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ORIGINAL ARTICLE

Effect of Surface Treatment on the Flexural Strength of Denture Base Resin and Tensile Strength of Autopolymerizing Silicone Based Denture Liner Bonded to Denture Base Resin: An In Vitro Study

Saloni Gupta

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Abstract Silicone based denture liners are superior to acrylic based denture liners but it has a problem of failure of adhesion with the denture base. To evaluate the effect on the tensile bond strength of silicone based liner and flexural strength of denture base resin when the latter is treated with different chemical etchants prior to the application of the resilient liner. Rectangular specimens of heat cured PMMA ($65 \times 10 \times 3.3$ mm^3) for flexural strength and ($10 \times 10 \times 40$ mm^3) for tensile strength were fabricated and divided into four subgroups each. One subgroup of each type acted as a control and the rest were subjected to surface treatment with acetone for 30 s, MMA monomer for 180 s, methylene chloride for 15 s, respectively. Silicone based denture liner was processed between 2 PMMA specimens ($10 \times 10 \times 40$ mm^3) in the space provided by a spacer, thermocycled (5–55°C) for 500 cycles and then their tensile strength measurements and flexural strength measurements were done. 180 s of MMA monomer treatment was found to be most effective in improving the bonding between the liner and denture base resin as well as producing the lowest decrease in flexural strength of denture base resin. Chemical treatment of denture base resin improves the bond strength of denture liner but it also decreases the flexural strength of denture base. So careful selection of chemical etchant should be done so as to produce minimum decrease in flexural strength of denture base resin.

S. Gupta
Department of Prosthodontics, Desh Bhagat Dental College, Muktsar, Punjab, India

S. Gupta (✉)
128-A, Jyoti Nagar, Near Income Tax Colony, Jalandhar City, Punjab, India
e-mail: salonigupta223@gmail.com

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Introduction

Soft denture liners are often used for the management of painful or atrophied mucosa, bony undercuts or ulceration of the denture bearing areas associated with wearing of the dentures. Denture liners provide comfort to the patient, may reduce residual ridge resorption by reducing the impact forces in the load bearing areas during function and also provide even distribution of functional load [1].

One of the first synthetic resins developed in 1945 as a soft liner was plasticized polyvinyl resin, followed by the introduction of silicones in 1958 [1–4].

Contemporary soft lining materials can be divided into two main groups: acrylic based and silicone based. Silicone based liners were found to have better compliance and rupture resistance, low sorption and solubility in saliva as compared to plasticized acrylic based denture liners [1]. However, the main problem with silicone based denture liners is the loss of adhesion at the interface with the denture base resin.

Acrylic based soft denture liners form a chemical bond with the denture base resin. Hence, the adhesion of acrylic based soft liners to denture base resin is higher than silicone based soft denture liners [5].

It is in this context that the present study "Effect of surface treatment on the flexural strength of denture base resin and tensile strength of autopolymerizing silicone based denture liner bonded to denture base resin" was undertaken to examine and assess the effect of denture base resin treatment with different chemical etchants prior to the application of silicone based denture liner on the flexural

strength of denture base resin and the tensile bond strength of the resilient liner.

Aims and Objectives

(a) To compare and evaluate the effect of denture base resin surface pretreatment with different chemical etchants preceding the placement of silicone based resilient liner on the tensile bond strength of the resilient liner bonded to denture base resin.
(b) To compare and evaluate the effect of various chemical etchants on the flexural strength of denture base resin.

Materials and Method

An in vitro study was conducted in the Department of Prosthodontics, GDC Amritsar to evaluate the effect of various surface treatments on the flexural strength of one commercially available heat cured denture base resin and tensile bond strength of commercially available autopolymerizing silicone based soft denture liner bonded to denture base resin.

The materials used in this study were (Fig. 1)

Material	Manufacturer	Type	Adhesive	Polymerization
UfiGel P	Voco, Germany	Silicone based soft denture liner	UfiGel P Adhesive 2076	Autopolymerization
Trevalon	Dentsply, USA	Heat cured PMMA denture base resin		Heat cure polymerization

The chemicals used for the surface treatment of specimens were (Fig. 2)

1. Acetone
2. MMA monomer
3. Methylene chloride

Two brass dies (Fig. 3) were used to prepare specimens for measuring tensile bond strength and flexural strength. First die was used to make specimens of PMMA of dimensions $10 \times 10 \times 40$ mm^3 each, with 3 mm thick removable brass spacer, for measuring tensile bond strength.

Second die was used for the fabrication of test specimens of PMMA of dimensions $65 \times 10 \times 3.3$ mm^3, for the flexural strength measurements.

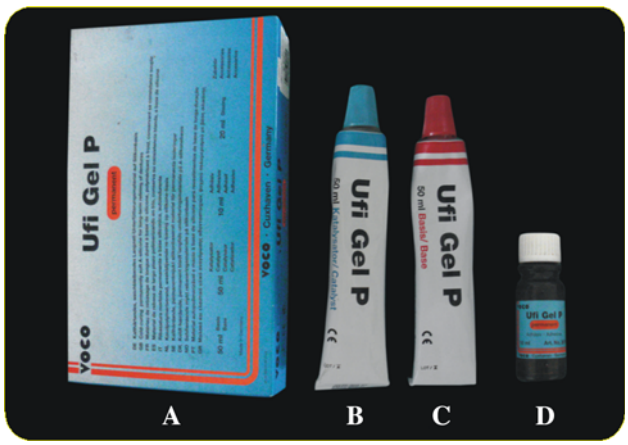

Fig. 1 Autopolymerizing silicone based denture liner-Ufigel P

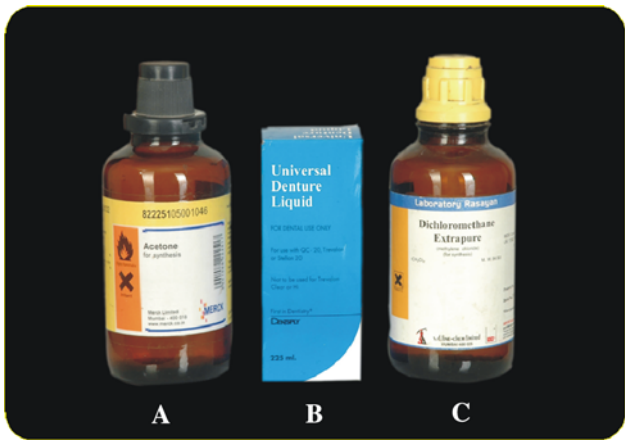

Fig. 2 Chemical etchant used for the surface treatment of denture base resin

Two groups (Group I and Group II) of 60 specimens each of heat cured PMMA denture base resin (Figs. 4, 5) were prepared for tensile bond strength and flexural strength measurements from first and second dies, respectively. Each group was further divided into four subgroups (A, B, C and D) of 15 specimens each.

Group I-A and Group II-A: Specimens served as control.
Group I-B and Group II-B: Specimens subjected to 30 s of acetone treatment.
Group I-C and Group II-C: Specimens subjected to 180 s of MMA monomer treatment.
Group I-D and Group II-D: Specimens subjected to 15 s of methylene chloride treatment.

Tensile bond strength measurements (Group I)

The bonding surfaces of the specimens were then given surface treatments with different chemical etchant used in

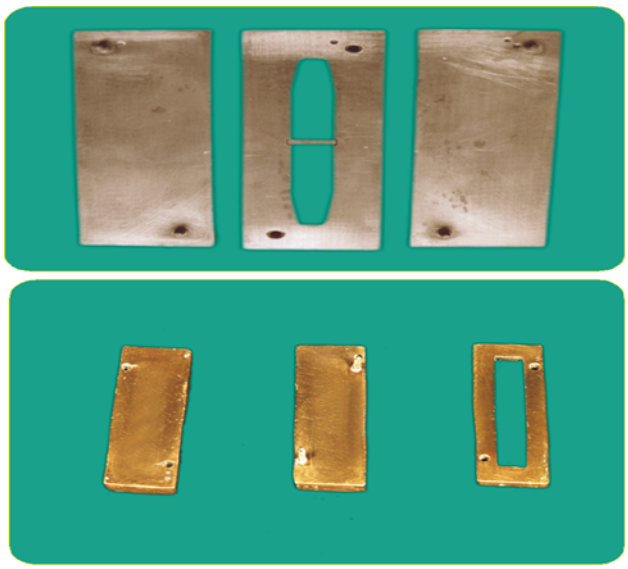

Fig. 3 Dies for the fabrication of specimens

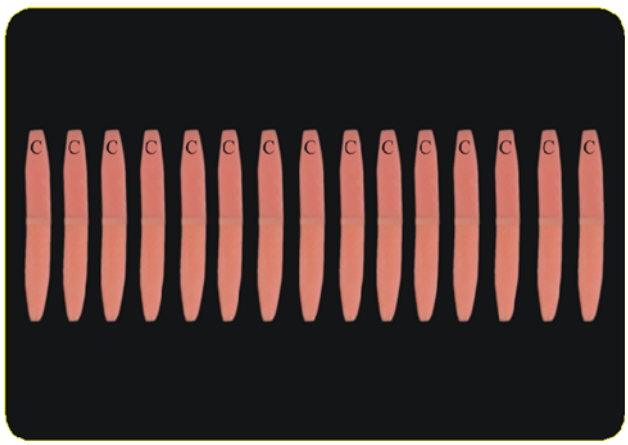

Fig. 4 Group I (tensile strength specimens)

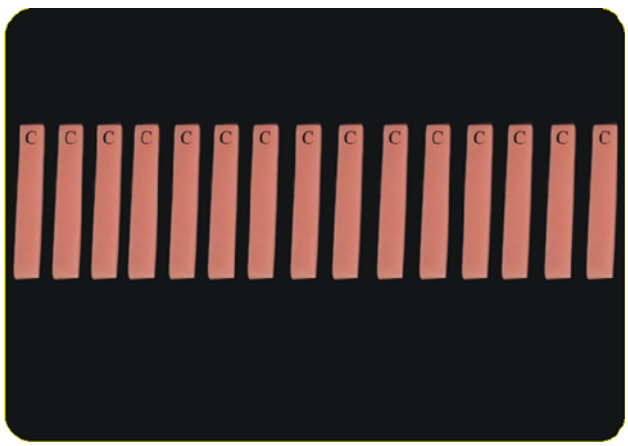

Fig. 5 Group II (flexural strength specimens)

the study according to their group. The blocks were then placed back in the die and the spacer was removed. The base and catalyst pastes of UfiGel P were then mixed in the recommended ratio of 1:1 and the material was placed in the space created by spacer. The die was closed and bench-pressed for 10 min. All the specimens were thermocycled (5–55°C) in two water baths for 500 cycles with a dwell period of 30 s in each bath.

All the samples (Group I, Group II) were then deformed in a Lloyds, Universal Testing Machine at the rate of 5 mm/min, to determine the tensile strength and flexural strength.

Statistical Analysis

The measurements of tensile bond strength of Group IA (control), IB (specimens treated with acetone), IC (specimens treated with MMA monomer), ID (specimens treated with methylene chloride) and flexural strength of Group IIA (control), Group IIB (specimens treated with acetone), Group IIC (specimens treated with MMA monomer), Group IID (specimens treated with methylene chloride) were subjected to statistical analysis to draw conclusions from the experimental data.

Descriptive statistical measures, such as mean, range between maximum and minimum values of tensile bond strength and flexural strength, standard deviation (SD), coefficient of variation (CV), standard error of mean (SE_m) were computed for all the study groups. The 95% confidence interval was also worked out for all the study groups. These statistical computations are presented in Tables 1 and 2.

In order to collectively compare the means of study groups, oneway ANOVA (analysis of variance) test was used. The result of the test have been presented in Table 3 (tensile bond strength) and Table 4 (flexural strength).

Analysis of tensile bond strength values for all the study groups by oneway ANOVA technique returned an F value of 455.86 at degree of freedom = 59. The computed F value was greater than critical F value of 2.77 and 4.16 at 5% and 1% level of significance, respectively, thus indicating a highly significant difference in the mean tensile bond strength values for all the groups ($P < 0.01$).

Analysis of transverse strength for all the study groups by oneway ANOVA technique returned an F value of 53.46. The computed F value was greater than critical F value, both at 5% and 1% level of significance, thus indicating that the difference in the flexural strength for all the study group was highly significant ($P < 0.01$)

Table 1 Basic statistics for tensile bond strength of the study groups (Group I)

Statistical measures	Tensile bond strength (kgf/cm^2)			
	Group IA	Group IB	Group IC	Group ID
No. of observations	15	15	15	15
Mean	8.40	12.53	16.81	12.70
SD	0.584	0.663	0.600	0.553
CV (%)	7.0	5.3	3.6	4.4
SE_m	0.16	0.18	0.16	0.15
95% of confidence interval	8.07–8.74	12.15–12.91	16.46–17.15	12.38–13.02
Range				
Maximum	9.23	13.58	17.92	13.85
Minimum	7.45	11.25	15.93	11.52
Range	1.78	2.33	1.99	2.33

Table 2 Basic statistics for flexural strength of the study groups (Group II)

Statistical measures	Flexural strength (kg/cm^2)			
	Group IIA	Group IIB	Group IIC	Group IID
No. of observations	15	15	15	15
Mean	781.19	711.81	725.09	715.78
SD	27.03	11.68	9.75	11.41
CV (%)	3.5	1.6	1.3	1.6
SE_m	7.22	3.12	2.61	3.05
95% of confidence interval	765.69–796.68	705.11–718.50	719.50–730.68	709.24–722.32
Range				
Maximum	858.92	730.64	739.22	730.45
Minimum	754.65	689.77	699.20	695.62
Range	104.27	40.87	40.02	34.83

Table 3 Oneway ANOVA table for tensile bond strength

Source of variation	Degree of freedom (df)	Sum of squares	Mean square	Variance ratio (F)		
				Computed	Critical	
					5%	1%
Between groups	3	529.75	176.58	455.86**	2.77	4.16
Within groups	56	21.69	0.387			
Total	59	551.44				

* Significant ($P < 0.05$)

** Highly significant ($P < 0.01$)

NS Non significant ($P > 0.05$)

Discussion

The failure of adhesion between a silicone based resilient liner and an acrylic denture base material is a significant clinical problem. Adhesive failure between the liner and the denture base resin creates a potential interface for microleakage leading to an environment for potential bacterial growth and accelerated breakdown of soft liner resulting in deteriorating prosthesis [4, 6].

To achieve better bonding between denture lining materials and denture base resin, several experimental procedures have been conducted such as mechanical

Table 4 Oneway ANOVA table for flexural strength

Source of variation	Degree of freedom (df)	Sum of squares	Mean square	Variance ratio (*F*)		
				Computed	Critical	
					5%	1%
Between groups	3	46936.0	15645.33	53.46**	2.77	4.16
Within groups	56	16388.0	292.64			
Total	59	63324.0				

* Significant ($P < 0.05$)

** Highly significant ($P < 0.01$)

NS Non significant ($P > 0.05$)

surface preparation i.e., roughening of denture base resin, effect of polymerization stage at which resilient liner is packed against the acrylic resin and chemical surface treatment of denture base resin [4, 7].

In the present study, the tensile bond strength values of the lining material (UfiGel P) to denture base resin obtained after testing were statistically analyzed using Student's *t* test. After analysis, it was found that the application of different chemical etchants on denture base resin increased the bond strength of silicone based lining material, UfiGel P, to denture base resin, compared to the control group (8.40 kg/cm^2).

The mean measured tensile bond strength of the resilient liner in descending order according to the type of chemical etchant applied was as follows; MMA for 180 s (16.81 kg/cm^2), methylene chloride for 15 s (12.70 kg/cm^2) and acetone for 30 s (12.53 kg/cm^2).

Sarac et al. [8] reported that wetting the denture base resin with 180 s of MMA monomer was an effective method for reducing microleakage between lining material and denture base resin when using silicone based lining materials.

The flexural strength values of the denture base resin obtained after testing were statistically analyzed using Student's *t* test. After analysis it was found that the chemical treatment of denture base resin significantly decreased the flexural strength of denture base resin as compared to the control group.

The mean values of measured flexural strength of denture base resin in the descending order, were as follows; control group (781.19 kg/cm^2), MMA for 180 s (725.09 kg/cm^2), methylene chloride for 15 s (715.78 kg/cm^2) and acetone for 30 s (711.81 kg/cm^2).

These findings were similar with the flexural strength conclusions of the study by Vallitu et al. [9]. The resultant decrease in strength of denture base resin may cause problems associated with denture base flexure during use [4].

The findings of this study were in agreement with the study of Sarac et al. [4] and Vallitu et al. [9].

Summary and Conclusions

In the present study it was observed that:

1. Surface treatment of denture base resin with chemical etchants increased the tensile bond strength of silicone based liner to denture base resin and decreased the flexural strength of denture base resin.
2. The increase in tensile bond strength value was highest with specimens subjected to 180 s of MMA surface treatment and lowest with control group specimens.
3. The decrease in flexural strength value was maximum with specimens subjected to 30 s of acetone treatment and lowest with control group specimens.

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