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COMPARISION OF TENSILE BOND STRENGTH BETWEEN TWO SILICONE SOFT LINERS AND DENTURE BASE RESIN CONDITIONED BY THREE MODES OF SURFACE TREATMENT FOLLOWED BY THERMOCYCLING: AN INVITRO STUDY

Prosthodontics

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ABSTRACT

Purpose- To evaluate the tensile bond strength of two resilient denture liners to the processed acrylic denture base resin, with three modes of surface pretreatment- sandblasting, monomer wetting and acetone along with the effect of thermocycling. **Materials and Methods -**Total of 80 test samples were prepared which were divided into Group A (Mollosil) and Group B (Dentuflex) with 40 samples each. In these groups, based on pre-treatment each group each group was subdivided into 4 subgroups, 1 control group and 3 test groups of n=10. All the specimens were subjected to tensile bond test using the universal testing machine. The maximum tensile stress before failure was recorded for each specimen. **Results-** Test groups samples showed increased tensile strength than the control group. Irrespective of the modes of surface treatment done, Dentuflex showed the highest tensile bond strength followed by Mollosil. There was statistically significant difference ($P<0.001$) between the groups when subjected to different modes of surface treatment followed by thermocycling. **Conclusion-** within the limitations of this in vitro study, surface treatment with methyl methacrylate monomer enhanced the tensile bond strength significantly in both the groups- Mollosil and Dentuflex. Dentuflex when surface treated with MMA monomer has showed the highest tensile bond strength overall.

KEYWORDS

Tensile Bond Strength, Silicone Soft Liners, Surface Treatments, Monomer Wetting, Acetone Conditioning, Sand Blasting, Thermocycling, Poly methylmethacrylate

INTRODUCTION

Resilient liners are basically acrylic or elastomeric polymers[1]. They help in fabricating removable complete and partial dentures because of their ability to alleviate inflamed mucosa, resulting in more equal distribution of forces on denture bearing tissues and improving the intaglio denture surface and retention of the prosthesis[2].

Ideal properties of resilient liners include resiliency over a long period of time and good bond to the denture base[3].

Contemporary resilient liner materials can be divided into two groups, acrylic resin based and silicone based. Both groups are available in auto polymerized and heat polymerized forms[4].

They can be also divided as definitive and interim resilient denture liners. Interim resilient liners are acrylic resin based and may harden at a faster rate than definitive materials, but has advantage like superior elastic quality.

Disadvantages of use of resilient liners are poor tear strength, failure of adhesion between liners and denture base especially with silicone liners. Bond failure between the liner and denture base creates a potential interface for microleakage. Any favourable properties of a denture liners are useless in the absence of a good bond to the denture base material.

A variety of parameters affect the bond strength like water absorption, surface primer and denture base composition.

Bonding between the denture base resin and silicone based lining materials relies completely on interfacial adhesive. Chemical etchants such as MMA, acetone or methylene chloride are used to increase the bond strength of repair material to PMMA.

The objectives of this study were to evaluate the influence of thermocycling on the tensile strength of two soft liner materials to denture base resin after three different modes of surface treatment-sandblasting, acetone and methyl methacrylate monomer. Surface treatments were done to enhance bond strength.

Materials And Methods

All the materials were collected through regular channels and data were obtained from laboratory-based studies.

PROCEDURE

1. Fabrication and distribution of specimen
2. Testing of specimen
3. Statistical analysis of the obtained data

1. Fabrication and Distribution of Specimen:

Preparation of Specimen:

Stainless steel dies measuring 40mm in length; 10mm in width and 1Omm in height (40x 10x10) were machined to prepare standardized poly methylmethacrylate resin blocks (Figure 1). Impressions of the Stainless steel dies were made using additional silicone putty material (Figure 2). Modelling wax was melted and poured into the mold obtained (Figure 3). The wax blocks were allowed to cool, harden and subsequently invested in dental stone in a dental flask (Figure 4). After the dewaxing procedure, the acrylic resin was packed into the mold space and processed as per manufacturer's instructions. After the deflasking procedure, all the polymerized acrylic samples were finished and polished except the testing surface (Figure 5). Then they were ultrasonically cleaned with distilled water and dried with compressed air to remove the surface impurities. Stainless steel spacer die measuring 10 mm long, 10 mm wide and 3mm thick (10x10x3) was prepared as spacer to ensure uniformity of the soft liner being tested, The dies for PMMA blocks and spacer were invested in putty to provide uniform space for lining material and for easy removal of the processed samples.

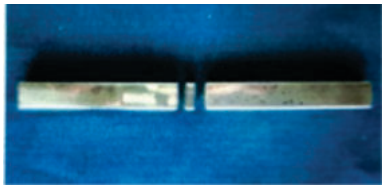


Figure 1 – Customized Stainless Steel Spacer And Metal Dies

Figure 2- Impression Of Die With Putty

Figure 3 – Wax Blocks Made With Modelling Wax

Figure 4 – Investing Of Wax Blocks

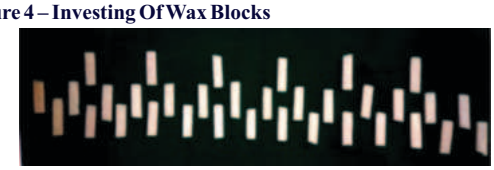


Figure 5 – Heat Cured Acrylic Dies

Distribution of Specimens

A total of 80 test samples were prepared of which 40 specimens prepared for Group A (Mollosil, figure 7) and 40 specimens for Group B (Dentuflex, figure 6). In these groups, based on pre-treatment of acrylic resin, specimens in each group were subdivided into four sub groups of 10 samples each.

Sub group Al and B1- Specimens (control group) without any surface treatment.

Sub group A2 and B2- Specimens were treated with Methyl Methacrylate monomer for 180 seconds before application of the soft liner.

Subgroup A3 and B3- Specimens were treated with chemical etchant Acetone for 30 seconds before application of the soft liner.

Sub group A4 and B4- Specimens were sandblasted at the interfacial surface of PMMA blocks by mechanical sandblasting with 250 um aluminium oxide particles at a pressure of 0.62 Mpa before application of the soft liner.

Group A n=40 Mollosil	Sub group Al -no surface treatment, lined with mollosil liner (control)
	Sub group A2- Monomer wetting
	Sub group A3 – Acetone
	Sub group A4- sandblasting
Group B n=40 Dentuflex	Sub group BI - no surface treatment, lined with dentuflex liner (Control)
	Sub group B2 - Monomer wetting
	Sub group B3 – Acetone
	Sub group B4 – sandblasting

Figure 6 – Dentuflex Liner Material

Figure 7 – Mollosil Liner Material

Figure 8 – Putty Index Of Metal Dies Along With The Spacer

After pretreatment, the two PMMA blocks were assembled within the additional silicone putty with the spacer in between. After the pre-surface treatments, primer adhesive supplied by manufacturer was applied for I minute and then the PMMA blocks were replaced in polyether mold. Equal amount of base and catalyst paste of soft liner was mixed according to manufacturer's instruction, PMMA blocks were lined with denture liner after removing stainless steel spacer and liner was allowed to polymerize.

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 in between two poly methylmethacrylate blocks. The control group specimens of both the groups were stored in sterile water and kept in incubator at 37 °C before testing and rest of the specimens of both the groups were subjected to 1500 thermocycles between water baths of 5°C and 55°C with a dwell time of 30 seconds in each bath.

2. Testing of Specimens:

All the specimens were subjected to Tensile bond test. They were aligned in Universal testing machine with one end of acrylic specimen attached to upper clamp and other end of acrylic specimen to the lower

clamp (figure 9) pulled with Crosshead speed of 5mm/min. They were placed under tension until separation of the liner occurs (figure 10). The maximum tensile stress before failure was recorded for each specimen. The peak load was converted to tensile bond strength by the formula

Tensile bond strength =

$$\frac{\text{Maximum load (N) at debonding}}{\text{Cross sectional area (mm) of the interface}}$$

Surfaces of bond failure were evaluated by using an explorer for determining the type of failure (cohesive or adhesive).

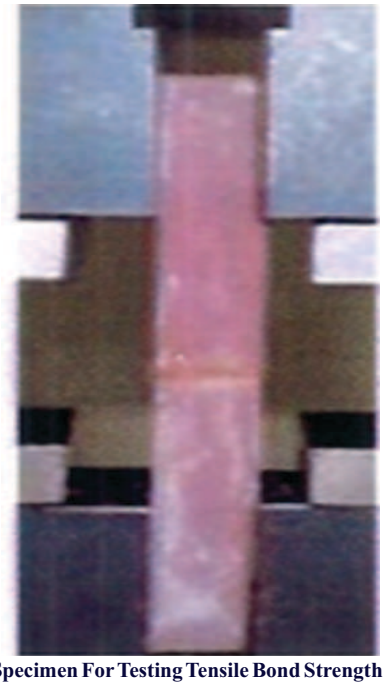


Figure 9 – Specimen For Testing Tensile Bond Strength

Figure 10 – Specimen After Bond Failure

3. Statistical Analysis of the Obtained Data:
Results were subjected to statistical analysis.

The statistical analysis within the same group were carried out using one way ANOVA test followed by Tukey's Post-Hoc Analysis.

The statistical analysis between two groups were carried out using unpaired t test.

RESULTS

The tensile bond strength values obtained from various groups were tabulated and analyzed for statistical significance.

Table I- Tensile bond strength of the specimens lined by Mollosil and Dentuflex (Group A and Group B)

	Group A (Mollosil) (Mean ± SD)	Group B (Dentuflex) (Mean ± SD)
Control Group (MPa)	0.45±0.04	0.78±0.06
Monomer Wetting (MPa)	0.76±0.04	1.21±0.29
Acetone Wetting (MPa)	0.56±0.06	0.92±0.09
Sandblasting (MPa)	0.6±0.04	0.81±0.03

The mean between 4 parameters within each group were compared using one way analysis of variance (ANOVA) followed by Tukey's Post hoc analysis.

Table 2- Comparision Of Tensile Bond Strength of MOLLOSIL Conditioned By Three Modes Of Surface Treatment Followed By Thermocycling

Surface treatments	Tensile Bond Strength (MPa) (Mean ± SD)
1.No surface treatment	0.45 ± 0.04
2.MMA Monomer wetting	0.76 ± 0.04
3.Acetone conditioning	0.56 ± 0.06
4.Sandblasting	0.6 ± 0.04
ANOVA	P <0.001(HS)
	2>4> 3> 1

When monomer wetting was done the tensile bond strength was the highest followed by sandblasting, acetone conditioning and least was for no surface treatment.

There was statistically significant difference (P<0.001) when compared between two modes of surface treatment followed by thermocycling.

Table 3 - Comparision Of Tensile Bond Strength of DENTUFLEX Conditioned By Three Modes Of Surface Treatment Followed By Thermocycling

Surface treatments	Tensile Bond Strength (MPa) (Mean ± SD)
1. No surface treatment	0.78 ±0.06
2. MMA Monomer wetting	1.21 ± 0.29
3. Acetone conditioning	0.92 ± 0.09
4. Sandblasting	0.81 ± 0.03
ANOVA	P <0.001(HS)
	2>3> 4> 1

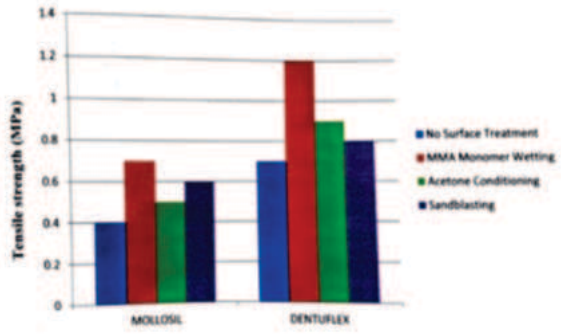
When monomer wetting was done the tensile bond strength was the highest followed by sandblasting, acetone conditioning and least was for no surface treatment.

There was statistically significant difference (P<0.001) when compared between two modes of surface treatment followed by thermocycling.

Table 4- Inter Comparision Of Tensile Bond Strength Between MOLLOSIL and DENTUFLEX

	Mean (MPa) ± Standard deviation (SD)	t' value	P' value
Mollosil	0.59±0.12	-2.86	0.02
Dentuflex	0.93±0.19		

Table 4 and Graph 1: shows the mean tensile bond strength of MOLLOSIL was 0.59+0.12 and DENTUFLEX is 0.93+0.19 which indicates mean value of DENTUFLEX was higher than MOLLOSIL. The results showed that there was statistically significant difference (P-0.02 which was less than 0.05) between the two groups.



Graph 1- Inter comparision of tensile bond strength between MOLLOSIL and DENTUFLEX

DISCUSSION

The results of this study support that the chemical and physical properties of denture base resin, ageing in water, as well as surface treatments affect the bond strength between resilient liner materials and denture base material. The control of all denture base materials showed significantly lower bond strength values than experimental groups.

The results of the present study showed that the application of different chemical etchants increased the bond based strength of silicone resilient denture lining material to denture base resin, compared to the control group.

In the present study, among the surface treated groups, in group A (Mollosil) the highest bond strength was obtained with the MMA treatment for 180 seconds, followed by sandblasting with aluminium oxide particles of 250 um and acetone for 5 Seconds respectively. In group B (Dentuflex) the highest bond strengih was obtained with the MMA treatment for 180 seconds, followed by acetone for 5 seconds and sandblasting with aluminium oxide particies of 250 µm respectively.

Chemical etchants such as MMA monomer and acetone caused swelling of the outer denture base resulted in the infiltration of the liner adhesive primer in to these pits and cracks, resulting in increased bond strength[6].

The lower bond strength values of air particle abraded specimens can be due to the stresses that develop at the interface of the poly methylmethacrylate resilient liner junction as the surface irregularities created by air particle abrasion may not allow a complete flow of soft denture liner. The lower bond strength values of air particle abraded specimens can be due to the stresses that develop at the interface of the poly methylmethacrylate resilient liner junction as the surface irregularities created by air particle abrasion may not allow a complete flow of soft denture liner and may result in a void formation by air entrapment[3,8].

Besides surface treatments, thermocycling also has an effect on the bond strength between liner and denture base material. Soft denture liners are expected to function in the oral environment for long periods of time. By means of thermocycling, cumulative effects of fatigue arising from sudden temperature changes can be determined. In the current study, soft denture liners were subjected to fatigue stress by virtue of temperature differences between 5 and 55° C, as these temperatures depict the temperature range of foods ingested during meals and which do not damage oral tissues[7].

After thermocycling the specimens were subjected to bond testing under Universal Testing Machine. In this study, Dentuflex had the strongest bond strength to the resin denture base in the control group, and the bond strength increased after thermocycling compared to Mollosil. A high bond strength could be seen as a positive aspect of the liner, preventing bacterial growth in the interface, allowing for better cleaning, and contributing to comfort and patient health; however, this increase maybe an indication that the material became more brittle and probably less viscoelastic[5].

The water stored Mollosil and Dentuflex groups had predominantly adhesive failures after tensile testing. The opposite was observed after thermocycling, which seemed to affect the tensile strength of the liners. The majority of Dentuflex specimens had adhesive failures after fracture and no case of cohesive failure; and Mollosil showed an adhesive, cohesive and mixed failures.

The results of the mechanical testing of resilient lining materials are important and help determining which materials have the better resistance under tensile loading. Thus comparing the tensile strength of the silicone liners used in the present study, both liner materials tested had good bond strength for clinical use.

Laboratory studies simulate an oral environment, however no simulation is entirely accurate. Considering this, the most appropriate testing environment is intraoral. Hence, invivo studies are necessary along with the invitro studies. Both the studies should be compared before drawing a final conclusion.

CONCLUSION

Both silicone based soft liners (Dentuflex and Mollosil) had higher bond strengths to the denture base resin than those reported as acceptable for clinical use. Comparatively, Dentuflex had higher bond strength values than Mollosil in both control and test groups i.e the group without any surface treatment and the groups with surface treatments respectively.

Treating a denture base resin surface with chemical etchants significantly increased the bond strength of a silicone based resilient denture liner to a denture base. Considering the results, the use of Methyl Methacrylate for 180 seconds was found to be the most effective chemical treatment overall.

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