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Influence of Adhesive on Shear Bond Strength Between Denture Base Materials and Self-Cured Silicon Soft Liner

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ABSTRACT

Background: Soft lining materials play an important 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 shear bond strength (SBS) of heat cured acrylic and injection-molded Valplast™ denture base materials to silicone self-cure soft lining materials, with and without adhesive, after storage in two different times in artificial saliva. **Materials and Methods:** 40 rectangular specimens were prepared from two types of self-cured silicone soft lining material, one with adhesive and the other without adhesive were applied to two types of denture base materials (heat polymerized Polymethyl methacrylate and injection-molded nylon denture base materials). Shear bond strength of the specimens was measured, after immersion in artificial saliva for different periods (72 hours or 10 weeks), using Lloyd universal testing machine. **Results:** Acrylic denture base bonded to soft liner with adhesive at 72 hours of immersion in artificial saliva showed the highest shear bond strength. Comparing SBS values of the tested soft lining materials revealed significant differences between adhesively bonded and non-adhesively bonded types. **Conclusions:** This study concluded that the bond strength of the silicone soft lining materials with denture base materials increased with adhesive. Silicone soft lining materials are affected by artificial saliva storage.

INTRODUCTION

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. So, the greater the accuracy of the base, the more stable is the prosthesis and the more the comfortable of the patient. As a result of the changes occurring in the oral tissues under complete or partial dentures, periodic relining of that prosthesis is needed to improve their adaptation to the supporting tissue ^[1].

KEYWORDS

Key Words: Dental adhesives, shear strength, soft liner, self-cure acrylic resin

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Relining is defined as the procedures used to re-surface the tissue side of the denture with new base material, thus producing an accurate adaptation to the denture foundation area [2].

Furthermore, Soft liners provide comfort to patients who cannot tolerate occlusal pressure [3]. They 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 reduce residual ridge resorption by reducing impact force in the load – bearing areas in the supporting structures during function [4]. Polymethyl methacrylate (PMMA) resins have been the most popular denture base resins because of their physical and esthetic properties, accurate fit, stability in oral environment as well as the material's availability, reasonable cost, and ease of manipulation [5,6].

The introduction of injection-molded nylon denture base materials allowed for the control of polymerization process through the flask design. A constant flow of the resin material from the sprue compensates the polymerization shrinkage [7].

The relining material used may be classified as either hard or soft; the selection depends on oral circumstance and treatment planning [8]. Soft liners can be either heat-polymerized or auto polymerized [9,10] and they are usually provided as powder and liquid. The powder consists of polymethylmethacrylate (PMMA) and the liquid contain ethyl alcohol (as solvent) and an aromatic ester (di-butyl phthalate) as the plasticizer agent which is responsible for maintaining material softness [11].

Softness is a desirable property of resilient liners. Their optimum thickness has been reported to be approximately 2.5 to 3 mm to provide good shock absorption [7]. One of the common problems with these materials usage is bond failure between the soft liner and the denture base. Any other desirable properties of a denture liner would not be beneficial, unless a good bond to the denture base is achieved. Other problems with soft liners include contamination and accumulation of microorgan-

isms, plaque and calculus formation, poor tear and tensile strength [9].

Several studies have been carried out about the effects of water and denture cleansers on the properties of soft lining materials [12]. But there are few published articles in regard to the effect of adhesives on the bond strength of denture base to resilient soft liner materials. Therefore, the aim of this study was to evaluate shear bond strength (SBS) of self-cured silicone soft lining material applied to polymethyl methacrylate and injection-molded nylon denture base materials.

MATERIALS AND METHODS

Specimens were prepared from two chemically different denture base materials

- 1- Compression-molded Polymethylmethacrylate (Heat cure acrylic, Acrostone (A), Anglo-Egyptian Company, Batch No.505/04).
- 2- Injection-molded nylon (Valplast international corp., New York, USA) denture base materials.

Two types of self-cure silicon soft lining material:

- a. One with adhesive Bredent [Melliodent, HeraeusKulzer, Berkshire, UK],
- b. And, the other one without adhesive [Zetalabor; Zhermack, BadiaPolesine, Rovigo, Italy) were chosen in this study.

Specimens grouping

As shown in Table (1), specimens of each denture base material were divided into two groups (10 specimens each) according to the type of the bonded soft liner. The first group included denture base material bonded to Zhermack™ soft liner without adhesive, while the second group included denture base material bonded to Bredent™ soft liner with adhesive. Then each group was subdivided into 2 subgroups (5 specimens each) according to the period of immersion in artificial saliva before testing of shear bond strength (72 hours and 10 weeks respectively).

Table (1) *Specimens grouping.*

Type of denture base material	Groups (10 specimens each)	Subgroups (5 specimens each)
Polymethylmethacrylate (Heat cure acrylic)	A: Heat cured acrylic denture base blocks with soft lining material without adhesive.	A1: Immersed in artificial saliva for (72) hours for shear bond strength test.
		A2: Immersed in artificial saliva for (10) weeks for shear bond strength test.
	B: Heat cured acrylic denture base blocks with soft lining material with adhesive.	B1: Immersed in artificial saliva for (72) hours for shear bond strength test.
		B2: Immersed in artificial saliva for (10) weeks for shear bond strength test.
Injection-molded nylon	C: Injection-molded nylon blocks with soft lining material without adhesive.	C1: Immersed in artificial saliva for (72) hours for shear bond strength test.
		C2: Immersed in artificial saliva for (10) weeks for shear bond strength test.
	D: Injection-molded nylon blocks with soft lining material with adhesive.	D1: Immersed in artificial saliva for (72) hours for shear bond strength test.
		D2: Immersed in artificial saliva for (10) weeks for shear bond strength test.
Total		40

Preparation of artificial saliva:

The artificial saliva composition used in this study conformed to that described by Fusayama et al. [13-17] and the recipe is presented in Table 2. The chemical reagents were added to the solutions in the order they are listed.

Preparation of Specimens for shear Bond Strength (SBS) testing

Fabrication of Specimens:

Shear adhesive strength was evaluated using a simple overlap-joint model. Stainless steel dies (50×10×3mm) were machined to prepare standardized resin blocks (Heat cure acrylic and Injection-molded nylon). Stainless steel dies (spacer for resilient liner) measuring (10×10×3 mm) were prepared as spacers to ensure uniformity of the soft liner being tested (Fig 1).

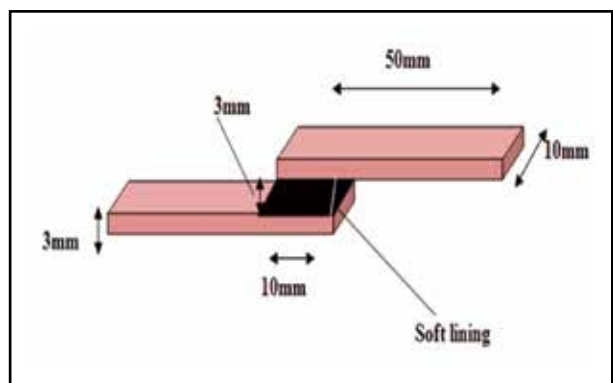


Fig. (1) Specimen configuration

Impressions of the Stainless steel dies were made in polyether putty (Impregum Penta Putty, 3M ESPE, Germany) material to fabricate resin blocks. Molten wax (Hindustan Modelling Wax, India) was poured in the mold obtained from the dies. The wax blocks were allowed to cool, harden and subsequently to be invested in dental stone in

a dental flask. After the dewaxing procedures, the acrylic resin was packed into the mold space and processed at 75 °C for 1.5 h, followed by 100°C for 1 h. After deflasking procedures, all the polymerized acrylic samples were finished and polished leaving the testing surface. They were then ultrasonically cleaned with distilled water and dried with compressed air to remove the surface impurities. The dies for resin blocks and spacer were invested in laboratory polyether rubber to provide uniform space for lining material and for easy removal of the processed samples.

Table (2) Chemical reagents for preparation of artificial saliva

Reagent	Amount (g/l)
NaCl	0.40
CaCl ₂ ·2H ₂ O	0.79
KCl	0.40
Na ₂ S 9H ₂ O	0.005
NaH ₂ PO ₄ ·H ₂ O	0.78
Urea-CO(NH ₂) ₂	1.00
Distilled water	1000ml

Packing of the Denture Lining Material

According to the manufacturer’s instructions, the application of Bredent™ was preceded by 1 min. application of the supplied primer, while for the other liner brand (Zhermack™), this step was absent. Equal lengths of base and catalyst of soft liner was mixed for 30sec. Lining the polymerized resin blocks with auto-polymerizing silicone soft denture liner was done after removing the Stainless steel spacer and allowed to polymerize for 10 min.

After polymerization all the specimens were recovered and excess liner flash was cut using sharp blade. Thus the final specimens were obtained with soft liner overlap between two resin blocks. The specimens were then immersed in artificial saliva for (72) hours and (10) weeks for shear bond strength test.

Shear bond Strength testing

Shear bond testing was done using Lloyd universal testing machine (model LRX plus II. Fareham, England). Testing Specimens for shear bond strength, all the specimens were aligned in Universal testing machine with one end of acrylic specimen attached to upper clamp and another end of acrylic specimen to the lower clamp. The specimen was pulled with a crosshead speed of 5 mm/min. All the specimens were placed under tension until failure in the specimen occurred. The liner was separated from acrylic resin specimen by pulling of clamps in opposing directions. The maximum shear stress before failure was recorded for each specimen. The peak load applied was recorded in chart recorder.

Paired t-test was performed using the Statistical Package for Social Sciences (version 17, SPSS) to determine if any statistical significant difference exists between groups. All statistical analyses were considered significant at the P value < 0.05 level.

RESULTS

Means and standard deviations obtained from the shear test are shown in (Table 3). Group B1 (acrylic denture base bonded to Bredent™ soft liner with adhesive at 72 hours of immersion in artificial saliva) showed the highest mean shear bond strength value (2.45), while the lowest mean value was recorded for group A2 (acrylic denture base bonded to Bredent™ soft liner with adhesive at 10 weeks of immersion in artificial saliva).

Descriptive statistical values and comparisons between the heat cured acrylic and injection-molded nylon are shown in (Table 4). Significant differences were recorded between SBS values of all groups (P <0.05) except groups A1 and C1. Comparing SBS values of different types of soft lining materials (Table 5) revealed significant differences among all groups (P < 0.05) except C2 and D2. The effect of immersion time in artificial saliva was analyzed as shown in (Table 6). The re-

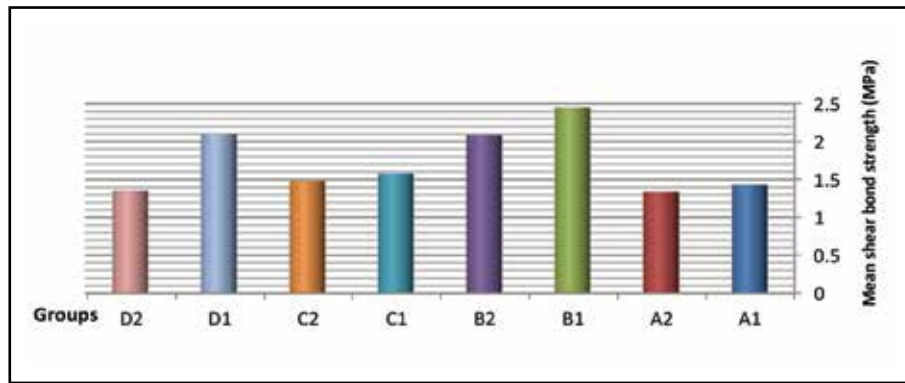


Fig. (2) Mean shear bond strength of all groups.

sults showed a significant difference only between groups D1 and D2 ($P < 0.05$).

Table (3) Shear Bond Strength Results (in MPa) for all groups.

Groups	Mean	Std. Deviation
A1	1.43	.064
A2	1.34	.050
B1	2.45	.048
B2	2.09	.222
C1	1.58	.186
C2	1.48	.046
D1	2.10	.035
D2	1.35	.102

Table (4) Comparison between SBS values of different types of denture base materials

Groups	Std. Deviation	P- value
A1 - C1	0.16460	0.152
A2 - C2	0.07767	0.033*
B1 - D1	0.05447	0.001**
B2 - D2	0.13475	0.002**

Table (5) Comparison between SBS values of different types of soft lining materials

Groups	Std. Deviation	P- value
A1 - B1	0.09215	0.000**
A2 - B2	0.22136	0.006**
C1 - D1	0.21000	0.016*
C2 - D2	0.14773	0.196

Table (6) Comparison between SBS values of different times of immersion in artificial saliva

Groups	Std. Deviation	P- value
A1 - A2	0.07416	0.083
B1 - B2	0.24391	0.063
C1 - C2	0.20903	0.379
D1 - D2	0.13675	0.002**

DISCUSSION

Studies have questioned the causes of interfacial stress distribution of liners bonded to acrylic substrates^[18,19]. Many tests have been used to simulate clinical stresses that affect the bond integrity between the two materials. Tensile test has been questioned in simulating the clinical

situation^[20]. However, the interpretation of the shear studies is difficult since different configuration are available in shear testing, and the test devices need improvements on the way of applying the load on the specimen^[21]. In addition to that, the conventional shear tests still have highlighted that tensile stress distribution is sometimes higher than the shear stress itself^[22].

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 their soft liner give only limited information on the strength of the liner material⁽²³⁾.

In the present study, the shear bond strength for the two types of denture base material were tested at (72 hours) and (10 weeks) after different types of soft lining materials application. The effects of soft lining materials type and artificial saliva storage on shear bond strength were tested.

Comparing the results showed that shear bond strength of the heat cure acrylic denture base material with prime was greater than that of injection-molded nylon denture base material. 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 materials⁽²⁴⁾.

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⁽²⁵⁾.

The present results showed a decrease in mean values of bond strength of the all types of denture base when specimens were immersed in artificial saliva, 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⁽²⁶⁾.

The sorption and solubility values which were very low due to the high cross linking nature of the soft lining materials⁽²⁷⁾, besides 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⁽²⁶⁾, 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⁽¹²⁾.

CONCLUSION

On the basis of the current study, it was concluded that:

- All of the tested lining materials were acceptable for clinical use.
- There were statistically significant differences among the studied denture base materials.
- Adhesives increase the bond strength of the silicone soft lining materials with denture base materials.
- Silicone soft lining materials are affected by artificial saliva storage.

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