Evaluation of the tensile bond strengths of heat cure acrylic and Valplast with silicone self cure soft liner


ABSTRACT

Background: Soft lining materials have a key role in modern prosthodontics because of their capability of restoring health of inflamed and distorted mucosa. Gradual changes of oral tissues require that complete or partial dentures be relined to improve their adaptation to the supporting tissue. This study aimed to evaluate the tensile bond strength of heat cure acrylic and Valplast denture base materials to silicone self-cure soft lining material stored in artificial saliva.

Materials and method: Two types of self cured silicone soft lining material (one with prime the other without prime or adhesive) applied to polymethylmethacrylate and injection-molded nylon denture base materials for tensile bond strength testing using Instron machine.

Results: The comparison between all test groups after (48) hours immersion in artificial saliva were highly significantly different from each other except for the comparison between groups PSP and VSP in which their means were non-significant. After (12) weeks, the comparison between all test groups were highly significantly different from each other when compared statistically.

Conclusion: This study indicated that prime (adhesive) increase the bond strength of the silicone soft lining materials with denture base materials. Silicone soft lining materials are affected by artificial saliva storage.

Key words: Self-cure silicone soft lining material, acrylic denture base, injection-molded nylon, tensile bond strength.

INTRODUCTOIN

Relining is defined as "the procedures used to resurface the tissue side of the denture with new base material, thus producing an accurate adaptation to the denture foundation area" (1).

A major objective in construction of complete dentures is to attain a denture base that conforms to the supporting tissues with a high degree of accuracy.

The greater the accuracy of the base, the more stable is the prostheses (2-4).

Polymethyl methacrylate resins have been preferred as denture base resins because of their physical and esthetic properties as well as the material’s availability, reasonable cost, and ease of manipulation (5).

The introduction of injection molding, which allows directional control of the polymerization process through the flask design. A constant flow of new material from the sprue compensates for the polymerization shrinkage.

Gradual changes of oral tissues require that complete or partial dentures be relined to improve their adaptation to the supporting tissue (4). Soft liners provide comfort to patients who cannot tolerate occlusal pressure (15). Soft liners are often used for management of painful or atrophied mucosa or traumatic ulceration associated with wearing dentures. The soft liner provides comfort for the patient and may it reduce residual ridge resorption by reducing the impact force in the load-bearing areas in the supporting structures during function (16).

During the use of soft liner, the materials are in continuous contact with saliva and during denture storage they are soaked in water or an aqueous cleaning solution (11). The desirable properties of soft liner include long term elasticity; loss of elasticity could result in delivery of higher occlusal forces to the underling mucosa. Also the soft liner should be resistant to imbibing of the oral fluids or releasing compounds into the saliva, fluid imbibition would result in liner discoloration and swelling and the potential growth of microorganism (26). The relining material used may be classified as either hard or soft, the selection depends on oral circumstance and treatment planning (24,10,21).

Silicone soft lining materials have the advantage of being inherently soft over a long period, whilst the development of polyvinylsiloxanes similar to those used in dental impression materials allows simple application procedures to be used. However, the achilles heel of silicone products is often an inadequate bonding to the denture base. Several publication have focused on the factors which can affect bonding, including the nature and direction of the de-bonding force and liner thickness and. The tear strength of the soft liner itself, the nature of the adhesive agent and variations in the structure of the acrylic resin denture base (29).

Relining materials are classified to three groups: hard reline materials, tissue conditioning materials and soft lining materials. There are many types of soft lining materials like plasticized acrylic type soft liner and silicone soft liner. They
basically consist of polydimethylsiloxane polymer to which filler is adding to give the correct consistency. The material harden by cross linking process, as the materials is already polymer this cross linking can be achieved either by heat, using benzoyl peroxide, or at room temperature, using tetraethyl silicate $^{(9,10)}$.

**MATERIALS AND METHODS**

Specimens were prepared from two chemically different denture base materials

1. Polymethylmethacrylate (Heat cure acrylic non cross linked ENTACRYL, ENTA B.V. Bergen op zoom the Netherlands ISO 9000, Holland).
2. Injection-molded nylon (Valplast INTERNATIONAL CORP., New York, USA) denture base materials.

Joined by two types of self-cure silicon soft lining material one with prime (bredent), the other one without prime or adhesive (Zhermack), they were evaluated for changes in tensile bond strength. (Immersion in artificial saliva at different time of immersion).

**Specimens grouping:**

Two major groups include (4) subgroups of specimens, (2) subgroup of polymethylmethacrylate and (2) subgroup of injection-molded nylon, with (2) types of self-cure silicone soft lining materials; the number of specimens in each subgroup was depending on the tests made. The specimens grouping for each major group were classified as follow:

**Group1:** Specimens immersed in artificial saliva for (48) hours for tensile bond strength test.

**Group2:** Specimens immersed in artificial saliva for (12) weeks for tensile bond strength test.

Each group was divided into (4) subgroup according to the material used:

- (PS) heat cures acrylic denture base blocks with soft lining material without prime or adhesive.
- (PSP) heat cures acrylic denture base blocks with soft lining material with prime.
- (VS) Valplast denture base blocks with soft lining material without prime or adhesive.
- (VSP) Valplast denture base blocks with soft lining material with prime.

**Preparation of the artificial saliva:**

Artificial saliva was prepared in the pedodontic department in the College of Dentistry /University of Baghdad, under supervisions of the seniors of the department $^{(14)}$.

The composition was as follows: 6.8 mM NaCl, 5.4 mM CaCl$_2$, 5.4 mM KCl, and 5.0 mM NaH$_2$PO$_4$, 0.021 mM Na$_2$S, 16.7 mM urea and deionized distilled water. (mM=mg/m.wt.In 1 liter) (m.wt.= molecular weight).

**Tensile bond strength test:**

80 Specimens were prepared for tensile testing in (2) groups, each groups was divided into (4) subgroups each one contains (10) specimens aging in 250 cc. closed polyethylene containers containing artificial saliva in an incubator at 37.5°C.

Specimens of each group were divided as follow:

1. (40) Specimens were tested after 48 hours immersion in artificial saliva
2. (40) Specimens were tested after 12 weeks immersion in artificial saliva.

Each specimens consisted of (2) heat-cure acrylic or Valplast blocks denture base with dimension of (6*6*30) mm width, depth, length respectively, and intermediate part of soft lining material with dimensions of (6*6*3) mm width, depth, length respectively joining the 2 pieces of denture base block so the total dimension of the specimen was (6*6*63) mm, using digital vernier for checking the dimension of the specimens $^{(2,3)}$.

**Preparation of denture base specimens:**

For the ease of sample preparation, a metal mould was constructed $^{(14)}$.Figure (1), it consisted of sample parts which consist of 2 pattern of samples, first pattern is (6*6*30) mm width, depth, length respectively indentations and the second pattern is (6*6*63) mm width, depth, length respectively indentation. The samples part contains a cover which is in intimate contact with samples part and held by screws. Before mixing of acrylic or soft liner the mould should be painted with separating medium $^{(14,28,3)}$.Fig (1 and 2).

**Figure 1:** Metal mould of denture base specimens for tensile testing
Test equipment and procedure:
The rectangular shaped specimens were tested using Instron testing machine with a suitable grips for the test specimens with cross head speed (5mm/min) using load cell with maximum load capacity (1000 N). Force at failure was recorded in Newton. The value of tensile bond strength were calculated for each test specimen as the force at the de-bonding divided by a cross-section area of interface according to the following formula:

\[ \text{Bond strength} = \frac{F}{A} \]  


Where: 
- \( F \) = force of failure (N)
- \( A \) = surface area of the cross section (\( \text{mm}^2 \))

RESULTS
The mean bond strength between the two types of soft lining materials and heat cured acrylic and Valplast after (48) hours and after (12) weeks in artificial saliva storage are listed in tables (1), and showed in figure (3).

<table>
<thead>
<tr>
<th>Type of Surface</th>
<th>48h P-value</th>
<th>12 weeks P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS-PSP</td>
<td>0.000 HS</td>
<td>0.000 HS</td>
</tr>
<tr>
<td>PS-VS</td>
<td>0.000 HS</td>
<td>0.39 HS</td>
</tr>
<tr>
<td>PS-VSP</td>
<td>0.000 HS</td>
<td>0.073 HS</td>
</tr>
<tr>
<td>PSP-VS</td>
<td>0.000 HS</td>
<td>0.000 HS</td>
</tr>
<tr>
<td>PSP-VSP</td>
<td>0.356 NS</td>
<td>0.373 NS</td>
</tr>
<tr>
<td>VS-VSP</td>
<td>0.000 HS</td>
<td>0.24 HS</td>
</tr>
</tbody>
</table>

*P<0.05 significant  
**P>0.05 Non significant  
***P<0.0001 High significant

The means of the bond strength of the heat cure acrylic with soft lining materials with prime gave rise to the greatest bond strength of all test groups (2.19N/mm²). The lowest value (1.42N/mm²) was for the acrylic with soft lining materials without prime, storage in artificial saliva for 12 weeks. Statistically, as seen in tables (2), the comparison between all test groups after (48) hours immersion in artificial saliva were highly significantly (p< .001) different from each other except for the comparison between groups PSP and VSP in which their means were non-significant (p > .05).

After (12) weeks, the comparison between all test groups were highly significantly (p< .001) different from each other when compared statistically as shown in table(2).

DISCUSSION
The results of this study support the hypothesis that the chemical and physical properties of denture base resins, as well as surface treatments, affect the bond strength of the soft lining materials with denture base materials.

Tensile bond strength test is a good method of investigating the bond strength of lining materials, because it gives information on the bond strength of the material (7, 18).

It is important to measure the adhesive bond instead of the cohesive strength of resilient liners to assess interfacial separation under oral conditions. Otherwise, cohesive rupture of the resilient liner give only limited information on the strength of the liner material (18).

The tensile bond strength for the two types of denture base material were tested at (48 hours) and (12 weeks) after different types of soft lining materials application. The soft lining materials type and artificial saliva storage effects on tensile bond strength were tested.

In general the bond strength of the heat cure acrylic denture base material (2.19 N/mm²) was greater than that with Valplast thermoplastic.
denture base material (2.15 N/mm2). This could be the result of the difference in the nature of the bond between the soft lining materials and the two types of denture base materials17,20,22,16. The results in the table (1), showed samples with PSP type of denture base obtained mean value higher than the other type of samples. Because there is no chemical reaction between soft liner and polymethylmethacrylate denture base resin 17, the bond level of the soft liner attributed to the acryloxyalkylsilicone which as well as improving the cross linking of the silicone soft liner, it intended to adhere to the (PMMA), besides; the adhesive contained a 4-Methacryloxypropyltrimethoxysilane which improved the adhesion and cross linking to the underlying (PMMA), this is according to 28.

The results in the table (1), showed samples with PS type of denture base obtained mean value lower than the other type of samples.

An adhesive is supplied to aid in bonding to denture base resin because silicone soft liner has little or no chemical adhesion to polymethylmethacrylate denture base resin 17.

While the sample with VS type of denture base obtained mean value higher than the PS type of samples.

Valplast denture base materials have a high level of roughness and sogginess of the surface than (PMMP), so there will be mechanical retention between Valplast denture base and soft lining materials 1.

Effect of Artificial Saliva Storage, Table (1) showed a decrease in mean values of bond strength of the all types of denture base, the pure silicone rubber has very low water sorption and solubility but it has been suggested that fillers and impurities presented besides inter molecular spaces are responsible for water sorption and solubility 3.

The sorption and solubility values which were very low due to the high cross linking nature of the soft lining materials, besides; according to 31, silicone soft lining materials shows very low level of microleakage at the bond liner/denture base surface; so the material was highly affected by artificial saliva storage. But this will lead to stresses concentration at the sharp edges of materials in which the stresses were applied 6, this causing decrease in the mean values of bond strength of the soft lining materials. The most common reason for the failure of dentures lined with a silicone-based soft lining material is the failure of adhesion between the denture base and soft lining materials. In a clinical setting, adhesive failure is initially observed at the edge of the denture border region as cracks involving localized unhygienic debris, and it usually spreads inside a denture with time. The stress occurs between the bonding surfaces when the soft lining material absorbs water. Thus, it is conceivable the adhesive failure starts from the edge of the denture because the edge can be immersed in saliva more easily. In addition to these facts, the recorded failure strength value and the mode of specimen failure were affected by the type of the test method such as peel, tensile and shear tests 30.

REFERENCES