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ORIGINAL RESEARCH

A Study to Evaluate and Compare the Shear Bond Strength of Resilient Liners with Heat Cure Denture Base Resins, with and without the Effect of Saliva: An *in vitro* Study

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ABSTRACT

Aim: To evaluate and compare the shear bond strength of resilient liners with heat cure denture base resins in the presence or absence of saliva.

Materials and methods: Two commercially available heat polymerized acrylics and three commercially available denture liners were immersed in artificial saliva for 7 days and 14 days, respectively. A total of 180 (Acralyn-H, No.90 and Lucitone - 199, No.90) specimens were prepared. Total of 90 overlapping joint specimens were prepared, 45 of them using Acralyn H (A-Group) and rest 45 using Lucitone-199 (L-Group). The specimens were tested for flexural strength with a 3-point bending test on an Instron universal testing machine. The results were analyzed with a one-way analysis of variance (ANOVA).

Results: The mean difference in shear bond strength (SBS) at different time intervals was found to be statistically significant ($p < 0.001$). Lucitone-199 recorded a significantly higher mean SBS compared to Acralyn H ($p < 0.001$). Further, significant differences between GC and Densply, GC and Aswin liners, and between Dentsply and Aswin were noted ($p < 0.001$). Difference between baseline and 7 days time interval, as well as, between baseline and 14 days time interval with respect to the mean SBS of these materials were significant ($p < 0.001$). Also, the mean difference in SBS between 7 days time interval and 14 days time interval was statistically significant ($p < 0.001$). Among the three different liners, GC yielded a higher mean SBS compared to Aswin and Dentsply at all the three time intervals. The mean SBS recorded in Dentsply and Aswin was almost same at 14 days time interval, but at baseline and 7 days, it was higher in Aswin compared to Dentsply.

Conclusion: Lucitone-199 recorded a higher mean SBS compared to Acralyn H. As the time interval increases, the mean SBS recorded in both the denture base materials decrease. Among the three different liners, GC yields a higher mean SBS compared to Aswin and Dentsply at all the three time intervals.

Clinical significance: The most common reason for failures of resilient linings in removable dentures is the separation of these linings from the denture base. Therefore, poor adhesive bond properties are one of the serious defects of the material in clinical practice.

Keywords: Heat cure resins, Methyl methacrylacte, Polymethyl-methacrylate, Percentage of cohesive, Failure, Shear bond strength.

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INTRODUCTION

Removable dentures are extensively used in rehabilitating partially/completely edentulous patients. Most of the removable dentures which rely upon tissue support transmit the load to the underlying bone though the mucous membrane. The soft denture bearing mucosa is confined between the hard denture base and bone. During function, considerable damage can be done to the supporting tissues due to high stress concentration, resulting in the chronic soreness, pathologic changes and resorption of the residual ridges.[10,17]

Hard acrylic denture bases are liable to stress the mucosa beyond its physiological level of tolerance leading to inflammation and resorption. A breakthrough in dissipating the forces seemed to be within the reach of the profession when resilient liners were introduced. The resilient liners through their absorption and redistribution of stresses to a great extent were able to dissipate the masticatory forces better than that of the hard acrylic resins.[30] Soft denture liners are categorized into three major groups: methyl/ethyl methacrylate, silicone rubber and other materials like the

polyphosphazene fluoroelastomer, polyolefin and isoprene-based monomer contained elastomer.

Denture liners are used to cover the tissue bearing aspect of a denture to improve its fit or to improve its comfort for patients who cannot tolerate the hard dental acrylic on their mucosa.[34] Patients with thin ridges are ideal candidates because they lack supporting structures for the denture.

The most commonly used methods to measure the bond strength of resilient lining materials to denture base materials include peel, tensile and shear tests. The most common reason for failures of resilient linings in removable dentures is the separation of these linings from the denture base.[9] Therefore, poor adhesive bond properties are one of the serious defects of the material in clinical practice.

This *in vitro* study, was designed to study the nature of bond strength of three commercially available liners (GC, Aswin, Dentsply) with two different denture base materials (Acralyn-H, Lucitone-199). Artificial saliva was used to simulate the oral environment as closely as possible at different intervals. Testing was done by using Instron universal testing machine.

MATERIALS AND METHODS

The materials used in the study have been enumerated in Table 1.

Preparation of Specimen

Three stainless steel dies of dimensions 46 × 13 × 3 mm were invested in a flask with type III dental stone according to manufacturer's instructions. After setting of stone the flask was opened and the stainless steel dies were removed resulting in a rectangular shaped mold in the stone for fabrication of heat polymerized acrylic specimens (Fig. 1).

The dental stone was lubricated with a thin layer of separating medium (Acralyn-H, Asian Acrylates, Mumbai). Monomer and polymer of heat polymerized acrylic resins luciton-199 and Acralyn-H were proportioned, mixed, packed in dough stage in to the mold. Polymerization of the resin was done according to the manufacturer's instructions. The rectangular resin specimens were then retrieved. Trimming and finishing was carried out. A total of 180 (Acralyn-H, No.90, abbreviated as 'A' specimens and Lucitone -199, No.90, abbreviated as 'L' specimens) specimens were prepared.

Two stainless steel dies of dimensions 46 × 13 × 3 mm were taken and arranged in such a way that 23 mm of each specimen was overlapped (Fig. 2). In between these overlapping specimens a stainless steel spacer measuring 23 × 13 × 2.5 mm was placed to create space for the liner. These overlapping joint specimens were invested in the flask using type III dental stone (Fig. 3). After setting of the stone the flask was opened and overlapping joint specimens were removed resulting a mold in the stone for fabrication of overlapping joint acrylic specimen (Fig. 4).

The dental stone was lubricated with a thin layer of separating medium (Acralyn-H Asian Acrylates, Mumbai). The prepared rectangular acrylic specimens were roughened for 23 mm with a coarse grit sandpaper. The purpose of roughening the surface was to increase the true surface area. These acrylic specimens were placed in the mold and the soft liner was mixed in a jar according to manufacturer's instructions.

Mixed soft liner was applied to the roughened area of acrylic specimen uniformly to avoid air bubbles and to maintain uniform thickness of the liner and processed using compression molding technique. After setting, the specimens were retrieved and finished.

A total of 90 overlapping joint specimens were prepared - 45 each using Acralyn-H (A-Group) and using Lucitone-199 (L-Group).

'A' Group was further divided into 3 subgroups as follows:

1. A_1 – 15 specimens prepared using GC liner
2. A_2 – 15 specimens prepared using Aswin liner
3. A_3 – 15 specimens prepared using Dentsply liner

'L' Group was subdivided into 3 subgroups as follows:

1. L_1 – 15 specimens prepared using GC liner
2. L_2 – 15 specimens prepared using Aswin liner
3. L_3 – 15 specimens prepared using Dentsply liner

Table 1: Materials, their trade name and manufacturers

Type	*Trade name*	*Manufacturers*
Conventional heat-polymerized acrylic resin.	Acralyn-H	Asian Acrylates, Mumbai
High impact heat cure acrylic resin	Lucitone-199	Dentsply, York Division
Sodium carbaxy methyl cellulose and glycerine	Wet Mouth	ICPA Health Products Limited, India
GC reline soft	GC	GC Corporation, Tokyo, Japan
Tissue treatment kit	Viscogel	Dentsply India Limited
Tissue treatment and relining material	Aswin	Dr. Jagadish Lal Seti, Delhi, India
Polishing agent	1. Acralyn-H (Methyl methacrylate) 2. Pumice	Asian Acrylates, Mumbai
Dental stone (Type III)	Diamond	JK Chemicals, Jamnagar
Separating medium	Acralyn-H	Asian Acrylates, Mumbai

Five specimens each from A_1, A_2, A_3 and L_1, L_2, L_3 were designated as 'base' groups and subdivided as A_1-B, A_2-B, A_3-B, L_1-B, L_2-B and L_3-B. These specimens were not immersed in artificial saliva and were subjected to evaluation of shear bond strength using Instron universal testing machine.

Another 5 specimens each from A_1, A_2, A_3 and L_1, L_2, L_3 were immersed in artificial saliva for 7 days and abbreviated as A_1-7, A_2-7, A_3-7, L_1-7, L_2-7, and L_3-7. Subsequent to immersion they were subjected to evaluation of shear bond strength using Instron universal testing machine.

Last 5 specimens each from A_1, A_2, A_3 and L_1, L_2, L_3 were immersed in artificial saliva for 14 days and abbreviated as A_1-14, A_2-14, A_3-14, L_1-14, L_2-14, and L_3-14. Subsequent to immersion they were subjected to evaluation of shear bond strength using Instron universal testing machine (Fig. 5).

RESULTS

The Table 2 gives the mean shear bond strength recorded at different levels of each factor. Table 3 gives the mean shear bond strength recorded among different factors and their levels.

From the factorial ANOVA (Table 4) we notice that denture base material is a significant factor influencing shear bond strength ($p < 0.001$). Liner is also a significant factor influencing shear bond strength ($p < 0.001$). Also, time interval is a significant factors influencing shear bond strength ($p < 0.001$). The interaction (joint effect) of denture base material and liner, denture base material and time interval, liner and time interval on shear bond strength is found to be significant ($p < 0.001$).

Also, the interaction of denture base material, liner and time interval together (3 factor interaction) is found to be significant ($p < 0.001$) Figure 6 we observe that liner and time interval are the most important factors influencing shear

Table 2: Mean shear bond strengths recorded at different levels of each factor

Factor	*Levels*	*Mean*	*Std. dev*	*Median*	*Minimum*	*Maximum*
Maerial	Acralyn-H	5.80	1.61	5.09	3.55	8.32
	Lucitone-199	7.32	2.48	6.24	4.00	12.24
Liner	GC	8.30	2.47	8.06	4.05	12.24
	Densply	5.32	1.15	5.06	3.55	7.24
	Aswin	6.06	1.63	5.78	4.00	8.24
Time interval	Baseline	8.30	1.88	8.07	6.00	12.24
	7 days	6.31	1.96	5.86	4.00	10.66
	14 days	5.07	1.48	4.69	3.55	8.77

Table 3: Mean shear bond strengths recorded among different factors and their levels

Liner	*Time interval*	*Acralyn-H*				*Lucitone-199*			
		Mean	*Std. dev*	*Minimum*	*Maximum*	*Mean*	*Std. dev*	*Minimum*	*Maximum*
GC	Baseline	8.12	0.13	8.00	8.32	12.10	0.10	12.00	12.24
	7 days	6.41	0.31	6.06	6.72	10.28	0.29	10.00	10.66
	14 days	4.70	0.38	4.05	4.99	8.17	0.34	8.00	8.77
Dentsply	Baseline	7.10	0.09	7.00	7.24	6.22	0.30	6.00	6.72
	7 days	4.29	0.40	4.00	4.99	5.50	0.29	5.00	5.72
	14 days	3.86	0.20	3.55	4.00	4.94	0.14	4.75	5.12
Aswin	Baseline	8.11	0.10	8.00	8.24	8.13	0.08	8.00	8.20
	7 days	5.16	0.23	5.00	5.55	6.23	0.43	6.00	6.99
	14 days	4.44	0.26	4.09	4.68	4.29	0.35	4.00	4.77

Table 4: ANOVA results

Source	*DF*	*Sum of squares (SS)*	*Mean SS*	*F*	*p-value*
Material	1	51.817	51.817	706.580	<0.001*
Liner	2	144.590	72.295	985.820	<0.001*
Time interval	2	159.043	79.521	1084.360	<0.001*
Material*liner	2	57.241	28.620	390.270	<0.001*
Material*time interval	2	3.875	1.937	26.420	<0.001*
Liner*time interval	4	9.062	2.265	30.890	<0.001*
Material*liner*time interval	4	5.557	1.389	18.940	<0.001*
Error	72	5.280	0.073	–	–
Total	89	436.463	–	–	–

*Denotes a significant difference; DF (Degree of freedom); n-1 number of independent variables

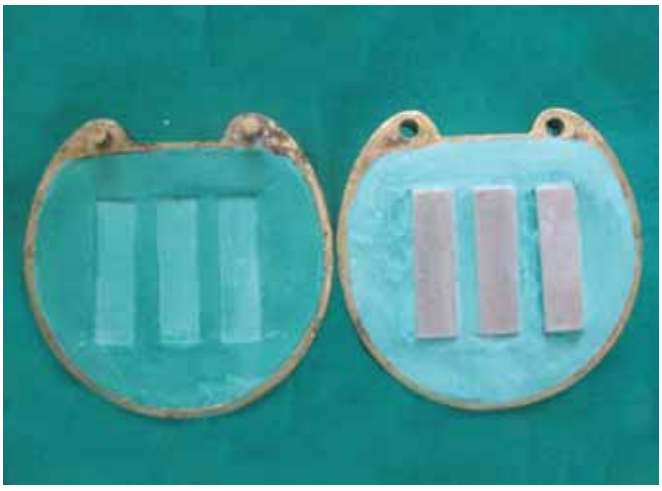

Fig. 1: Rectangular mold formed with stainless steel specimens

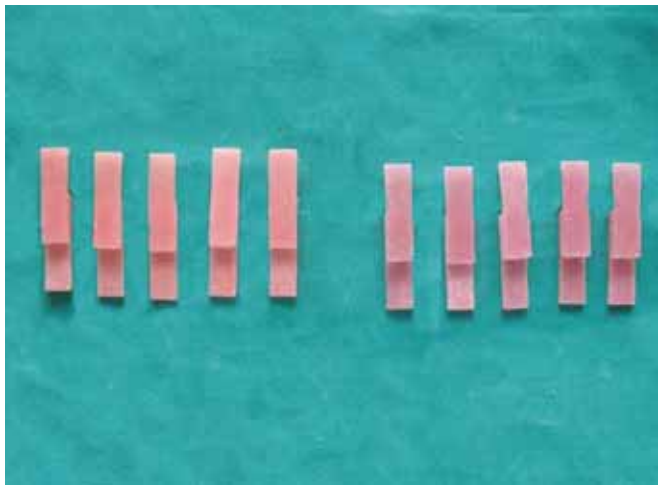

Fig. 4: Overlapping joint specimen

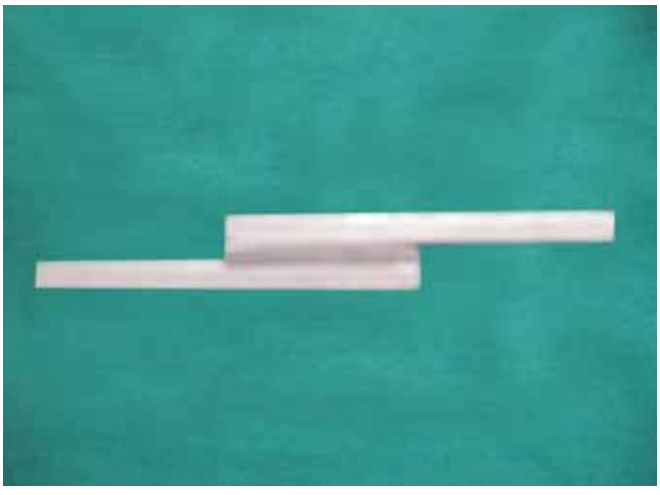

Fig. 2: Overlapping stainless steel joint specimen

Fig. 5: Universal testing machine

Fig. 3: Overlapping joint mold

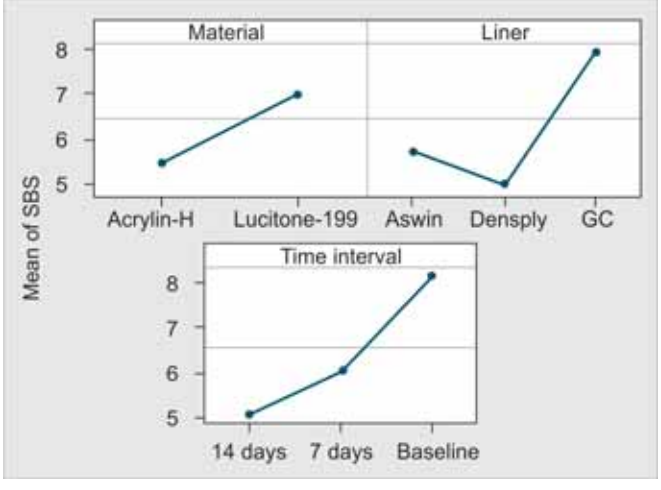

Fig. 6: Main effects plot for SBS

bond strength followed by denture base material. Among the different liners, SBS was found to be higher for GC followed by Aswin and Dentsply. The mean SBS between the different liners were found to be statistically significant ($p < 0.001$).

Among the different time intervals, baseline was found to have a higher mean SBS followed by 7 and 14 days time interval. The mean difference in SBS at different time intervals was found to be statistically significant ($p < 0.001$).

Tables 5A and B: Multiple comparisions (Dependent variable: SBS bonferroni)

A

(I) Liner	(J) Liner	Mean difference (I-J)	Std. error	Sig.	95% confidence interval	
					Lower bound	Upper bound
GC	Dentsply	2.9817*	0.06992	0	2.8103	3.1531
	Aswin	2.2403*	0.06992	0	2.0689	2.4117
Dentsply	GC	–2.9817*	0.06992	0	–3.1531	–2.8103
	Aswin	–0.7413*	0.06992	0	–0.9127	–0.5699
Aswin	GC	–2.2403*	0.06992	0	–2.4117	–2.0689
	Dentsply	0.7413*	0.06992	0	0.5699	0.9127

B

(I) Time interval	(J) Time interval	Mean difference (I-J)	Std. error	Sig.	95% confidence interval	
					Lower bound	Upper bound
Baseline	7 days	1.9863*	0.06992	0	1.8149	2.1577
	14 days	3.2277*	0.06992	0	3.0563	3.3991
7 days	Baseline	–1.9863*	0.06992	0	–2.1577	–1.8149
	14 days	1.2413*	0.06992	0	1.0699	1.4127
14 days	Baseline	–3.2277*	0.06992	0	–3.3991	–3.0563
	7 days	–1.2413*	0.06992	0	–1.4127	–1.0699

Based on observed means
*The mean difference is significant at the 0.05 level

Between the two denture base materials, Lucitone-199 recorded a higher mean SBS compared to Acralyn-H and this difference was found to be statistically significant ($p < 0.001$).

From the Tables 5A and B we notice that there is a significant difference between GC and Denstply as well as between GC and Aswin liners with respect to the mean SBS ($p < 0.001$). Also, the mean difference in SBS between Dentsply and Aswin is found to be statistically significant ($p < 0.001$).

We notice that there is a significant difference between baseline and 7 days time interval as well as between baseline and 14 days time interval with respect to the mean SBS ($p < 0.001$). Also, the mean difference in SBS between 7 days time interval and 14 days time interval is found to be statistically significant ($p < 0.001$).

From the Figure 7 we notice that at different time intervals, Lucitone-199 records a higher mean SBS compared to Acralyn-H. As the time interval increases, the mean SBS recorded in both the materials decreases. Higher mean SBS is recorded in Lucitone-199 at all time intervals compared to Acralyn-H.

Among the three different liners, GC yields a higher mean SBS compared to Aswin and Dentsply at all the three time intervals. The mean SBS recorded in Dentsply and Aswin is almost same at 14 days time interval, but at baseline and 7 days, the mean SBS in found to be higher in Aswin compared to Dentsply.

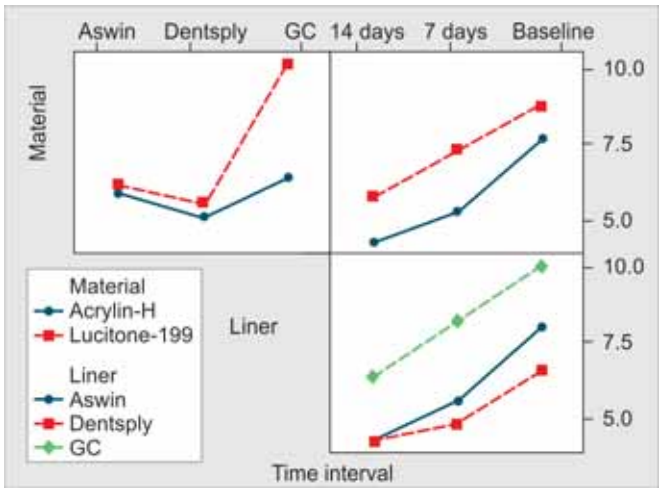

Fig. 7: Interaction plot for SBS

DISCUSSION

The most common[9] reason for failure of resilient linings in removable dentures is the separation of these linings from the denture base. Therefore poor adhesive bond properties are one of the serious defects of the material in clinical use. The desirable properties of resilient denture lining are widely recognized and many studies have been conducted over the years. The properties of interest are compatibility with oral tissues, dimensional stability, inhibition of fungal growth, wettability, rupture properties, friction characteristics and adhesion to the denture base.

A weak bond probably will result in adhesive failures at the interface between the reline resin and denture base material under relatively low stresses.[17] Successful bonding between the denture reline and base polymers relies on the effective penetration of monomers emanating from the polymerizing denture reline polymer in to denture base. An adequate amount of monomer has to be available to interact with denture polymer to form an interpenetrating polymer network to secure bond.[19]

When acrylic denture base surface was roughened the shear bond strength increases. This increase could be due to the frictional force that is generated when two contact surfaces are move relatively to each other, as in shear testing. The frictional force is increased when the surface is roughened. This increases the load that is required to break the bond.

We notice that there is a significant difference between GC and Dentsply as well as between GC and Aswin liners with respect to the mean SBS ($p < 0.001$). Also, the mean difference in SBS between Dentsply and Aswin is found to be statistically significant ($p < 0.001$).

In order to find out among which pair of time intervals there exists a significant difference. We notice that there is a significant difference between baseline and 7 days time interval as well as between baseline and 14 days time interval with respect to the mean SBS ($p < 0.001$). Also, the mean difference in SBS between 7 days time interval and 14 days time interval is found to be statistically significant ($p < 0.001$).

We notice that Lucitone-199 yields a higher SBS when used with any of the liners. However, the SBS is very high when Lucitone-199 is used with GC liner. The mean SBS is almost same in Acralyn-H and Lucitone-199 when used with Aswin liner. Lucitone records a slightly higher SBS compared to Acralyn-H when used with Dentsply liner.

At different time intervals also, Lucitone-199 records a higher mean SBS compared to Acralyn-H. As the time interval increases, the mean SBS recorded in both the materials decrease. Higher mean SBS is recorded in Lucitone-199 at all time intervals compared to Acralyn-H. Among the three different liners, GC yields a higher mean SBS compared to Aswin and Dentsply at all the three time intervals. The mean SBS recorded in Dentsply and Aswin is almost same at 14 days time interval, but at baseline and 7 days, the mean SBS in found to be higher in Aswin compared to Dentsply.

CONCLUSION

Within the limits of the *in vitro* study and based on the results of the statistical analysis the following conclusion can be drawn:

- We notice that Lucitone-199 yields a higher SBS when used with any of the liners. However, the SBS is very high when Lucitone-199 is used with GC liner. The mean SBS is almost same in Acralyn-H and Lucitone-199 when used with Aswin liner. Lucitone records a slightly higher SBS compared to Acralyn-H when used with Dentsply liner.
- At different time intervals also, Lucitone-199 records a higher mean SBS compared to Acralyn-H. As the time interval increases, the mean SBS recorded in both the denture base materials decrease. Higher mean SBS is recorded in Lucitone-199 at all time intervals compared to Acralyn-H.
- Among the three different liners, GC yields a higher mean SBS compared to Aswin and Dentsply at all the three time intervals. The mean SBS recorded in Dentsply and Aswin is almost same at 14 days time interval, but at baseline and 7 days, the mean SBS in found to be higher in Aswin compared to Dentsply.

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