Research Article

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Characterization of the Tensile Bond Strength Between Silicon Based Permanent Soft Liner and Processed Heat-Cure Acrylic Denture Base Material: An In Vitro Study

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ABSTRACT

Background: It has been observed that the bond between soft liner and heat cure denture base material is weak in nature, which leads to food lodgment and bacterial growth. Thus there was a need to improve bond between soft liner and heat cure denture base resin. In this particular study different type of surface treatments were tested to find out to improve bond between currently used soft liner and heat cure denture base resin. Thus there was need to undertake this particular study.

Material and methods: The test specimen consisted of two heat cured acrylic blocks of dimension (10-10-30) mm^3 width, depth, length respectively and intermediate part for relining material with dimension of (10-10-3) mm^3 width, depth, length. Total length of specimen was (10-10-63) mm^3.100 specimens of heat cured acrylic base were prepared for the test & which was divided to 5 major groups. Each major group was further divided in to 2 subgroups 10 specimens from each group were stored in distilled water and other 10 specimens were stored in beverage solution.50% specimens of this 10 specimens were evaluated after 24 hours and then remaining 50% after 1 week. After storage in distilled water & beverage solution for 24 hours and for 7 days, stored specimens were tested for tensile bond strength using Universal Testing Machine cross head speed 4 mm/min at a load capacity of 50 KN. All data were collected and analyzed by ANOVA and DUNNETT D TEST.

Results: There were no significant increases in tensile bond strength after various surface treatments. Comparatively acetone group had more tensile bond strength to other groups.

Conclusions: Within limitation of this *in-vitro* study, the following conclusions were drawn such as all surface treatment methods tested in the study are acceptable for clinical usage.

Keywords: Soft denture liner, tensile bond strength, Acrylic resin, Sandblasting, Aluminium oxide, Acetone, Monomer.

INTRODUCTION

Soft denture lining materials have a very important role in removable prosthodontics. The combined use of soft and hard plastics may give superior results in the complete denture where the patient shows a marked senile atrophy, in developing maximal retention where the residual ridges are

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bilaterally undercut, in mouths where a hard median palatal raphae is associated with a poor retentive potentiality and in obturators for acquired and congenital clefts of the palate.[1] Requirements for a successful material of this type have been suggested as easy of processing, dimensional stability during and after processing, low water sorption, adequate bond strength to the rigid denture-base resin, high abrasion resistance, permanent resilience, colour stability and no adverse effects on the denture base such as distortion, loss of strength, crazing, or blanching.[2] Bond failure creates a potential surface for bacterial growth, plaque and calculus formation. Soft denture liners have several problems associated with their use such a loss of softness, water sorption, colonization of Candida Albicans and adhesion failure between liner and denture base.[3, 4] A weak bond was also decrease the strength of the denture and cause fractures. Any favourable properties of a denture liner were useless in the absence of a good bond to the denture base material. A variety of parameters affect the bond between the soft lining materials and the denture base, including water absorption, surface primer use and denture base composition.[5] Mechanical modifications improve the bond strength by increasing the surface area and mechanical retention. Chemical or mechanical treatments change the morphology or surface chemistry of the acrylic resin base material to promote better adhesion. [5]Pretreatment may also help to allow soft liner adhesive to penetrate deeper into the denture surface, allowing a more intimate and stronger bond. Therefore, effective bonding is important for the longevity of soft-lined dentures and long-term bonding can be realized only by preventing leakage of fluids between the liner and denture base.[5]

In this particular study different type of surface treatments were tested to find out which option is best to improve bond between currently used soft liner and heat cure denture base resin.

MATERIALS AND METHODS

The test specimen consist of two heat cured acrylic blocks of dimension (10-10-30) mm and intermediate part for relining material (10-10-3) mm in width ,depth and length respectively. Total length of specimen was 63 mm. The acrylic blocks were fabricated by duplication of a metal die (1) of size 30x10x10 mm. A silicon mould was prepared out of metallic die and wax pattern was made using mould. The space for wax patterns was made using mould. The space for resilience liner was standardized using a metal die (2) of size 3x10x10 mm. **(Fig. 1)**

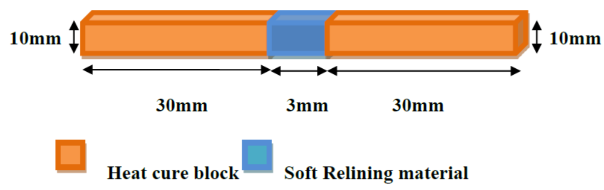


Fig 1: Diagram showing length of each acrylic block of 30mm and relining material of 3mm.

The wax patterns thus made were sealed on both sides of metallic die (2) which act as spacer in later stage of experiment. The entire assemblies were then invested in a denture flask and plaster mould will be prepared. The mould at this stage contains space for acrylic resin and the intervening metallic spacer which later will be removed to accommodate the resilient liner. Acrylic resin was filled on both side of metallic space and processed in a water bath at curing cycle of 74^{0} C for 2 hrs and 100 ^{0}C for 1 hrs. After processing acrylic portion will be lifted out of mould and all surfaces will be treated and finished and reseated in mould .Metallic spacer was then lifted out of the mould and creating a standard space for resilient liner. Spacer was then packed with resilient liner. 100 specimens of heat cured acrylic base were prepared for the test & which was divided to 5 major groups

Group P (20) - Polished acrylic surface specimens.

Group S (20)-Sandblasted acrylic surface specimens where the surface was sandblasted with aluminum particles of 50Mn for 20 secs.

Group G (20)-Retentive grooved surface specimens where grooves were made of 1 mm width and 1 mm length

Group M (20)-Monomer applied surface specimens where specimen was coated with cotton pellet and waited for 180 sec. Monomer used was same as required for heat cured acrylic resin .

Group A (20) - Acetone applied surface specimens where specimens were immersed in acetone for 3 secs. Each major group was further divided in to 2 subgroups 10 specimens from each group were stored in distilled water and other 10 specimens were stored in beverage solution like pepsi.50% specimens of this 10 specimens were evaluated after 24 hours and then remaining 50% after 1 week . After surface preparation all specimens were washed with distilled water and dried to remove any remaining on prepared surface. After storage in distilled water & beverage solution for 24 hours and for 7 days .Stored specimens were tested for tensile bond strength using Universal Testing Machine cross head speed 4 mm/min at a load capacity of 50 KN.

Table 1: Materials used in this study and their trade names are listed.

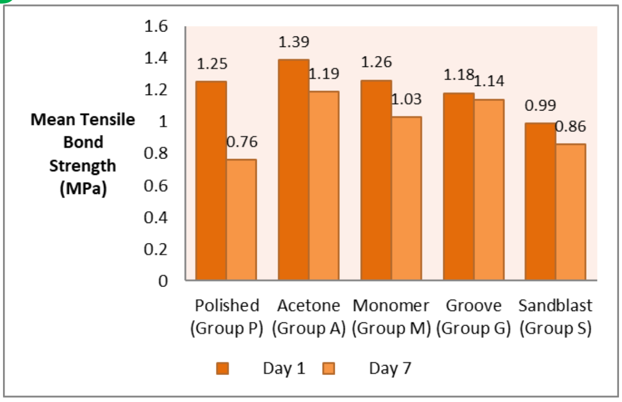
Sr No.	Name	Trade Name	Manufacturer	Batch No.
I.	Heat polymerizing Polymethyl methacrylate resin(PMMA)	TREVALON-HI (High Impact denture material)	Densply India Pvt. Ltd.	TH130603
II.	Heat cure silicone soft-liner material	MOLLOPLAST–B Soft denture liner – silicon based	Detax Gm bH	150801
III.	Putty consistency silicone investing material	DUR LAB- SIL PUTTY	W + P Dental	140249
IV.	Aluminum oxide particle (50 Mn)	Korox -50	BEGO	54300
V.	Acetone	Acetone	Excelar Qualig ens Fisher Scientific India pvt. Lmt	32005
VI.	Beverage solution	Pepsi	PepsiCo SMV Beverages Pvt. Ltd.	365
VII.	Distilled Water	Distilled water	135,INDLarea Richhal	A131

Student's paired t test

Table 2: Comparison of tensile bond strength (MPa) in an individual group between Day 1 and Day 7 when specimens are stored in distilled Water.

	Day – 1 (MPa)	Day- 7 (MPa)	Mean Difference (MPa)	t-Value	P-Value
Polished (Group P)	1.25±0.17	0.76±0.19	0.48±0.04	26.12	0.000 S,p<0.05
Acetone (Group A)	1.39±0.43	1.19±0.39	0.19±0.80	0.53	0.619 NS,p>0.05
Monomer (Group M)	1.26±0.29	1.03±0.19	0.22±0.17	2.971	0.041 S,p<0.05
Groove (Group G)	1.18±0.38	1.14±0.44	0.03±0.54	0.156	0.884 NS,p>0.05
Sandblast (Group S)	0.99±0.19	0.86±0.17	0.13±0.35	0.847	0.445 NS,p>0.05

- **NS = Non significant , S = Significant**



Graph 1: Comparison of tensile bond strength (MPa) in an individual group between Day 1 and Day 7 when specimens are stored in Distilled Water.

RESULTS

At day 1 minimum tensile bond strength was 0.89 (MPa) in sandblast group and maximum tensile bond strength was 1.39 (MPa) in acetone group and at day 7 minimum bond strength was 0.73 (MPa) in polished Surface group and maximum tensile bond strength was 1.19 (MPa) in acetone group in both distilled water and beverage solution.

By using one way ANOVA no statistically significant variation was found in mean tensile bond strength of five groups at day 1(F-value=1.038, p-value=0.412) and at day 7(F=1.817, p-value=0.165) in distilled water and in beverage solution no statistically significant variation was found in mean tensile bond strength of five groups at day 1(F-value=1.007, p value=0.427) and at day 7(F=0.732, p-value=0.581). On comparing tensile bond strength in all four groups with control polished group no statistically significant difference was found at day 1 and day 7 both in distilled water and beverage solution.

By using student's paired t test statistically significant difference was found in group P (polished surface) and group M (Monomer) in mean tensile bond strength at day 1 and day 7 and no statistically significance difference was found in group A (Acetone), Group G(Groove), Group S (Sandblast) in distilled water **(Table 2 & Graph 1)** and no statistically significant difference was found in mean tensile bond strength at day 1 and day 7 in all subgroups in beverage solutions.

By using student's unpaired t test no statistically significant difference was found in mean tensile bond strength between Distilled Water and Beverage solution after Day 1 & 7 in all the groups.

DISCUSSION

To obtain adequate bond strengths, soft liners usually need special bonding agents that interact with the surface layer of the denture base polymer and the soft liner. Several different types of bonding agents were used for silicone soft relining materials. A popular formula used for recent materials contains a polymeric substance dissolved in a solvent. A solvent-based bonding agent enhances bond strength by swelling the surface and improving wettability of the substrate. Solvents also have the advantage of cleaning the surface from environmental pollutants and dissolving and dispersing loose particles covering the surface of PMMA. Some of the solvents are also capable of displacing water and reaching deeper into the polymer and thus facilitating the penetration of monomers.[6]

Bonding between soft liner and denture base is a crucial factor because a soft liner can perform only if it is adhered to the denture base properly. Polymethyl methacrylate (PMMA) denture base resin and silicone lining material have different molecular structures and cannot be chemically bonded. The bond is achieved by means of silicone polymer (methyl siloxane) in a volatile solvent or by the use of alkyl silane bonding agents.[5]

Bonding has been a topic of interest for many scientists as evidenced by the abundance of literature on bonding alone. Studies conducted by **Eick J.D.[7], Zafrulla Khan [8], Fumiaki Kawano [9]etc,** stand testimony to this fact. The effect of various beverage and surface treatment has not been studied in detail in the past. The present study was designed to find out the effect of beverage solution like pepsi on the bonding between the soft liners and denture base resin after various surface treatments with the help of sandblasting, acetone, and monomer and groove preparation.

In the present study all dies and spacers were prepared to the same dimensions to standardize the shape of the denture base blocks and the thickness of the soft denture liners. The dies and spacers were invested in hard but flexible silicone rubber to facilitate removal of the processed specimens from the flask. Methodology of present study is nearly similar to the study of **Ayse Mese et al.**[10] Several factors may affect the bond between the soft lining materials and the denture bases, such as aging in water, use of adhesive, and the nature of the denture base material.

It has been reported that a 4.5 kg/cm^2 (0.44 MPa) bond strength is minimum value for the clinical use of soft denture lining materials.[11] Tensile bond strength of all specimens was found to be above this 0.44 MPa, so all method of surface treatment are clinically acceptable.

On comparing tensile bond strength in all four surface treated groups in the comparison with control polished group no statistically significant difference was found in day 1 and day 7 in both distilled water and beverage solution. This finding contradicts the study conducted by **Sarac et al**[5] who concluded that application of different chemical etchants increased the bond strength of silicone based soft denture lining material to denture base resin, compared to the control group. In present study Molloplast B heat cured reline material was used. **Nistha Madan** [11] concluded that heat polymerized soft dentures require more processing time than autopolymerising liners but they display much better adhesion properties to denture base resin and should thus be preferred when soft liner has to be used for a longer duration of time. Bonding between the denture base resin and silicone based lining material relies completely on the adhesive, a solvent that dissolves the denture base resin surface such as acrylic resin monomer. In present study no significant difference was found between airborne particle and monomer presurface treatment both in distilled water and beverage solution which is again contrast to the study by **Y Sinsi Sarac et al** [5] who observed that the swelling of the outer denture base by MMA wetting and the penetration of the adhesive that results reduces the leakage of fluids within this interface better than mere roughening alone. It can be concluded that difference in the result might be due to difference in methodology and soft liner used. The results of The mechanisms of adhesion of hard relining materials to PMMA denture base materials are dependent on swelling of the surface by monomer or solvent, diffusion of monomers into swollen PMMA denture base material, polymerization and formation of IPN interprismatic network. Primers that consist of solvents may dissolve the surface of the denture base and promote penetration of reline acrylic resin into the denture base resin. Artificial Saliva may affect the pH of surface treated area and bond strength. When compared tensile bond strength (MPa) in Group P polished surface significant difference was found in mean tensile bond strength at Day 1(1.25 MPa) and Day 7 (0.76 MPa) in distilled water and Comparison of tensile bond strength (MPa) in Group M monomer surface significant difference was found in mean tensile bond strength at Day 1(1.26 MPa) and Day 7 (1.03 MPa) in distilled water. **Ayse Mese et al** [10] explained that hardness values of soft liner materials were higher in conjuction with increased duration of water storage but bond strength values were lower. Hardness, weight change, tensile strength, tear strength and color stability are additional properties of soft denture liners. There were significant differences both in the hardness and bond strength values of soft liner materials. The definitive silicone-based heat-polymerized (Molloplast-B) soft liner had significantly higher bond strength and lower hardness values than the others. Prolonged exposure to water produced significantly higher hardness values and lower bond strength values. Each group of specimens was stored in water for 1 day, 1 week or 1,3 or 6 months. The bond strength values of all the soft liner materials were lower with increasing duration of immersion. These results agree with those of other investigators **Zafrulla khan et al** [8]and **Polyzois GL** [13]who suggested that water storage reduced soft liner bond strength.

Based upon the chemical compositions and increased time, bond strength was significantly lower over time. In the present study specimen stored in distilled water for 1 day and 1 week. Tensile bond strength of all specimens decreases but clinically significance difference was seen in polished surface where there was no surface treatment and Group M- monomer presurface treated specimens. These results are in partial agreement with **Polyzois** [13] who reported that water storage reduced the bond strength of soft liner. The bonding strength values were changed with time while the samples were kept in water. **A.K.Aydin et al**[2] reported that Molloplast-B had the highest tensile strength value and the best filling capacity among the soft lining materials and had almost no change. **Mustafa Murat Mutlulay et al** [14] concluded that monomers or solvents used to enhance bonding should be compatible with both lining and denture base polymers. **Emmer et al** [15], **Dootz et al** [16] who reported that tensile strength of soft lining materials increased after storage in water. In this present study tensile bond strengths of all presurface treated specimens are decreased in beverage solutions but statistically no significant difference are seen with duration of time. When immersed, soft denture liners undergo two processes; leaching out of plasticisers and other soluble materials and absorption of water and saliva. The balance between these two processes affects both the compliance and dimensional stability of the denture. Molloplast-B material demonstrated no separation initially and later on and can be assumed as the best adhesion to the base acrylic material. In present study tensile bond strength of all groups decreases but statistically no significant difference seen at day 1 and at day 7. Decrease in bond strength was due to the hydrolysis of bond by Pepsi combined with stress concentration and entrap of air at the bond interface area. This result may be attributed to the acidic and basic composition of Pepsi which cause the hydrolysis of PMMA. The PMMA contain ester group which easily hydrolyze by acidic and basic contain to carboxylate and alcohol. These results are agreement with **A Safari** [17] who suggested that beverage solution would not cause significant deleterious effects on the hardness and bonding properties of temporary soft lining materials compared to water but in their study they evaluated the effect of different beverages on hardness of two temporary acrylic based soft lining materials and their bond strength to the denture base after 12 days. **Nistha Madan**[11] suggested that bond strength of Molloplast –B decreased after thermocycling. Bond strength of Molloplast-B decreased which may be attributed to the high water uptake caused by the filler content. This reduction in bond strength might be the result of swelling and stress build up at bond interface or of the changed viscoelastic properties of the soft lining material stiffer and transmit external loads the bond site.

CONCLUSION

Within limitation of this *in-vitro* study, the following conclusions were drawn:

1. Tensile bond strength observed in this study was minimum 0.73 MPa; all surface treatment methods tested in the study are acceptable for clinical usage.

2. Surface treatment of denture base resin by different methods did not led to significant ($P < 0.05$) increase in tensile bond strength between denture base resin and soft liner in comparison to polished surface with no surface treatment.

3. Tensile bond strength decreased with storage in distilled water, but no significant ($P< 0.05$) decrease was observed with groove, sandblast and acetone treatment after 7 days.

4. In beverage solution, tensile bond strength was decreased in all surface treatment methods tested in the study but statistically no significant difference ($P< 0.05$) was seen after 7 days.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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