rebase mostly saw the resin and liner being separated at the border, which is the separation type A. In soft liner Dura base, too, separation A mostly appeared, but for soft liner Coe-soft, only the liner part was broken which is the separation type C.

### 4. Conclusions

This study, in order to identify a new chemical bond for heat curing denture base resin and liner to improve their tensile bond strength, resin solutions often used for chemical surface treatment and solutions of TEGDMA and MPS were used and the results were compared. The use of a cross-linker agent in general polymer composites after hardening the molecular mass is increasing. In the case of cross-linker agent that is poly-functional, the bonding improves. The polymers that have seen bonding increase due to the cross-linker agent sees its solubility decrease, becomes harder and the bonding contraction of the resin also increases. In general, the cross-linker agent commonly used in dental treatment, TEGDMA, has two functions and has a relatively high molecular mass. Silane coupling agent reacts with the hydrogen acid on the filler surface to create siloxane. The formula for organic silane is $R'-Si-(OR)3$. $R'$ is an organic group and the three alkoxy groups are referred to as $R^2O$. The chemical reaction starts

**Table 1.** Failure modes of specimens

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<tr>
<th>Group</th>
<th>Failure mode</th>
<th>Reliner</th>
<th>Vertex SC</th>
<th>Lang</th>
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<th>Rebase</th>
<th>Dura base</th>
<th>Coe-soft</th>
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with the hydrolysis of the alkoxide group. Therefore, the silane coupling agent intermediates the adhesion between the inorganic and the organic matrix and consists of a combination of organic and inorganic matter through the two types of reactivity\textsuperscript{26}. Silane coupling agent, most commonly used in dental treatment is a solution of pH 4-5 made from 3-Methacryloxypropyltrimethoxysilane which has singular reactivity and diluted mix of ethanol and water. Silane coupling agent is used to increase the bonding between the matrix resin and filler of the composite material. For this reason, MPS is often used in dental resin composites. Other studies noted that clinically, the force affecting the contact surface between the two materials is closely related to the shear bond strength and tensile bond strength\textsuperscript{27}.

In this experiment, the commonly used silane coupling agent which is MPS, TEGDMA, and heat curing resin monomer were used to review the tensile bond strength with the liner. For repair resin, Lang had higher tensile bond strength than Vertex SC, while for hard liners, Kooliner ranked higher on all groups than Rebase. For soft liners, Dura base ranked higher than Coe-soft in all groups. When looked at by chemical surface treatment method, in repair resins, Lang saw the surface-treated experiment all groups ranking higher than the control group. In Vertex SC, the experiment group whose surface was treated with MPS and heat-curing resin monomer ranked higher. In hard liners, for Kooliner, MPS ranked higher than the control group and other experiment groups treated with other solutions. For Rebase, the experiment group treated with MPS and heat curing resin monomer ranked higher. In soft liners, for Kooliner, MPS ranked higher than the control group. For Rebase, the experiment group treated with MPS and heat curing resin monomer ranked higher than the control group. In soft liners, Dura base saw the surface-treated experiment groups rank higher than the control group, while Coe-soft saw no significant difference from the control group. The separation pattern of the soft liner was mostly separation type C. Such a pattern indicates that the strength of shear in the soft liner can be weaker than the bond strength with the denture. In the case of soft liners, since the bonding body melts and takes on gel form, it was reported that the shear strength is low, which leads to separation type C\textsuperscript{28}.

In\textsuperscript{29} noted that among the experiment groups whose surface was treated with heat curing denture base resin, self curing resin solution and acetone, the experiment group treated with heat curing denture base resin showed the greatest bond strength. Reference\textsuperscript{30} saw MMA recording the highest bond strength among the groups whose surface was treated with MMA, chloroform and acetonitrile. While in other studies, MMA and heat curing resin monomer saw greater bond strength, in this study, MPS-treated surfaces saw greater tensile bond strength.

As such, it is assumed that the chemical treatment of surfaces between the denture base resin and each of the liners affects the tensile bond strength, and that MPS intermediates the adhesion between the organic and inorganic matter to increase the bonding. Therefore, chemical treatment of the surface using TEGDMA and MPS, as well as heat curing resin monomer is effective in improving the tensile bond strength. Among them, chemical surface treatment using MPS and heat curing resin monomer appeared to be the most effective.

5. References