Comparative evaluation of tensile bond strength of a polyvinyl acetate-based resilient liner following various denture base surface pre-treatment methods and immersion in artificial salivary medium: An *in vitro* study

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Abstract

Background and Aim: This study was formulated to evaluate and estimate the influence of various denture base resin surface pre-treatments (chemical and mechanical and combinations) upon tensile bond strength between a poly vinyl acetate-based denture liner and a denture base resin. **Materials and Methods:** A universal testing machine was used for determining the bond strength of the liner to surface pre-treated acrylic resin blocks. The data was analyzed by one-way analysis of variance and the *t*-test (α =.05). **Results:** This study infers that denture base surface pre-treatment can improve the adhesive tensile bond strength between the liner and denture base specimens. The results of this study infer that chemical, mechanical, and mechano-chemical pre-treatments will have different effects on the bond strength of the acrylic soft resilient liner to the denture base. **Conclusion:** Among the various methods of pre-treatment of denture base resins, it was inferred that the mechano-chemical pre-treatment method with air-borne particle abrasion followed by monomer application exhibited superior bond strength than other methods with the resilient liner. Hence, this method could be effectively used to improve bond strength between liner and denture base and thus could minimize delamination of liner from the denture base during function.

Keywords: Denture base resin, denture liner, tensile bond strength

Introduction

Resilient denture liners have been used with increasing popularity to refit the surface of complete dentures and to help condition traumatized tissues.[1] The silicon soft liners, despite various denture base surface pre-treatments, tend to have a compromised adhesive strength with the denture base in due course of time during function.[2] When immersed in water, acrylic-based denture liners undergo leaching of plasticizers and other soluble materials into water and water imbibitions, thus compromising their physical and mechanical properties. Hence, as a potential alternative, polyvinyl acetate liners can be used as a provisional denture liner intra-orally for up to 30 days. The advantages claimed are better bond to the denture base, increased comfort to the patient, non-porous nature, and improved resistance to microbial contamination. If denture base surface pre-treatments are carried out, it could greatly augment the bond strength between the denture base and the denture liner.[3]

It has been shown that the use of organic solvents increases the bond strength between denture liners and denture bases.[4-7] Chemical etchants such as monomethyl methacrylate,[6] acetone,[8,9] or methylene chloride[10,11] have been used to increase the bond strength of repair material to polymethyl methacrylate denture base.

Hence, this study was formulated to evaluate and compare the influence of various denture base resin surface pre-treatments (chemical and mechanical and combinations) on the tensile bond strength between a poly vinyl acetate-based denture liner and a denture base resin.

Materials and Methods

Hundred and forty-seven polymethyl methacrylate (PMMA) denture base resin specimens [TREVLON/INDIA] consisting of 2 rectangular blocks measuring 10 × 10 × 40 mm were prepared and divided into 3 equal categories (n = 49) representing the time of immersion in artificial saliva before measuring the bond strength. For preparation of the blocks, the method used by Duygu Sarac and Sinasi Sarac was followed.[12] The materials used in this study have been summarized in Table 1. The specimens were divided into 7 groups (n = 14) for each of the 24 hours, 1 week, and 1 month categories.

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Access this article online	
Quick Response Code:	Website: www.contempclindent.org
	DOI: 10.4103/0976-237X.103622

Table 1: Materials used in this study

Material	Product	Manufacturer/Country
Polyvinyl acetate resilient liner	Dinabase	Italy
Heat polymerized acrylic resin	Trevalon	Dentsply
Acetone	-	Merck
Methyl methacrylate	Cold cure acrylic material	DPI, India
Sand paper, 1000 grit silicon carbide paper	Zetaplus	Zhermack Spa
Alumina (50 microns) air abrasion	Basic Duo *air abrasion unit*	Renfert

Two PMMA blocks with 3 mm thick metal spacer between them was invested in denture flask using silicone rubber to allow for easy removal of the specimens from the flask. The PMMA blocks were then removed from the flask, and the surface to be bonded was pre-treated with different chemical, mechanical, and chemico-mechanical methods as mentioned in Table 2. Next, the PMMA blocks were placed back into the molds, and the polyvinyl acetate-based resilient liner (Dinabase, Italy) was packed into the space made by the brass spacer. After 10 minutes, the specimens were removed from the flask, and excess liner was carefully removed with a scalpel. Tensile bond was calculated for each specimen until failure after 24 hours ($n = 7$ for each group), 1 week ($n = 7$ for each group), and 1 month ($n = 7$ for each group) of storage in artificial saliva. Universal testing machine at a crosshead speed of 5 mm/min was used for this test. Bond strength (Mpa) was calculated as stress at failure divided by the cross-sectional area of the specimen. The data was analyzed by 1-way analysis of variance and the *t*-test ($\alpha = .05$).

Results

Figures 1, 2, and 3 show the mean tensile bond strength of the 7 groups in each of the 24 hour, 1 week, and 1 month categories.

The highest mean tensile bond strength in each of the 3 categories was obtained by the methyl methacrylate monomer with air-borne particle abrasion group, and the lowest mean tensile bond strength in each of the 3 categories was obtained by the control group.

The overall highest mean tensile bond strength from all 3 categories ranked together was obtained by the methyl methacrylate monomer with air-borne particle abrasion group tested 1 week post-bonding. The overall lowest mean tensile bond strength from all 3 categories ranked together was obtained by the control group tested 24 hours post-bonding.

Table 2: Surface pretreatments and groups

Group	Abbreviation	Surface pretreatment
1	C	Untreated (control)
2	A	Immersion in acetone for 30 seconds
3	MMA	Immersion in methyl methacrylate for 180 seconds
4	SP	Sand papered using 1000 grit silicon carbide paper for 5 seconds
5	APA	Sand blasted using 50 micron alumina particles for 5 seconds
6	SPMMA	Sand papered using 1000 grit silicon carbide paper for 5 seconds and methyl methacrylate immersed for 180 seconds
7	APAMMA	Sand blasted using 50 micron alumina particles for 5 seconds and methyl methacrylate immersed for 180 seconds

The results of the one-way ANOVA tests for tensile bond strength values obtained 24 hours, 1 week, and 1 month post-bonding revealed that the differences in tensile bond strength values obtained in each of the 7 groups were statistically significant.

Discussion

The results of this study show that surface pre-treatment of the denture base increases the tensile bond strength between the denture base and the polyvinyl acetate denture liner and different surface pre-treatments would have varying influences on the tensile bond strength between the denture base and the polyvinyl acetate denture liner.

Group 1 specimens (control) exhibited least bond strength. This could be due to the limited available surface area for bonding when compared to the other pre-treated groups.

Group 2 specimens pre-treated with acetone exhibited significant increase in the bond strength after immersion in artificial saliva compared to the control groups ($P < .05$). This is in accordance with a study conducted by Sarac *et al*. on a silicone-based resilient liner.[12] Acetone, being an organic solvent, could have penetrated into the surface of the poly methyl methacrylate resin creating microvoids in the resin surface, thus increasing the surface area for the liner to bond to the denture base.

Group 3 specimens pre-treated with methyl methacrylate monomer exhibited significant increase in the bond strength after immersion in artificial saliva compared to the control groups ($P < .05$). This is in accordance with a study conducted by Sarac *et al*. on a silicone-based resilient liner.[12] Monomer provided additional etching and increased the surface area by creating microvoids, thus increasing the surface area available for the liner to bond to the resin.

Group 4 specimens pre-treated with sandpaper exhibited significant increase in the bond strength after immersion in artificial saliva compared to the control groups ($P < .05$).

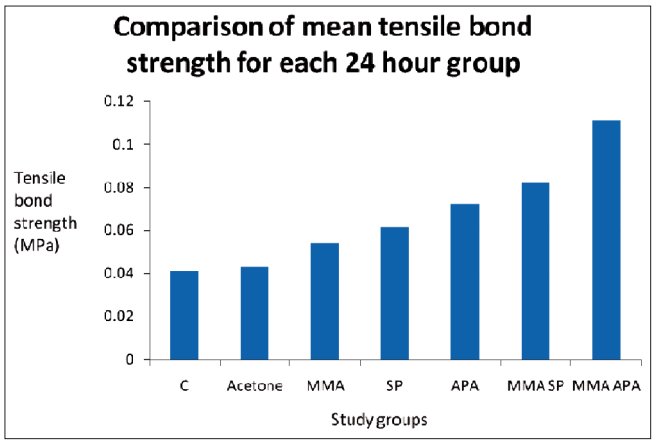

Figure 1: Comparison of mean tensile bond strength for each 24 hour group

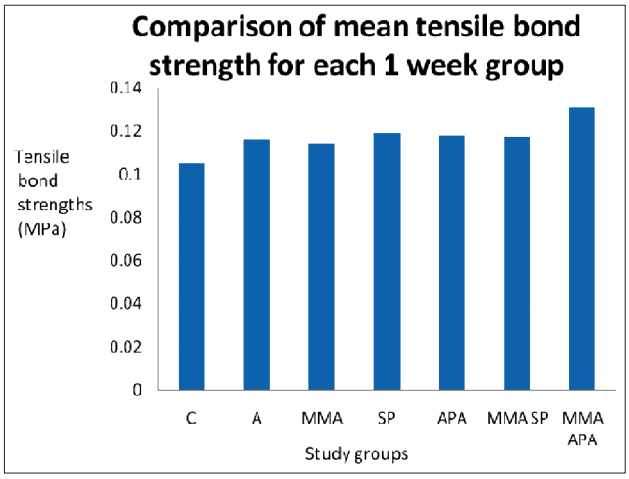

Figure 2: Comparison of mean tensile bond strength for each 1 week group

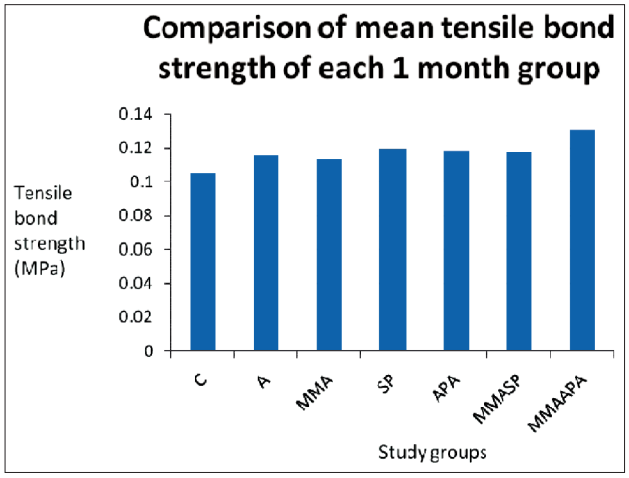

Figure 3: Comparison of mean tensile bond strength for each 1 month group

Sandpapering created micro roughness of the surface resin block, which helped to bond stronger. This is in accordance with Craig's suggestion[13] that a roughened acrylic denture base surface can be used in order to improve the adhesion between the denture base and resilient liner and Li Xiao-na and Zhao Yi-min's[14] findings in their study on silicone liners.

Group 5 specimens pre-treated with air-borne particle abrasion exhibited insignificant increase in the bond strength after immersion compared to the control groups ($P < .05$). This may be due to insufficient increase in surface area of the denture base to cause a significant increase in the bond strength when compared to the control group. This is in accordance with a study conducted by Nancy *et al*.[15] and Minami H *et al*.[11] for silicone-based soft liners.

Group 6 specimens pre-treated with sandpaper and monomer exhibited a significant increase in the bond strength at 24 hours (0.082 MPa) and 1 month (0.1176 MPa) and insignificant increase in bond strength at 1 week (0.1178 MPa) compared to the control groups ($P < .05$). This may be due to insufficient increase in surface area of the denture base to cause a significant increase in the bond strength when compared to the control group after 1 week of immersion. The latent polymerization of unreacted units in the resilient liner may be responsible for the significant increase in tensile bond strength when measured after 1 month of immersion. Sand papering- caused microvoids and monomer acted as a superficial solvent of the poly methyl methacrylate resin, which enhanced bond strength.

Group 7 specimens pre-treated with sandblasting and monomer exhibited significant increase in the bond strength after immersion in artificial saliva compared to the control groups ($P < .05$). Sandblasting caused microvoids and monomer acted as a superficial solvent of the poly methyl methacrylate resin, which enhanced bond strength.

Among the chemical methods, pre-treatment with monomer (Group 3) exhibited higher bond strength of (0.054 MPa) than acetone group (Group 2) (0.043 MPa) when evaluated at 24 hrs. This is in accordance with a study conducted by Sarac *et al*. on a silicone-based resilient liner.[12] One week results showed (0.114029 MPa) and (0.116186 MPa), and 1 month results were (0.113871 MPa) and (0.116014 MPa), respectively, after immersion in the artificial saliva.

Among the mechanical methods, air-borne particle abrasion group (Group 5) exhibited higher bond strength (0.0727 MPa) than sand paper group (Group 4) (0.0615 MPa) within 24 hrs. When 1 week samples were tested, bond strength was (0.1182 MPa) and (0.1193 MPa), respectively. One month samples exhibited bond strength of (0.1181 MPa) and (0.1192 MPa), respectively.

The results of mechano-chemical method showed highest

bond strength of (0.111 Mpa) for air-borne particle abrasion with monomer group when tested with in 24 hrs and sandpaper with monomer group exhibited (0.082 MPa). One week results exhibited (0.131 Mpa) and (0.1178 MPa) and 1 month exhibited (0.130 Mpa) and (0.1176 MPa), respectively.

All surface pre-treated specimens immersed in artificial salivary medium for a period of 1 week showed 118 - 270% increase in bond strength compared to specimens at 24 hours. This could be attributed to the latent polymerization of unreacted units in the resilient liner. The tensile bond strength evaluation after a period of 1 month was analogous with the result obtained after 1 week. This may be attributed to less salivary sorption and resultant microleakage and subsequent delamination of the poly vinyl acetate denture liner.

Among the various methods of pre-treatment of denture base resins, it was inferred the mechano-chemical pre-treatment method with air-borne particle abrasion followed by monomer application exhibited superior bond strength than other methods with the resilient liner. Hence, this method could be effectively used to improve bond strength between liner and denture base and thus could minimize delamination of liner from the denture base during function.

There are few limitations pertaining to this study. This is an *in vitro* study and hence some variations might be experienced when tested under *in vivo* conditions owing to fluctuations in the pH of saliva, varying concentrations of ions in the saliva, presence of immunoglobulin's and serum markers in the saliva, different occlusal schemes, use of disinfectants and stain removers during denture maintenance. These factors could modify bond strength during functions.

This study opens new scope for further research such as evaluation of the effect of various denture base surface pre-treatments on other properties of the polyvinyl acetate denture liner such as water sorption, co-efficient of thermal expansions, creep, dynamic modulus, and resilience of the liner. Several investigators[16] have microscopically examined the nature of the interface between conventional resilient liners and the denture base materials. There is a need for microscopic evaluation of bonding behavior of polyvinyl acetate denture liner with pre-treated denture base.

Conclusion

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

1. Pre-treating the surface of a denture base before application of a polyvinyl acetate denture liner increased the tensile bond strength between the denture base and the liner compared to untreated denture bases.
2. Tensile bond strength between the denture base and the polyvinyl acetate denture liner showed higher values at 1 week post-bonding when compared to measurements made after 24 hours and 1 month post-bonding.
3. Among the experimental groups, the highest tensile bond strength measurements were obtained when the denture base was pre-treated with air-bourne particle abrasion followed by monomer immersion.

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How to cite this article: Philip JM, Ganapathy DM, Ariga P. Comparative evaluation of tensile bond strength of a polyvinyl acetate-based resilient liner following various denture base surface pre-treatment methods and immersion in artificial salivary medium: An *in vitro* study. Contemp Clin Dent 2012;3:298-301.

Source of Support: Nil. **Conflict of Interest:** None declared.