Research Article

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Comparative Evaluation of Tensile Bond Strength Between Silicone based Soft Liners and Processed Denture Base Resin by two Mode of Surface Treatment and their Failure Mode Analysis: An In Vitro Study

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ABSTRACT

Background: The objective of the present study was to compare and evaluate the tensile bond strengths of silicone-based soft linining materials (Ufi Gel P Voco & Elite Soft Relining,Zhermack) with different surface pre treatments of heat cure Pmma denture base acrylic resin.

Materials & Method- Stainless steel dies measuring 40mm in length; 10mm in height (40x10x10) were machined to prepare standardized for the polymethyl methacrylate resin blocks. Stainless steel dies(spacer for resilient liner) measuring 3mm thick; 10mm long and 10mm wide were prepared as spacers to ensure uniformity of the soft liner being tested. 30 specimens were prepared for Group A(ufi gel p) and 30 samples for Group B Elite Soft Relining,Zhermack). In these groups,based on pretreatment of acrylic resin specimens each group was subdivided into 3 subgroups of 10 samples each. Subgroup 1- without any surface treatment, Sub group 2-sandblasted and Sub-group 3- treated with methyl methacrylate monomer.

Result- The results were stastically analysed by Kruscal Wallis Test, Mann-Whitney U Test, and Independent T Test. The specimens treated with pmma monomer wetting showed superior and significant bond strength than those obtained by other surface treatments.

Conclusion- The samples belonging to sub group of Elite Reling Soft (Zhermack) exhibit superior tensile bond strength than sub groups of Ufi Gel P (Voco). The modes of failure of all specimens were mostly adhesive in nature.

Keywords: Silicone Soft Denture Liner, Denture Base Resin, Tensile Bond Strength.

INTRODUCTION

Soft denture liners, because of their viscoelastic properties act as a cushion for the denture bearing mucosa through even distribution of functional load avoiding local stress concentrations and improving retention of dentures and providing comfort to the patient The liners are commercially marketed based on their chemical composition as acrylic and silicone liners. One of the chief disadvantages of soft

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denture liners is. debonding from the denture base which can be attributed to the different chemical composition of the two basic materials and microleakage between them. Various surface pre-treatments have been done to enhance the bond strength This study was undertaken to evaluate the effect of sandblasting and monomer pre-treatment of denture base resin on tensile bond strength of two long term resilient liners viz. Ufi Gel P, Voco and Elite Soft Relining, Zhermack Denture liners. with two different surface pre-treatments (airborne-particle-abrasion and monomer wetting).

MATERIALS AND METHODS

A total of 60 test samples were prepared of which 30 samples were prepared for Group a (Ufigel P, Voco) and 30 samples for Group b (Elite Soft Relining, Zhermack). In these groups, based on Pre-treatment of acrylic resin specimens each group was subdivided into 3 sub groups of 10 samples each.

Distribution of specimens

Heat polymerizing PMMA resin blocks with soft liners (n=60)

Group a- Ufi gel P, Voco (n=30)

Group b- Elite Soft Relining, Zhermack (n=30)

Preparation of specimens for sample preparation

Stainless steel dies measuring 40 mm in length; 10 mm in width and 10 mm in height (40×10×10) were machined to prepare standardized moulds for the polymethyl methacrylate resin blocks (fig 1). Stainless steel dies (spacer for resilient liner) measuring 3 mm thick; 10mm long and 10 mm wide were prepared as spacers to ensure uniformity of the soft liner being tested.

Impressions of the Stainless steel dies were made in silicone putty material to fabricate PMMA blocks. Molten wax was poured in the mould 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 in to the mould space and processed in acryliser at 75 ◦ C for 1½ hour, followed by 100 ◦ C for 1 hour (manufacturer's instructions) 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 (fig.3).

The dies for PMMA blocks and spacer were invested in laboratory silicone rubber to provide uniform space for lining material and for easy removal of the processed samples.After pretreatment the two PMMA blocks are assembled with in the polymer putty with spacer in between.

Pre treatment of the acrylic blocks-

Sub-group a and Sub-group b control specimens were without any surface treatment.

Sub-group a and Sub-group b sandblasting specimens were sand blasted at the interfacial surface of PMMA blocks by mechanical Sand blasting (Micro-V abrasive blaster system) with 250µm aluminium oxide particles at a pressure of 0.62 Mpa before application of the soft liner.

Sub-group a and Sub-group b monomer specimens were treated with Methyl Methacrylate monomer for 180 seconds before application of the soft liner . The coding was done as follows:

$\mathbf{a_c^{01\text{-}10}}$ Sub-group a control specimens

$\mathbf{a_s^{01\text{-}10}}$ Sub-group a sandblasting specimens

$\mathbf{a_m^{01\text{-}10}}$ Sub-group a monomer specimens

$\mathbf{b_c^{01\text{-}10}}$ Sub-group b control specimens

$\mathbf{b_s^{01\text{-}10}}$ Sub-group b sandblasting specimens

$\mathbf{b_m^{01\text{-}10}}$ Sub-group b monomer specimens

Packing of the denture lining material and preparation of final samples:

After the pre surface treatments, primer adhesive supplied by manufacturer was applied for 1min, and then the PMMA blocks were replaced in the silicone mould.. Lining the polymerized PMMA blocks with autopolymerizing silicone soft denture liner was done after removing the Stainless steel spacer and allowed to polymerize for 10 Minutes (fig4) Thus the final specimens were obtained with soft liner in-

Table 1: Tensile bond strength analysis values of group a specimens: ufi gel- p,voco (N=30)

Samples	**Group A_c (N/Sqmm)**	**Group A_s (N/Sqmm)**	**Group A_m (N/Sqmm)**
1	0.832	0.726	1.215
2	0.817	0.637	1.363
3	0.793	0.746	1.192
4	0.826	0.761	1.262
5	0.847	0.628	1.084
6	0.776	0.716	1.317
7	0.808	0.748	1.295
8	0.782	0.693	1.371
9	0.872	0.621	1.234
10	0.716	0.678	1.296
Mean	0.807	0.695	1.263
SD	0.043	0.052	0.086

Table 2: ensile bond strength analysis values of group b specimens: elite soft relining, zhermack (N =30).

Samples	Group B_c (N/Sqmm)	Group B_s (N/Sqmm)	Group B_m (N/Sqmm)
1	1.363	1.261	1.612
2	1.422	1.315	1.596
3	1.461	1.273	1.687
4	1.314	1.307	1.527
5	1.373	1.318	1.646
6	1.412	1.354	1.531
7	1.472	1.414	1.733
8	1.407	1.266	1.532
9	1.382	1.313	1.692
10	1.299	1.222	1.584
Mean	1.391	1.304	1.614
SD	0.056	0.054	0.074

Table 3: Represents the inferential statistics for comparing the mean, standard deviation and test of significance of mean values between different subgroups of group a.

SUBGROUPS COMPARED	MEAN	SD	MANN WHITNEY U VALUE	P -VALUE	SIGNIFICANCE LEVEL
A_c Vs A_s	0.807 0.695	0.043 0.052	4.5	0.00058	**
A_c Vs A_m	0.043 0.086	0.043 0.086	0	0.000157	**
A_s	0.695	0.052			

Vs A_m	1.263	0.086	0	0.000157	**

Table 4: Data represents the inferential statistics for comparing the mean, standard deviation and test of significance of mean values between different subgroups of group b.

SUBGROUPS COMPARED	MEAN	SD	MANN WHITNEY U VALUE	P-VALUE	SIGNIFICANCE LEVEL
B_c Vs B_s	1.391 1.614	0.056 0.074	15	0.008151	**
B_c Vs B_m	1.391 1.614	0.043 0.086	0	0.000157	**
B_s Vs B_m	1.304 1.614	0.054 0.074	0	0.000157	**

Table 5: Mean, standard deviation and test of significance of mean values between different subgroups of group a and group b.

Sub Group	**Group A**		**Group B**				**P VALUE**	
	MEAN	SD	MEAN	SD	T VALUE	Df		SIG
Control	0.807	0.043	1.391	0.056	25.90626876	18	0.00000000000	**
Sandblasting	0.695	0.052	1.304	0.054	-25.63615889	18	0.00000000000	**
Monomer	1.263	0.086	1.614	0.074	-9.782643488	18	0.00000001251	**

Table 6: Mean, standard deviation and test of significance of mean values between different subgroups of group a and group b.

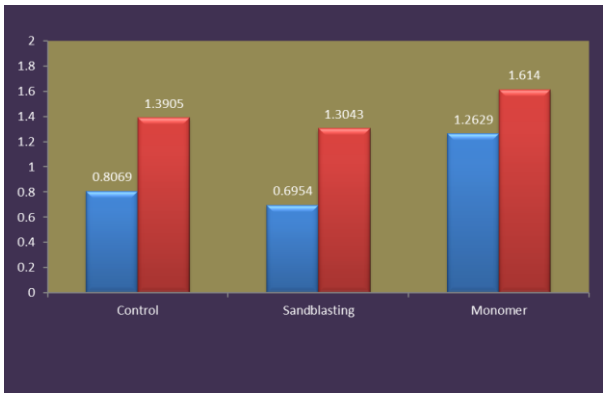
GROUPS COMPARED	MEAN	SD	T VALUE	Df	P VALUE	SIGNIFICANCE LEVEL
A B	0.922 1.436	0.257 0.146	9.538692104	58	0.00000000000	*

between two polymethyl methacrylate blocks (fig 5). The specimens were kept in incubator at 37°C before testing. Two silicone soft denture liners (Ufi Gel-P, Voco and Elite Soft Relining, Zhermack) were used in the study.

Testing of specimens

All the specimens were subjected to tensile bond test. Testing was carried out in Instron Universal Testing Machine at 21± 1°C

Testing specimens for Tensile bond strength



Graph 1: Mean Values Of The Tensile Bond Strength Of The Different Subgroups.

All the specimens 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. 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 (fig 6). The liner was separated from acrylic resin specimen by pulling of clamps in opposing directions. The maximum tensile stress before failure was recorded for each specimen. The peak load applied was recorded in chart recorder. The peak load was converted to tensile bond strength by the formula,

$$\text{Tensile bond strength} = \frac{\text{Maximum load (N) at debonding}}{\text{Cross sectional area (mm2) of the interface}}$$

Failure mode evaluation

The type of failure was assessed visually and was recorded as being adhesive or cohesive mode of failure.

Adhesive-Indicated sepration occurring at liner-acrylic interface(fig 7).

Cohesive-Indicated failure within the liner material(fig 8).

Results were analyzed by using Mann-Whitney U test,Kruscal wallis test and independent samples t test.

RESULTS

All the specimens (Group a+Group b) were placed in universal testing machine (Instron) to evaluate the tensile bond strengths as *Force at debonding /cross-sectional area of the interface was recorded in N/square mm.*

The Sub group control in Group a and Group b were without any surface treatment is taken as control group.

From these respective Groups, Sub groups were compared and in overall both groups (Group a and Group b) were compared and analyzed(Tables-1,2,3) and overall comparison in both group in (Table 4,5,6).

- The bond strength of Ufigel P, Voco lining material of subgroup a control ranged from 0.716 N/mm2 to 0.872 N/mm2 with a mean value of 0.807 N/mm^2
- The bond strength of Ufigel P, Voco lining material of subgroup a sandblasting ranged from 0.637 N/mm2 to 0.761N/mm2 with a mean value of 0.695 N/mm^2
- The bond strength of Ufigel P, Voco lining material of subgroup a monomer ranged from 1.084 N/mm2 to 1.371N/mm2 with a mean value of 1.263 N/mm^2
- The bond strength of Elite Soft Relining, Zhermack lining material of subgroup b control ranged from 1.314 N/mm2 to 1.472 N/mm2 with a mean value of 1.382 N/mm^2
- The bond strength of Elite Soft Relining, Zhermack lining material of subgroup b sandblasting ranged from 1.222 N/mm2 to 1.414 N/mm2 with a mean value of 1.304 N/mm^2
- The bond strength of Elite Soft Relining, Zhermack lining material of subgroup b monomer ranged from 1.527 N/mm2 to

1.733 N/mm2 with a mean value of 1.614 N/mm^2

- The statistical analysis of the 3 subgroups of each soft liner were compared by Kruscal Wallis test were found to be significantly different. The comparison between each subgroups were made using Mann Whitney u test (Nonparametric) for both the soft liners. The overall comparison between the two groups for each surface made using Independent t test (parametric test) for equality of means with the help of statistical package for social science [SPSS] software. The following tables and graphs give a detailed description of the results obtained from the various statistical tests.

After testing the results of the study showed that Elite soft Relining Zhermack denture liner revealed highest bond strength for MMA monomer wetting, and least for Air abraded specimens when compared with the control group.

- The results of the study for Ufi Gel P,Voco liner also had highest bond strength for MMA monomer wetting, and least for Air abraded specimens of when compared with the control group.

- Among the two groups, Elite soft Relining Zhermack Supersoft denture liner revealed higher bond strength Ufi Gel P liner in all modes of surface pre treatment.

DISCUSSION

The effect of roughening the bonding surface by air particle abrasion[3,4] had higher bond strength compared with the smooth surface because of its irregularity which provides mechanical retention[5]. Other studies reported that mechanical surface preparation of acrylic resin denture base surfaces had an adverse effect on bonding of lining material and is not warranted. Pre-treatment of denture base resin with monomer had shown to be effective in increasing the strength of repaired denture segments[6]. **Sinasi Sarac.Y** et al in his study reported that wetting with MMA monomer prior to application of the adhesive to the denture base acrylic resin seemed to be an effective surface treatment procedure. The various surface pre-treatment include air particle abrasion, wetting with MMA monomer, and wetting with acetone.

As silicone based resilient liners have lower tear strength than the other types, the adhesive strength of such materials would best be characterized by the use of tensile bond test[9]. The bond strength of silicone liner depends not only on the tensile strength of the material but also on the adhesive used for that particular liner.

A reduced rate of 5mm/min for tensile bond test was used in this study as advocated by Kulak Ozkan Y et al to promote adhesive rather than cohesive failure of the specimens. After testing the results of the study showed that Zhermack Supersoft denture liner revealed highest bond strength for MMA monomer wetting, and least for Air abraded specimens when compared with the control group. The results of the study for Ufi Gel P liner also had highest bond strength for MMA monomer wetting, and least for Air abraded specimens of when compared with the control group.

The results of Ufi Gel P are in agreement with findings of KulakOzkan.Y who demonstrated Ufi Gel P had sufficient tensile bond strength (0.51 Mpa) for prosthetic applications. The results contradicted Aydin et al who reported the tensile strength of Ufi Gel P was inadequate. The reslts of Elite soft relining, zhermack are similar to those obtained by McCabe[12].

However a direct comparison of these studies cannot be made due to the difference in test parameters and research protocols. The results of the mechanical surface treatment (APA) on the tensile bond strength between the soft liner and PMMA denture base were found to be negative and non-significant when compared with the untreated control group. In fact the bond strength decreased by sandblasting and was considered as an ineffective method. The lower bond strength values of air particle abraded specimens can be due to the stresses that develop at the interface of the polymethyl methacrylate (PMMA)/resilient liner junction as the surface irregularities created by air particle abrasion may not allow a complete flow of soft denture liner . The bond strength of silicone liner with PMMA denture base achieved with the application of MMA monomer was found to be

affirmative and significant than those obtained by other surface treatments.

The reason which can be suggested for higher bond strength value in MMA monomer wetting is that MMA monomer most probably reaches deep in to the polymer chains and facilitates the penetration of adhesive primer. Presence of significant bond strength values are a sign of absence or less microleakage, the high bond strength values resulting from chemical surface pre-treatments in the present study are similar to the results of microleakage study by **Sinasi Sarac et al[13].** No work is reported concerning the effect of PMMA surface chemical surface pre-treatments on tensile bond strength between resilient liner and denture base, so the results of this study cannot be directly compared to others.

Clinically, the ability of denture lining materials to resist debonding and internal fracture under masticatory stresses is extremely important. So the mode of failure was observed for all the specimens. All the samples of Ufi Gel- P, Voco and Elite Soft Relining, Zhermack specimens showed adhesive mode of failure. This indicates that the bond strength with in the liner molecules was greater than the bond strength between the liner and PMMA resin.

This study was mainly an in vitro study. Although the tensile bond test used in the present study is an accepted method, the test conditions may not simulate the clinical situation, because the test specimens had double adhesive surfaces and clinical cases have a single adhesive surface. SEM observation is warranted to confirm the clinical usefulness of this application method.

CONCLUSIONS

Within the parameters of the materials used and the study design, the following inferences were drawn:

1) The specimens treated with MMA monomer wetting showed superior and significant bond strength than those obtained by air abraded specimens with Al_2o_3 particles.

2) Among the two silicone liners Elite Soft Relining, Zhermack showed an overall superior performance over Ufi Gel P,Voco.

3) Both Elite soft relining, Zhermack and Ufi Gel P had satisfactory bond strength to PMMA denture base resin, which is clinically acceptable.

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