ORIGINAL RESEARCH

Assessment of Tensile Bond Strength of a Soft Liner to the Denture Base Resin with Different Surface Treatments: An *In Vitro* Study

Turki Almuraikhi

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Abstract

Aim: The aim of the current research was to evaluate the tensile bond strength of a soft liner to the denture base resin with different surface management techniques.

Materials and methods: Dies made up of stainless steel and having dimensions of 40 × 10 × 10 were used to fabricate polymethyl-methacrylate resinous blocks. To make sure of the regularity of the soft liner in the test, dies made up of stainless steel and having dimensions of 10 × 10 × 3 were fabricated to serve as spacers. These acrylic resinous blocks were allocated to three groups depending upon the particular surface management technique as: group I—Absence of surface treatment (Control), group II—Surface management with methyl methacrylate (MMA) monomer, and group III—Surface management with Phosphoric acid. All the samples underwent thermocycling at 5° centigrade and 55° centigrade in two water baths for 500 cycles at a dwell tenure of 30 seconds in every bath to reproduce the oral circumstances. The samples were then subjected to testing in the universal testing machine for evaluation of the tensile strength.

Results: The highest tensile strength was noted in the soft liner with denture base resin that was subjected to treatment with a monomer having a mean score of 1.88 ± 0.11 in pursuit by surface management using phosphoric acid at 1.16 ± 0.90 as well as the control group at 0.94 ± 0.02 in that order. There was a statistically noteworthy disparity amid the three dissimilar surface management techniques with a *p*-value <0.001. There was a statistically noteworthy differentiation amid group I vs group II as well as group II vs group III with a *p*-value <0.001. However, there was no statistically significant disparity amid group I vs group III with *p*-value >0.001.

Conclusion: The current research arrived at the conclusion that the samples subjected to treatment with MMA monomer exhibited higher and noteworthy bond strength than those attained by additional surface management techniques for soft lining of the denture base resins.

Clinical significance: Soft denture lining materials play a pivotal position in contemporary prosthodontic practice as they possess the ability to restore the health of swollen as well as deformed mucosal tissues. They are comfortable in those individuals who are unable to endure pressure from occlusal forces, like in a situation of residual ridge resorption, sore tissues, and ridges that attain a knife-edge shape. Failing bond causes delamination of the reliner and therefore lack of adaptability of the denture to the oral mucosal tissues. For this reason, superior bonding to the denture base beneath is critical for the clinical triumph of relining agents.

Keywords: Denture base resin, Soft liners, Surface treatments, Tensile strength

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Introduction

Preservation of the supporting dental tissue structures is of chief significance in the branch of prosthodontia. Numerous systemic as well as metabolic diseases are an immense impediment to the tissue reaction on functional loading following prosthetic replacement. As a consequence, various alterations may be noticed in the denture-bearing hard/soft tissues that impact mastication.[1]

The technique of resurfacing the denture area that faces the tissue is known as denture relining. This procedure gets rid of the requirement to fabricate another denture for individuals when the required modifications are minimal and the denture in hand is in a fairly good state. Relining agents may be employed by the chair-side, permitting the dentist to resurface the removable prosthetic appliances within the oral cavity. Two kinds of chair-side denture relining substances may be employed, namely the hard as well as soft reliners. Within the hard reliners, there are diverse subtypes like heat-cure, self-cure, and light-cured. On the basis of their chemical constitution, the soft relining substances may be split into four groups that are: group I—plasticized acrylic resins (chemical/heat-cure), (II) vinyl resin materials, (III) rubbers (polyurethane/polyphosphazine form), and (IV) silicone rubbers. Soft/resilient relining agents are favored for the susceptible mucosal tissue structures.[2]

A frequently stumbled upon disadvantage of employing soft denture reliners is the deficiency of interfacial bond potency. Feeble bond strength supports the entrance of oral fluids as well as microbiota at their intersection, which if additionally destabilized may cause delamination of reline agent off the denturebase.[3] This

Department of Prosthodontics, College of Dentistry, Majmaah University, AL-Majmaah, Kingdom of Saudi Arabia

Corresponding Author: Turki Almuraikhi, Department of Prosthodontics, College of Dentistry, Majmaah University, AL-Majmaah, Kingdom of Saudi Arabia, Phone: +966566552933, e-mail: t.almuraikhi@mu.edu.sa

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thus makes it essential to be acquainted with the bond strength of the reliner, such that the same is optimal for use with the denture base. It is documented that the bond strength of denture reliners to the denture base polymer is dependent on the tendency of the components of the relining agent to infiltrate the denture polymer as well as ascertain an interweaving polymer complex.[4] A variety of surface premanagement techniques have been performed to augment the bond potency and assess micro leakage flanked by the liner as well as denturebase by coarsening the bonding surface as well as monomer wetting. Therefore, the bond of soft silicone denture reliners depends on a blend of adhesive primers, exterior treatment, and reliner's tensile strength.

The bonding capacity of a denture relining material to a denture base polymer mainly depends on the tendency of the contents of the relining material to infiltrate the denture polymer and exhibit an interwoven polymer network. Soft liners and denture base resin adhesion can be enhanced by treating the denture surface with an appropriate chemical such as methyl MMA before applying the soft liner; it etches the surface by changing the chemical properties and morphology of the denture base resin. Characteristics like tensile bond strength have been depicted as reliant on the chemical constitution of the reline materials as well as denturebase resins together. A feeble bond can accumulate bacteria, and encourage stain formation on the lining agent. In addition, it is hypothesized that the bond strength amid the denture reliner and the denturebase polymer might have an effect on the mechanical power of the relined denture base.[5] For this reason, the current research was performed to evaluate the tensile bond strength of a soft liner to the denture base resins with diverse surface management.

Materials and Methods

Preparation of Specimens

A total of 60 samples were fabricated for the purpose of this *in vitro* research. In order to maintain standardization, dies made up of stainless steel and having dimensions of 40 × 10 × 10 were used to fabricate polymethyl-methacrylate resinous blocks. To make sure the regularity of the soft liner in the test, dies made up of stainless steel and having dimensions of 10 × 10 × 3 were fabricated to serve as spacers. The PMMA blocks were fabricated subsequent to the making of stainless steel die impressions with polyether putty (Impregum Penta Putty, 3M ESPE, Germany). Wax was dispensed into the mold that was thus procured from the dies. These blocks of wax were permitted to cool, harden, and were then subjected to investment in dental stone within a dental flask. Next after de-waxing, the acrylic resin (Ivocap, Ivoclar, and Vivadent) was subjected to packing within the mold space followed by processing in an acrylizer at 75°C for 2 hours, followed by 100°C for 1 hour. Following deflasking, each of the polymerized acrylic specimens was subjected to finishing and polishing except the test surface. These were cleansed ultrasonically using distilled water followed by compressed air drying to get rid of the surface contamination. The dies for PMMA blocks and spacer were subjected to investment within laboratory polyether rubber to offer homogeneous room for the lining agent and ease of taking away the processed specimens. Subsequent to pretreatment the 2 PMMA blocks were subjected to assembly in the polyether putty with an intervening spacer.

Surface Treatment of Acrylic Resin Blocks (20 samples in each group)

Group I—Absence of Surface Treatment

The bonding region of the heat-cure acrylic resinous blocks was not subjected to treatment with any solution.

Group II—Surface Treatment Using MMA Monomer

The surface treatments of the blocks by the side of the region to be subjected to relining were immersed in MMA monomer (Ivocap, Ivoclar Vivadent) for hundred and 80 seconds. Swabbing of the surface was performed in a single direction with the application of two coats employing a camel hair brush subsequent to which they were subjected to washing with water and air-drying.

Group III—Surface Treatment Employing Phosphoric Acid

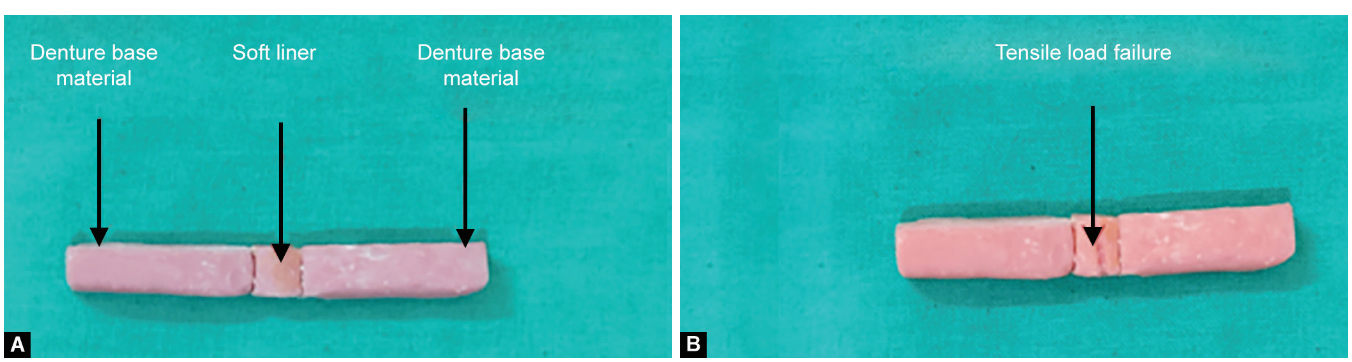
The block surfaces were subjected to etching and washing for 30 seconds followed by twenty second duration drying.

Application of the Soft Liner

Spacer dies of dimensions 10 mm in length by 10 mm in width, and 3 mm in thickness (10 × 10 × 3) were organized as a spacer to make certain consistency of the soft liner in test. Molloplast-B (Detax, Germany Silicone-based soft denture liner) was procured with the aid of a dirt free spatula and subjected to packing within the space produced by the spacer in the die beside the resinous acrylic dough. After the closure of the flask, bench pressing was done for 15 minutes. Curing was performed by insertion of the flask in the cold water with gradual heat exposure up to 100° centigrade for about 2 hours. The flask was then subjected to gradual cooling. The sample was detached and the surplus flash was subjected to trimming (Fig. 1).

Measurement of Tensile Bond Strength

All the samples underwent thermocycling at 5° centigrade and 55° centigrade in two water baths for five-hundred cycles at



Figs 1A and B: (A) Denture base material blocks lined with soft denture liner; (B) Tensile load failure of the soft liner material

Table 1: Mean tensile strength of soft liner to the denture base resin with different surface treatments

Groups	*n*	*Mean ± Std. Deviation*
Group I: No surface treatment (Control)	20	0.94 ± 0.02
Group II: Surface treatment with MMA monomer	20	1.88 ± 0.11
Group III: Surface treatment with phosphoric acid	20	1.16 ± 0.09

dwell tenure of 30 seconds in every bath to reproduce the oral circumstances. The samples were then subjected to deformation in the universal testing machine at a rate of 5 mm/min to establish the highest tensile load prior to failure. The greatest force signifying the point of disconnection was documented.

Bond strength was measured using the formula:

$$\text{Bond strength} = \frac{\text{Greatest load prior to failure kilogram force (KgF)}}{\text{Cross-sectional area in centimeter square cm}^2}$$

Greatest load is the power necessary prior to breakdown of samples in Kgf.

$$\text{Cross-sectional area of the specimen} = \text{Width (mm)} \times \text{Height (mm)}$$
$$= 10 \text{ mm} \times 10 \text{ mm} =$$
$$= 100 \text{ mm}^2 = 1 \text{ cm}^2$$

The interpretation acquired was in kilograms, which were afterwards transformed to Newton by means of the change of 1 kg equal to 9.81 Newton.

Statistical Analysis

The values thus recorded were statistically analyzed. The bond strength of every soft liner agent was then established statistically employing a one-way ANOVA in pursuit by *post hoc* test for several pair-wise comparative assessments to evaluate any noteworthy disparities amid the groups. The statistical tests were done at a significance level set at 0.05.

Results

The mean tensile strength of the soft liner to the denture base resin is depicted by dissimilar surface management techniques in Table 1 and Figure 2. 0.94 ± 0.02 was the tensile strength following the absence of surface treatment or in the control group, 1.88 ± 0.11 with the treatment of soft liner along denture base resin using monomer, and 1.16 ± 0.90 with use of phosphoric acid.

Table 2 shows the comparative assessment of mean tensile strength of soft liner to the denture base resin with dissimilar surface management techniques. The highest tensile strength was noted in the soft liner with denture base resin that was subjected to treatment with monomer having a mean score of 1.88 ± 0.11 in pursuit by surface management using phosphoric acid at 1.16 ± 0.90 as well as control group at 0.94 ± 0.02 in that order. There was a statistically noteworthy disparity amid the three dissimilar surface management techniques with a *p*-value <0.001.

Numerous comparative assessments of mean disparities of soft liner to the denture base resin with dissimilar surface managements employing Tukey's *post hoc* test has been elaborated in Table 3. There was a statistically noteworthy differentiation amid group I vs group II as well as group II vs group III with a *p*-value <0.001. However, there was no statistically significant disparity amid group I vs group III with *p*-value 0.426.

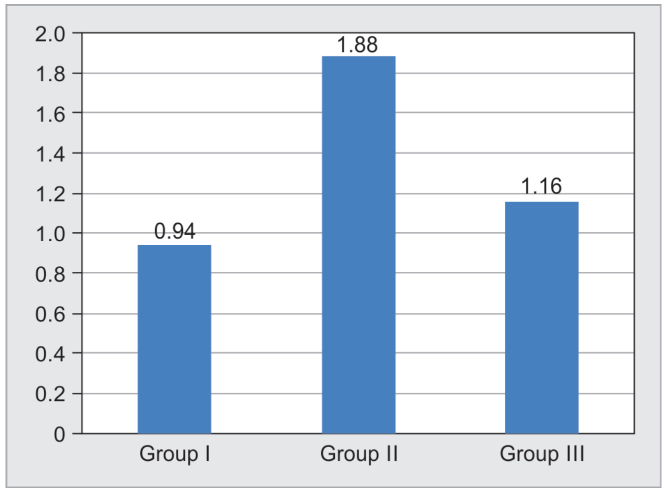


Fig. 2: Tensile strength of soft liner to the denture base resin with different surface treatments

Table 2: Comparison of mean tensile strength of soft liner to the denture base resin with different surface treatments

Groups	*Mean ± SD*	*Std. error*	*F*	*p-value*
Group I: No surface treatment (control)	0.94 ± 0.02	0.0346		
Group II: Surface treatment with MMA monomer	1.88 ± 0.11	0.1719	18.328	0.001
Group III: Surface treatment with phosphoric acid	1.16 ± 0.09	0.2382		

Table 3: Multiple comparisons of mean difference of soft liner to the denture base resin with different surface treatments using Tukey's *post hoc* test

Groups	*Compared with*	*Mean difference*	*Sig.*
Group I	Group II	−0.94	**0.001**
	Group III	−0.22	0.426
Group II	Group I	0.94	**0.001**
	Group III	0.72	**0.001**
Group III	Group I	0.22	0.426
	Group II	−0.72	**0.001**

Bold values indicate highly significant

The inference of the current study shows that samples treated with MMA monomer showed superior and significant bond strength than with phosphoric acid surface treatments and with a control group.

Discussion

Soft lining agents have been employed on the tissue surface of the denture for absorption of a certain quantity of energy that is created by forces of mastication that functions as a shock absorber. The chief prerequisites of soft liners include enduring resiliency, soaring dimensional steadiness, high-quality adhesion to the denture base, sufficient tear resistance, nontoxicity, lack of causing tissue irritation along with incapability of supporting microbial (bacteria/fungi) growth. The main drawback of this material is its softness as well as meagre tear resistance as well as lack of bond amid liner as well as the denture base that produces a possible edge for micro leakage causing liner delamination off the denture. The amount of bond strength is crucial as the adhesion collapse amid the liner as well as denture base can produce an atmosphere for probable bacterial development as well as hastened failure of the soft liner.[6]

The samples underwent tensile bond testing as recommended by Bates and Smith.[7] The bond potency of liners may be subjected to test employing peel, tensile, shear, fatigue, creep, and impact testing. Soft-liners that are made up of silicon exhibit lesser tear strength vs the various remaining kinds, and so the adhesive potency of these agents is preeminently distinguished by the employment of tensile bond analysis.[8]

It has been documented that liners used for dentures face higher shear/tear force. Clinical circumstances are associated intimately with the shear bond strength vs the tensile test as noted by Chladek et al.[9] Meager shear strength scores result from an unequal distribution of the stress in soft liners with concentration toward the ends. The result is also influenced by crosshead pace. Tensile failure cannot be attributed to tensile forces in entirety as certain shear forces additionally develop in tensile testing as documented by Jagger et al.[10] This could result from silicone liners that delineate a greater Poisson's ratio owing to the decrease in the liner cross-sectional area occurs as it is stretched following exposure to tensile loads, while the bonded part sustains a stable area.

According to the current research, the highest tensile strength was noted in the soft lining material with denture base resin subjected to treatment with monomer, subsequently by surface handling with phosphoric acid, then the control group in that order. Sarac et al.[11] recommended enhancement in bond strength of soft lining materials to denture base resins following surface premanagement techniques using chemically available etchants for thirty or 45 seconds; monomer for 180 seconds; prior to applying the silicone type soft liners. Superior enhancement of bond strength has been noted with MMA monomer surface premanagement for 180 seconds and highly efficient as noted in the research of Takahashi and Chai.[12] Więckiewicz et al.[13] assessed and judged the tensile as well as shear bond strength scores of three modern auto-polymerizing silicone-based reliners that were subject to bonding to acrylic plates and established that every agent in test had suitable adhesion scores to acrylic resin. Leles et al.[14] also subject denture base resins to premanagement prior to applying auto-curing liners with MMA monomer, isobutyl methacrylate monomer, investigational adhesive agents, chloroform, as well as acetone and verified enhanced bond strength while using the MMA monomer.

The polymerizing ability of the denture base monomers has been delineated in the research of Al-Athel et al.[15] The infiltration of these agents within the denture bases in theory enhances bonding by partaking in polymerization. Infiltration of the denture base resin with MMA monomer improves the bond by creation of surface unevenness. It has also been recommended that heat-polymerized acrylic resin areas wet using MMA monomer for a tenure of hundred and eighty seconds, causes dissolution of the polymethyl methacrylate surface architecture, improvising the heat-cured resin with the relining agent. Kulkarni and Parkhedkar[16] through their research exhibited that regardless of the commercial type of the lining agent, premanagement using MMA monomer appreciably enhanced shear bond strength. Greater bond-strength scores with MMA monomer wetting may be attributed to the fact that the MMA monomer penetrates deeply within the polymer sequences as well as promotes the diffusion of the primer adhesives. The existence of considerable bond strength scores is a mark of nonexistence or a smaller amount of micro leakage.

The limitation of the current research is that dentures that are subjected to relining clinically endure repeated mechanical stresses from masticatory forces. Parameters such as saliva along with its constituents, dietary habits of patients, temperature alterations, oral cleanliness, along with the existence of systemic diseases must be given consideration as it affects the durability of lining agents that may subsequently cause a change in the bond strength scores. Other parameters of soft lining agents that necessitate consideration and further evaluation include processing techniques, water absorption, thermal stresses, hardness, tear strength, and color constancy to envisage the finest clinical management. Thus, additional exploration is needed to assess the bonding underneath strongly replicated clinical settings.

Conclusion

The current research arrived at a conclusion that the samples subjected to treatment with MMA monomer exhibited higher and noteworthy bond strength than those attained by additional surface management techniques for soft lining of the denture base resins.

Bond failure leads to delamination of the relining material and thus it leads to the loss of denture adaptation to the mucosa. Therefore, a better bonding to the underlying denture base is more essential for the clinical success of these materials.

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