Comparative Evaluation of Heat-Polymerized and Auto-Polymerized Soft Liners with Regard to Transverse Bond Strength, Peel Bond Strength and Water Sorption: An in vitro Study

ABSTRACT

Purpose: This is an in vitro study for comparative evaluation of transverse bond strength, peel bond strength and water sorption properties between heat polymerized and auto-polymerized resins.

Materials and methods: Two denture soft liners (Molloplast-B, Coe-Soft) were investigated. A total number of 60 specimens were used. Twenty specimens were used for evaluation of each physical property of soft liner. For transverse bond strength, ten specimens (64 × 2.5 × 10 mm) of each liner were made by processing the denture liners with heat cure polymethyl methacrylate (Meliodent). All specimens for transverse bond strength were conducted on samples immersed in distilled water at 37°C for 50 hours by using three-point transverse flexural tests in a Lloyd’s Universal Testing Machine and transverse bond strength was calculated based on the maximum load, span length, breadth and thickness. Another set of ten specimens of (75 × 25 × 3 mm) of each denture liner were bonded over 25 mm of heat cure PMMA and separated over the remaining 50 mm of acrylic plate to estimate the peel bond strength. The peel bond strength were conducted on specimens which were dried at room temperature for 48 hours and tested at 21 ± 1°C in a Lloyd’s testing machine that was linked to an IBM Compatible Computer. The specimens were deformed with a cross head speed of 5 mm/minute according to ASTM-D-903 and peel bond strength was calculated when peel angle was 180°. For water sorption tests, ten disc shaped samples of each liner of 50 mm in diameter and 0.5 mm in thickness were fabricated. After polymerization of the liners, the samples were then stored in distilled water at 37°C for 7 days. After one week, excess moisture was removed and each sample was weighed using electronic weighing machine.

Results: The transverse bond strength of Molloplast-B and Coe-Soft were almost similar and did not show any significant difference in their values. But, there is a significant decrease in the peel bond strength and water sorption property of Molloplast-B and Coe-Soft.

Conclusion: The reason for transverse bond strength results being similar for both the liners is because they were polymerized chemically with the denture base resins and this chemical affinity could have made its bond strength almost equal. Since, there is a decrease in the peel bond strength of Molloplast-B, the chances of stripping of the liner at the flanges of the denture is minimal. The decrease in water sorption of Molloplast-B can be expected to retain the bond with the denture and sustain the resilience property of the material for a longer time.

Keywords: Soft liners, Water sorption, Transverse flexural tests, Peel bond strength, Resilience.


Source of support: Nil

Conflict of interest: None

INTRODUCTION

The success of complete or partial dentures depends on maximum comfort, pleasing esthetics and adequate function. Many denture wearers develop soreness of oral mucosa beneath the denture base. The soft tissue of denture bearing area is interposed between the denture and alveolar bone on the other side resulting in chronic soreness. This problem is even more pronounced in those patients who suffer from diabetes mellitus and other debilitating diseases.

In the past, the management of such patients was difficult but recent development of materials in prosthodontics has contributed to more efficient treatment of denture-abused tissues.

Tissue conditioners and soft liners are two types of materials which provide a cushioning effect for the irritated tissue, while tissue conditioners help the soft tissues to recover, they are intended for short-term use only. Main disadvantage of tissue conditioner is that when the patient tends to wear a complete denture with

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Table 1: Materials used

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Type</th>
<th>Form</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Molloplast-B</td>
<td>Heat cure</td>
<td>Single component paste</td>
<td>Detax, Germany</td>
</tr>
<tr>
<td>2</td>
<td>Coe-Soft</td>
<td>Cold cure</td>
<td>Powder liquid</td>
<td>GC, America</td>
</tr>
<tr>
<td>3</td>
<td>Meliodent</td>
<td>Heat cure</td>
<td>Powder liquid</td>
<td>Heraeus, Kulzer</td>
</tr>
</tbody>
</table>

which a tissue conditioner is coated after an extended period, it hardens and roughens continued leaching of the plasticizer from the tissue conditioner makes its useful limited.

Due to this disadvantage of tissue conditioners, long-term management of abused oral tissues in denture wearers was frustrating to the prosthodontist, until the introduction of soft denture liners by 'Mathews' in 1942.

Plasticized polyvinyl chloride was one of the first soft lining materials, used with acrylic resin dentures. It was the forerunner of the development of resilient liners. They have the property of springiness which means returns to the original shape after they are stressed.

In 1958, Lammie and Storer classified processed resilient materials as natural rubber, polyvinyl chloride, methyl methacrylate polymer and silicone. These resilient liners are elastomer-polymers used in the treatment of chronic soreness of mucosa beneath the dentures and provide for preservation of supporting structure for a long time. Soft liners are used with existing complete dentures after heat processing or auto polymerization.

Many investigators have reported that the soft liners can be used from 6 months to 5 years, depending upon the type of soft liner. Among the materials used for soft liners, vinyl and acrylic polymers are made resilient by adding oil or alcohol type of plasticizer or by copolymerization with a monomer. Soft liners have shock absorbing nature and such a property is useful in treating patients with ridge atrophy, bony undercuts, bruxism, xerostomia, etc. A major drawback, however, is lack of a durable bond to the denture base. Obviously, a soft liner with better bond strength will be the choice for clinical use. Long-term exposure to saliva and other liquids leads to possible water sorption also. This decreases the mechanical properties of the soft liner. Solubility can also occur, resulting in leaching out of unreacted monomer, with a possible of soft tissue reaction. So, the main purpose of this study was to evaluate the transverse bond strength, peel bond strength and water sorption properties of two different types of soft liners.

MATERIALS AND METHODS

Two commercially available lining materials were used and the type of polymerization were different. Their types, batch numbers and manufacturers are presented in Table 1. Molloplast-B is a single component paste, and Coe-Soft is a powder liquid system.

Twenty regular acrylic bars of dimension 64 mm in length, 2.5 mm in height and 10 mm thick for each liner were prepared from Meliodent denture base acrylic resin according to manufacturer's instructions in the silicone rubber molds. After polymerization, the samples were ground with 320 grit silicon carbide paper to remove the surface impurities. The PMMA specimens, as shown in Figure 1 for transverse bond strength, were prepared by investing rectangular brass dies with 64 × 25 × 10 mm to prepare the silicone rubber molds for the bars of acrylic denture base resin. The hard and flexible silicone rubber mold was further supported by dental stone in the flask. This procedure was used to facilitate the easy removal of processed samples from the flask. For optimal polymerization, the flask was kept in like warm water at 40 to 45ºC and was heated to 70ºC in 20 minutes and maintained at the same temperature for 5 to 10 minutes and then was cooled down slowly. After heat polymerization, the brass spacer and the PMMA resin specimens were removed from the mold. A 10 mm square selection was cut in the center of each sample to create space for adding liner. The Meliodent bars were placed back into the mold and the auto polymerizing and heat polymerizing liners were placed in the 10 mm square sections, trial packed and polymerized according to manufacturer's instructions. After deflasking excess material was removed by trimming and immersed in distilled water at 37ºC for 50 hours. The twenty specimens of each material were divided into two groups as G1 for Molloplast-B and G-4 for Coe-Soft and the force measurements were made with a Lloyd's testing machine at a cross head speed of 0.05 cm/minute by using a three-point bending flexure with a span of 50 mm. The transverse bond strength was calculated as maximum load and span length divided by breadth.
and thickness. After recording the values, the data analysis was done by using the statistical package for social science (SPSS) version 4.0.1.

For determining the peel bond strength, a rectangular brass dimension of 75 x 25 x 3 mm was used to form the silicone rubber mold for preparing the acrylic plates of denture base acrylic resin. The silicone rubber molds were invested in the flask and further supported by stone. A total number of twenty specimens were made by using heat cured PMMA as mentioned earlier. The liners were bonded over 25 mm of an acrylic resin sample and separated over the remaining 50 mm of acrylic plate. The area that was not to be bonded with the liner was 50 mm long. For Molloplast-B, the area not to be bonded was painted with a layer of Coe-lubricant, supplied by the manufacturer. The liners were then packed and cured according to manufacturer’s instructions. Again the twenty samples were divided into two groups as G2 for Molloplast-B and G-5 for Coe-Soft to determine the peel bond strength as shown in Figure 2. Before testing, all samples were stored dry at room temperature for 48 hours. All were tested at 21 ± 1°C in a Lloyd’s Universal Testing Machine that was linked to an IBM compatible computer. The specimens were deformed with a cross-head speed of 5 mm/minute according to the American Society of Testing and Materials, ASTMD-903. The peel bond strength was calculated at a peeling angle of 180° and based on the force applied divided by the width of specimens in the peeling area along with the ratio of stretched to unstretched length. After finding the values, the same SPSS version 4.0.1 was used for data analysis.

To evaluate the water sorption property, a disk-shaped stainless steel mold of diameter 50 mm and a thickness of 0.5 mm was used to prepare the sample disks in accordance with the International Standards Organization Specification no 1567. The stainless steel mold was invested in a hard but flexible silicone rubber and further supported by dental stone in the flask. Again the samples were named as G3 for Molloplast-B and G6 for Coe-Soft liners. After polymerization of the disk shaped samples with the liners, the samples were dried in the desiccator at 37°C for 7 days. After storage interval of 1 week, the samples were removed and overt moisture on the surface was removed quickly, as shown in Figure 3, and each sample was weighed in the electronic weighing machine. The water sorption value was determined by initial weight of the desiccated sample and weight after the sample has been saturated divided by the surface area and expressed in mg/cm². The values were determined by SPSS version 4.0.1.

RESULTS

The data obtained after the transverse bond strength (Table 2), peel bond strength (Table 3) and water sorption tests (Table 4) were evaluated by the statistical package

Table 2: Comparison of the mean, standard deviation and test of significance of mean values between two different study groups for transverse bond strength

<table>
<thead>
<tr>
<th>Force N/mm²</th>
<th>Molloplast-B</th>
<th>Coe-Soft</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6731</td>
<td>2.1388 ± 0.379</td>
<td>2.1345 ± 0.448</td>
</tr>
</tbody>
</table>

Table 3: Comparison of the mean, standard deviation and test of significance of mean values between two different study groups for peel bond strength

<table>
<thead>
<tr>
<th>Force N/mm²</th>
<th>Molloplast-B</th>
<th>Coe-Soft</th>
</tr>
</thead>
<tbody>
<tr>
<td>33.925</td>
<td>1.4988 ± 0.176</td>
<td>3.3394 ± 0.160</td>
</tr>
</tbody>
</table>

Table 4: Comparison of the mean, standard deviation and test of significance of mean values between two different study groups for water sorption

<table>
<thead>
<tr>
<th>Soft liner</th>
<th>Initial weight after desiccation W1 mg</th>
<th>Final weight after desiccation W2 mg</th>
<th>Sorption value mg/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molloplast-B</td>
<td>205.964</td>
<td>2060.74</td>
<td>0.0610</td>
</tr>
<tr>
<td>Coe-Soft</td>
<td>2805.65</td>
<td>2642.250</td>
<td>0.33</td>
</tr>
</tbody>
</table>
SPSSPC and SPSS version 4.0.1 further calculated by mean and standard deviation. In the present study, \( p \leq 0.05 \) was considered as the level of significance.

Table 2 presents the transverse bond strength of two different soft liners and there was no statistical difference \( (p > 0.05) \) between the two soft liners. Table 3 clearly indicates that there is a significant decrease \( (p < 0.0001) \) in the peel bond strength of heat polymerized soft liner (Molloplast-B) compared with autopolymerized soft liner (Coe-Soft). Based on the bar diagram in Graph 1, the water sorption property of Molloplast-B was less \( (p < 0.008) \) compared to Coe-Soft soft liner. All the above-mentioned mean values were compared by student’s independent t-tests and illustrated in the bar diagram in Graph 1.

**DISCUSSION**

Soft liners were introduced in prosthodontics for their salient properties, such as long-term resilience and durable adhesion to the existing denture base, making the use of complete dentures more comfortable and patients enjoy the benefits with satisfaction. Soft liners can be processed either by heat curing or by autopolymerization. Laboratory processed materials are used as long-term denture liners for the management of sore or atrophied mucosa, traumatic ulceration and obturators. The desirable properties of the soft liners are high bond strength to the denture base, dimensional stability of the liner during and after processing, permanent softness or resilience, low water sorption, color stability and ease of processing. Bond strength between the soft liner and the denture base resin and the water sorption phenomenon of a soft liner are two physical properties which affect the long-term use of a soft liner.

This study was conducted using a laboratory processed heat-cured soft liner (Molloplast-B) and a self-cured soft liner (Coe-Soft). Molloplast-B supplied in the paste form, is a silicone-based soft liner composed of dimethylsiloxane polymer, triethoxysilanol as cross-linking agent and dibutyltin dilaurate as catalyst. The adhesive consists of silicone polymer in a volatile solvent. Coe-Soft, a plasticizing self-curing acrylic material—consists of polymethyl methacrylate and peroxide initiator in the powder and aromatic esters, ethanol and tertiary amines in liquid. A problem of concern to the prosthodontist is failure of adhesion of soft liners with the denture base resin. Bond failure is initiated by routine masticatory stresses having various components of forces, manual cleaning of dentures and forces from parafunctional habits.

The more fundamental importance of adequate bond strength between the denture reline and denture base polymers is to ensure the retention of the reline polymer on the surface of the denture base to maintain the function of the reline polymer. A weakened bond between the denture base and the soft liner allows percolation of oral fluids, which can increase staining and harboring of bacteria, whereas complete bond failure inevitably results in the delamination of the reline polymer. The test of such bond strength is important and a transverse bond test was performed to evaluate it. Long-term service ability of soft liners primarily depends upon bond strength and the ability to resist water sorption. Assessment of bond strength was done with two modes of test, transverse bond test and peel bond test. Results revealed that the transverse bond strength of silicone soft liner (Molloplast-B) was 2.1388 N/mm². The transverse bond strength of acrylic soft liner (Coe-Soft) was found to be 2.135 N/mm². An analysis of the result clearly shows that the two materials have almost similar transverse bond strength values. It is common knowledge that a material bonded to a denture base resin by heat curing method will have comparatively more bond strength than the material which is added to the base resin by auto-polymerization: in contrast, this study showed that Coe-Soft (auto-polymerizing resin) had a transverse bond strength almost similar to that of Molloplast-B (heat polymerization silicone). One possible explanation for this could be that in spite of being polymerized chemically with the denture base resin, Coe-Soft is chemically similar to the denture base resin, i.e. it has a methacrylate group as a recurring unit. This chemical affinity could have made its bond strength almost equal to that of Molloplast-B, which is chemically dissimilar to the denture base resins.

Peel bond test is believed to stimulate the horizontal component of the masticatory forces that causes lateral displacement of the denture. This displacement may...
cause stripping of the liner at the flanges of the denture, particularly the distolingual flange of the mandibular denture at the mylohyoid eminence and the distobuccal flange of the maxillary denture in the tuberosity region. Results of the peel bond strength conducted in the study revealed that the peel bond strength of Molloplast-B was 1.48 N/mm and Coe-Soft was 3.339 N/mm. Thus, the peel bond strength for Coe-Soft has been found to be more than twice the value for Molloplast-B. This is in agreement with the results of Omar Kutay. He reported a peel bond strength of 0.640 N/mm for Molloplast-B and 3.090 for an acrylic copolymer (Coe-Supersoft). Wright reported a peel bond strength of 4.97 N/mm for Molloplast-B which is greater than the peel bond strength in this study, whereas Sinobad et al reported a peel bond strength of 1.8 N/mm for Molloplast-B. For the results, it could be found that the chemical affinity was a vital factor in increasing the bonding of a soft liner with the denture base resin.

Water sorption test reveals a sorption value of 0.061 mg/cm² for Molloplast-B and 0.33 mg/cm² for Coe-Soft. Dental acrylic resins absorb water and expand slowly over a period of time. This expansion is a volumetric change and therefore is expressed in three dimensions. Water molecules act according to laws of diffusion. According to Ristic and Carr, the diffusion presumably occurs between the macromolecules, which are forced slightly apart. This separation renders the molecules mobile, and the inherent stresses created during heat curing of the acrylic resin can be relieved with consequent intermolecular relaxation and possible change in the shape of the denture. Significant changes occurring as a result of water sorption are those that affect the occlusion. These changes affect both vertical and horizontal dimensions. The change in centric occlusion after water sorption is the result of expansion in the horizontal and vertical planes. Horizontal expansion leads to cross arch changes and unplanned movement of individual teeth. Increase in occlusal vertical dimension reduces the interocclusal distance and the patient may experience discomfort. Therefore, it is necessary to quantify the amount of alteration in occlusion caused by water sorption. Knowledge of the time required to reach equilibrium after water sorption helps the clinician to fit the denture at appropriate time. Increase water sorption will eventually lead to loss of elasticity. Compromised elasticity results in damaging occlusal forces exerted over the underlying mucosa. Ideally, a soft liner must also be resistant to imbibitions of fluids in the mouth which can lead to discoloration of the soft liner. Consequently, swelling of the liner and potential growth of micro organisms are subsequent sequelae. Release of cured or soluble products from the soft liner may also occur which would subject the patient to unknown substances of undermined biologic activity.

The balance between leaching out of plasticizers and absorption of water or saliva affects the compliance and dimensional stability of the relined dentures. When the material swells due to water sorption, stress builds up between the bonding surfaces and the viscoelastic properties of the resilient liners change. The material becomes brittle and failure of bonding occurs. The present study revealed comparatively greater water sorption by acrylic based soft liner (Coe-Soft). The results of this study was similar to the study of El-Hadary and Drummond and the values were close to the study of Collis for silicone based liner (Molloplast-B). These results were in agreement with Kawano et al who reported a values of 0.23 mg/cm² for Molloplast-B. After 1 week, the water sorption value of the plasticized acrylic resin soft liner (Coe-Soft) was 0.46% in this study. Mese et al compared the effect of storage duration on the hardness and tensile bond strength of silicone and acrylic resin based resilient denture liners to processed denture base acrylic resin and found that the prolonged water sorption resulted in higher hardness values and lower bond strength values.

The silicone soft liner (Molloplast-B) gets cross-linked by heat application which could explain its lesser water sorption. Increased sorption by the acrylic liners (Coe-Soft) could be due to the plasticizer content and also the loss of ethanol. Coe-Soft contains ethyl alcohol and increased water sorption can lead to early failure of the bond and hence the autopolymerizing Coe-Soft material should be used for a shorter period of time, while Molloplast-B, due to its lesser water sorption, can be expected to retain the bond for a longer time. This property can be expected to sustain the resilience of the material for a long time.

The recent research conducted by Chladek et al explains the addition of silver nano particles concentration ranging from 20 to 40 ppm to both silicone-based and acrylic-based soft liners and exhibited decrease in bond strength and increase in water sorption but not worse than those of the materials without silver nanoparticles and enhanced in vitro antifungal efficiency.

An ideal soft liner possessing all the required attributes for the intended purposes is yet to be made available. Further studies may pave the way to introduce a soft liner which could fulfill all the basic requirements.

**CONCLUSION**

- Transverse bond strengths of heat-cured soft liner (Molloplast-B) and a self-cured soft liner (Coe-Soft) were almost similar.
• Peel bond strength of autopolymerizing soft liner (Coe-Soft) was greater than the peel bond strength of heat-cured soft liner (Molloplast-B).
• The heat-cured soft liner (Molloplast-B) showed lesser water sorption than the self-curing soft liner.

REFERENCES
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