Effect of glass fiber reinforcement surface treatment on the soft liner retention and longevity

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ABSTRACT

Background: Denture liners have been used in dentistry for many years. Soft denture liner is one of the denture liners which used to enhance the fit of poor fitting dentures and prevent trauma to sensitive mucosa. One of the disadvantages of the soft denture liner is the frequent debonding from the denture during clinical use thus reducing the longevity of such prosthesis. Glass fibers integrated at or on the fitting surface of the denture used to improve the bonding of the silicone soft liner to the acrylic surface.

Materials and methods: The shear bond strength calculated to evaluate the effect of the glass fiber surface treatment on the bonding between the acrylic surface and the silicon soft liner. 120 samples were prepared and divided into 3 major groups: Group I for the conventional heat cure acrylic, Group II for the pour acrylic and Group III for the light cure acrylic. Each one of these major groups divided into 2 subgroups, the first one for the Mollosil silicon soft liner and the second one is for the Molloplast-B silicon soft liner. Each one of these sub groups consist of 2 types of the acrylic surface: smooth (control) and glass fiber net surface treatment.

Results: this study revealed that some types of the surface treatment exhibited a highly significant improvement in the bonding between the acrylic surface and the soft liner.

Conclusion: glass fiber surface treatment could improve the bonding between the acrylic surface and the soft liner.

Key words: silicon soft liner, glass fiber, shear bond strength, surface treatment.

INTRODUCTION

Denture liners have been used in dentistry for many years. They are classified into hard reline material, permanent tissue liners and tissue conditioners. (1) They are used to enhance the fit of poor fitting dentures and prevent trauma to sensitive mucosa by forming a cushioned layer between the denture base and the oral mucosa. (2) Soft liners suffer from low tear strength, porosity, water absorption and frequent de bonding from denture during clinical use, thus reducing the longevity of such prosthesis. (3) Silicon soft liners have been used as resilient liners for denture bases since the early 1960s. Their resilience at mouth temperature is not derived from the use of plasticizer but from an intrinsic of this type of polymer therefore they retain resilience throughout their working life, also Silicon type may be chemically or heat activated. Bond strength between denture bases and resilient materials has been evaluated by several tests such as tensile, (4) shear (5) and peel tests. (6)

Shear tests are suitable for examining bond strength of liner to acrylics, as masticatory forces in the oral cavity are similar to tear and shear forces rather than tensile forces. (7)

Glass fibers are used to increase the impact strength of heat cured acrylic denture bases especially when the minimum required acrylic thickness is unobtainable.

The present study is not concerned with fiber reinforcement of the acrylic. Rather, the focus is on the potential for the fiber, integrated at or on the fitting surface of the acrylic, to improve bonding of the liner to the acrylic surface.

MATERIALS AND METHODS

A total of 120 samples were prepared. These 120 samples divided into 3 major groups: I, II and III (100 sample for each major group) . Group I for the heat cure acrylic, group II for the pour acrylic and group III for the light cure acrylic. Each one of the 3 major groups divided into 2 subgroups (20 specimen for each subgroup): group I divided into subgroup A (heat cure acrylic relined with Mollosil) & subgroup B (heat cure acrylic samples relined with Moloplast B), group II divided into subgroup C (pour acrylic samples relined with Mollosil) & subgroup D (pour acrylic samples relined with Moloplast B) and group III divided into subgroup E (light cure samples relined with Mollosil) & subgroup F (light cure samples relined with Moloplast B). Each one of these subgroups consist of 2 types of acrylic interface (10 specimen for each type):

- Smooth surface (control group), surface without any treatment.
- Treatment with glass fiber net.

Each specimen consist of 2 acrylic blocks with dimensions of (3 inch × 1 inch × 3/16 inch

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length, width, depth respectively) with stopper of depth about 3mm.\(^{(8)}\) One block of the acrylic put over the other block leaving a space between them of dimensions (1 inch × 1 inch × 3mm length, width and depth respectively). The thickness of the handle of the acrylic specimen is 5 mm, this thickness is important for the clamping of the specimen by the Instron machine.

**Preparation of the heat cure acrylic specimens**
The heat cure acrylic specimens prepared as that for the complete denture preparation.

**Heat cure acrylic interface preparation**
(3) Smooth surface
The acrylic surface was smoothed by pressing the acrylic while it is in the dough stage against the mould and after polymerization it was left without polishing or any treatment.

(4) Glass fiber net addition
In this group before curing of the acrylic a multidirectional glass fiber net was cut that fit the acrylic interface (of 0.1g weight) then this net impregnated in the thin mix of the acrylic of weight of 0.02gm and the net was put in the mould in the area of the acrylic interface.

![Figure 1: acrylic sample with glass fiber net surface treatment](image)

**Pour acrylic specimens preparation**
The same metal pattern which was used for the construction of the heat cure acrylic specimens was used for the construction of the pour acrylic specimens. 2 wax sprues were added to the metal pattern for the purpose of pouring the acrylic. After finishing with pouring wait for 3min. before placing the model in the pressure vessel (Ivomet). Polymerize at 55°C for 30 min. and pressure to 2.5 bars.

After polymerization take out the model and remove the putty 1:1, remove the sprues and start to trim and finish the specimen.

**Pour acrylic interface preparation**
1. Smooth surface
The acrylic interface was left without any treatment. It takes the shape and smoothness from the mould of the putty material which was prepared from the metal pattern. The samples cleaned by the ultrasonic cleaner and stored in distilled water for 48h.

2. Addition of glass fiber net
A multidirectional glass fiber net that fit the acrylic interface (0.1g in weight) was impregnated in the thin mixture of the pour acrylic (0.2g powder/0.2 g liquid) and applied to the putty 1:1 mould in the area that will form the acrylic interface. After that the pour acrylic is poured in the mould and the steps of the sample preparation completed as usual.

![Figure 2: glass mould used for the light cure acrylic specimens preparation](image)

**Preparation of the light cure acrylic specimens**
A glass mould constructed for the purpose of the study was used for the preparation of the specimens. The separating medium was applied to the mould and the sheet of the light cure acrylic was knead and applied to the glass mould and then put it in the light cure acrylic polymerization unit for 10min. to each one of the 2 sides of the glass mould.

**Light cure acrylic interface preparation**
1. Smooth surface
Acrylic surface smoothed by pressing the acrylic dough against the glass mould then after complete polymerization the acrylic surface left without any treatment.

2. Glass fiber net application
A multidirectional glass fiber net cut to the size that fit the acrylic surface which will face the soft liner (0.1g in weight) was added to the glass mould in the area of the acrylic interface. Then the light cure acrylic dough added to the glass mould and polymerized as usual.

**Soft Relining Material Application**
Mollosil application (silicon-based cold curing chair side soft liner)
The acrylic surface was coated with the adhesive material. Let the adhesive dry for 1min. A homogeneously equal lengths of mollosil base material and catalyst were mixed for 30 seconds. The mixed material was applied with spatula onto the acrylic surface. Then each pair of the acrylic specimen joined together and the excess of the material was removed by using sharp knife.
and the specimen was put under weight of 2.5Kg and left for 30 min for bench cure.

After complete curing the specimens were stored into distilled water containers in an incubators at 37°C for 24 hours.

Molloplast-B soft liner application

This material is supplied as a one paste system. The primo adhesive (chemical bonding of Molloplast B) was brushed uniformly onto the acrylic surface and let the primo adhesive air dry for approximately 60 min prior to applying Molloplast B. Take Molloplast B with a clean spatula from the jar and apply it evenly on the acrylic surface. Then join the pair of acrylic specimen and put it in the flask. The Molloplast B polymerized by placing the flask in cold water and heat up slowly up to 100°C for approximately 2 hours. After complete polymerization the flask cooled down slowly. After opening the excess material was cut with a sharp knife.

![Figure 3: Two acrylic samples joined together with the soft liner between them](image)

Shear bond testing procedure

Each specimen was tested after 24 hours after processing using universal Instron testing machine with a suitable grips for the test specimens. The specimens subjected to 1 KN load at a cross head speed 10 mm/min until failure occurred.

The maximum load required for the failure was recorded in order to calculate the value of shear bond strength for each test specimen

\[
\text{Bond strength (N/mm}^2) = \frac{\text{Maximum load}}{\text{Cross sectional area}} = \frac{F}{A}
\]

RESULTS

Shear bond test of the three types of acrylic relined with Mollosil soft liner

The samples of the control group of the conventional heat cure acrylic showed a mean value of the shear bond strength equal to 0.508 N/mm². The results of the t-test show that there is a significant increase in the bonding between the heat cure acrylic and the Mollosil soft liner with the glass fiber net addition.

The samples of the smooth surface of the pour acrylic showed a mean value of the shear bond strength equal to 0.483 and for the glass fiber net group equal to 0.714. The results of the t-test show that there is a highly significant increase in the bonding between the pour acrylic and the Mollosil soft liner with the glass fiber net addition.

The samples of the smooth surface of the light cure acrylic showed a mean value of the shear bond strength equal to 0.294 while the glass fiber net group showed a mean value of the shear bond strength equal to 0.284 and the results of the t-test show a non significant difference from the control.

![Figure 4: Bar chart for the mean distribution of the shear bond strength of three types of the acrylic relined with the Mollosil soft liner.](image)

Shear bond test of the three types of acrylic relined with Molloplast-B soft liner

The samples of the control group of the conventional heat cure acrylic showed a mean value of the shear bond strength equal to 1.233 N/mm² while the mean value of shear bond strength for the glass fiber net group equal to 1.199 N/mm². The results of the t-test show that there is a non significant difference in the bonding between the heat cure acrylic and the Molloplast-B soft liner with the glass fiber net addition.
Table 1: Modes of the bonding failure of different types of the acrylic with the Molloplast-B soft liner

<table>
<thead>
<tr>
<th>Acrylic type</th>
<th>Surface treatment</th>
<th>Failure type (in numbers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional heat cure acrylic</td>
<td>Smooth surface</td>
<td>C/M/A</td>
</tr>
<tr>
<td></td>
<td>G.F. net</td>
<td>7/3/0</td>
</tr>
<tr>
<td>Pour acrylic</td>
<td>Smooth surface</td>
<td>C/M/A</td>
</tr>
<tr>
<td></td>
<td>G.F. net</td>
<td>8/2/0</td>
</tr>
<tr>
<td>Light cure acrylic</td>
<td>Smooth surface</td>
<td>C/M/A</td>
</tr>
<tr>
<td></td>
<td>G.F. net</td>
<td>9/1/0</td>
</tr>
</tbody>
</table>

C = cohesive failure  
M = mixed failure  
A = adhesive failure  
G.F. = glass fiber

Table 2: Modes of bonding failure of different types of the acrylic with the Molloplast-B soft liner

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<th>Failure type (in numbers)</th>
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</tr>
<tr>
<td></td>
<td>G.F. net</td>
<td>10/0/0</td>
</tr>
<tr>
<td>Pour acrylic</td>
<td>Smooth surface</td>
<td>C/M/A</td>
</tr>
<tr>
<td></td>
<td>G.F. net</td>
<td>3/7/0</td>
</tr>
<tr>
<td>Light cure acrylic</td>
<td>Smooth surface</td>
<td>C/M/A</td>
</tr>
<tr>
<td></td>
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C = cohesive failure  
M = mixed failure  
A = adhesive failure  
G.F. = glass fiber

The samples of the smooth surface of the pour acrylic showed a mean value of the shear bond strength equal to 1.581N/mm² and for the glass fiber net group equal to 1.516N/mm². The results of t-test show that there is a non significant difference in the bonding between the pour acrylic and the Molloplast-B soft liner with the glass fiber net addition.

The samples of the smooth surface of the light cure acrylic showed a mean value of the shear bond strength equal to 1.021N/mm² and for the glass fiber net group equal to 0.832N/mm². The results of the t-test show that there is a highly significant reduction in the bonding between the pour acrylic and the Molloplast-B soft liner with the glass fiber net addition.

DISCUSSION

The bonding of silicon elastomers depend on the strength of the silicon elastomers and the adhesive primers used. Besides, the strength of the bond also depends on the treatment modalities of the acrylic resin surface. [11]

In the conventional heat cure acrylic relined with the Mollosil soft liner, the Glass fiber net group show significant difference, the increase in the bond strength can be attributed to changes in the topography of the acrylic interface due to the presence of the glass fiber. The adhesive used penetrated the resin matrix that impregnates the net shaped glass fibers leading to enhanced chemical adhesion with the liner this in agree with Hatamleh M.M. (2010) finding that the sticktech net fiber-reinforced surface exhibited a stronger bond to the soft liner.

In the pour acrylic relined with Mollosil soft liner the adhesive used prior to the application of the Mollosil penetrate the resin matrix which impregnate the glass fiber net which was used in the surface treatment so that increase the bonding between the pour acrylic surface and the soft liner this in agree with Hatamleh M.M. (2010) finding that the sticktech net fiber-reinforced surface exhibited a stronger bond to the soft liner.

In the light cure acrylic relined with the Mollosil soft liner, the glass fiber net affect the surface of the light cure acrylic and likely act as impurities and loose particles on the light cure acrylic surface which reduce the bonding between the two materials. Also it reduce the surface area of the bonding site.

In the conventional heat cure acrylic relined with the Molloplast-B soft liner, the Glass fiber net surface treatment show a non significant difference from the control because the same chemical bonding occur. Which is attributed to
the acryloxyalkylsilicone which as well as improving the cross linking of the silicon soft liner, it intended to adhere to PMMA, besides; the adhesive contained a -Methacryloxy propyl trimethoxysialie which improve the adhesion and cross linking to the underlying PMMA this is according to Wright (1984).

In the pour acrylic relined with Molloplast-B soft liner, The glass fiber net surface treatment affect the bonding in non significant difference from the control because the same adhesion and cross linking of the soft liner adhesive to the underlying pour acrylic surface occur.

In the light cure acrylic relined with the Molloplast-B soft liner, the glass fiber net surface treatment reduce the bonding because it reduce the bonding area because these glass fibers weren't covered by light cure acrylic matrix because the light cure acrylic supplied as sheet so the glass fibers couldn't be covered by the matrix and applied directly to the surface so it reduce the surface area of the bonding site.

Most of specimens of the conventional heat cure acrylic and pour acrylic bonded to the Mollosil soft liner and the conventional heat cure acrylic, pour acrylic and light cure acrylic bonded to the Mollosil-B show cohesive failure. It means that the bond strength between the acrylic and the soft liner were stronger than the strength of the soft liner itself. While in the case of light cure acrylic relined with Mollosil the mode of failure is adhesive because of low adhesion between the two materials due to the low compatibility between them.

REFERENCES