Evaluation of Bond Strength of Silicone and Acrylic Resin Based Resilient Denture Liners Over A Period of Storage in Water.

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ABSTRACT

Background: Two potential problems commonly identified with a denture base incorporating a resilient liner are a failure of the bond between the acrylic resin and resilient liner material and a loss of resiliency of the resilient liner material over time. **Methods**: The current study was performed to assess the bond strength and hardness of acrylic resilient liner in both auto-polymerized and heat-polymerized forms and silicone resilient liner in auto-polymerized form to a processed denture base resin over a period of water storage for 1 day, 1 week and 1 month. The denture liners investigated were acrylic resin-based heat-polymerized (Super-soft), acrylic resin-based autopolymerized (Coe-Soft) and silicone based autopolymerized (GC-reline) resilient liner. The resilient liners were processed according to manufacturer's instructions. Tensile bond strength was measured in ASI Instron universal testing machine at a crosshead speed of 20 mm/min, and hardness was measured using a Shore-A durometer. **Results**: Two-way ANOVA and Tukey HSD tests were used to analyze the data (α=0.05). The results indicated that there were significant differences both in the hardness and bond strength values of resilient liner materials. **Conclusion**: Autopolymerized silicone resilient liner has increased bond strength and hardness values than autopolymerized acrylic liner but the bond strength and hardness values of autopolymerized silicone liner was less than heat cure acrylic resilient liner.

Keywords: Resorption, Relining, Tensile strength, tissue conditioner.

INTRODUCTION

Ill-fitting dentures currently are treated by dentists with the use of tissue conditioners and soft liners. Some edentulous patients cannot tolerate a conventional hard denture base due to the presence of a thin and relatively non-resilient mucosa or due to severe alveolar resorption. In these situations, permanent soft liners are sometimes applied to the fitting surface of the denture. Contemporary resilient liner materials can be divided into 2 groups: acrylic resin based and silicone resin based. Both groups are available in auto-polymerized and heat-polymerized forms. There are several problems associated with the use of resilient denture liners, including bond failure between the liner and denture base, colonization by Candida albicans, porosity, poor tear strength, and loss of softness. One of the most serious problems with these materials is bond failure between the resilient denture liner and denture base. Bond failure creates a potential surface for bacterial growth, and plaque and calculus formation. A variety of parameters affect the bond between the resilient lining materials and the denture base, including water absorption, surface primer use, and denture base composition.[1,2] A study was conducted to assess the bond strength of acrylic resin based auto-polymerized and heat-polymerized soft liners, and silicone based auto-polymerized resilient liner to a processed denture base acrylic resin.

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MATERIALS AND METHODS

Two rectangular brass dies of 10 x 10 x 40 mm dimensions were used and invested in the hard but flexible silicone rubber material. The mould obtained was used for the preparation of wax blocks, which was later used for the preparation of the PMMA specimens using conventional acrylization technique. Heat polymerized acrylic denture base resin (PMMA) was used to prepare 90 rectangular acrylic blocks with 10 x 10 x 40 mm dimensions. The acrylic blocks (specimens) were prepared by mixing polymer and monomer for 1 minute, packing it into the mold, processing in a water bath at 100°C for 30 minutes. After this process, the polymerized PMMA specimens were removed from the flask and trimmed, and the surfaces that were to be bonded were smoothed using 120-grit carbide paper. Two PMMA blocks with 3 mm brass spacer between them were invested in a denture flask using dental plaster. The brass spacer was later removed from the flask and the resilient denture liner material was packed into the space left by the brass spacer, trial packing and then polymerization of resilient liner was done as per the manufacturer's instructions for different materials and are grouped as follows consisting of 90 specimens i.e. 30 specimens for each group are obtained (10 specimen for each storage period). The Grouping of these specimens is as follows:

Group A: GC-Reline Auto-polymerized silicone liner (30 specimens).

Group B: COE-soft Auto-polymerized acrylic liner (30 specimens).

Group C: GC-Super soft Heat-polymerized acrylic liner (30 specimen).

For Super Soft (heat cured acrylic liner), the polymer-monomer was mixed in a plastic mixing cup for 60 seconds and placed in the flasks. The flasks were placed under pressure for 15 minutes, and immersed in a water bath for 3 hours at 70°C, followed by 30 minutes at 100°C. For Coe-Soft (autopolymerized acrylic soft liner), the polymer-monomer was mixed, placed in the flasks, and the flasks were placed under pressure for 15 minutes. For GC-Reline soft the adhesive (Primer) was applied on the acrylic surface to be bonded with resilient liner, which was allowed to dry for 1 minute. For polymerization of resilient liner, the flasks were placed under pressure for 30 minutes. After polymerization, the specimens were removed from the flask and trimmed with a sharp blade. No adhesive was necessary for the acrylic resin-based resilient liner materials. Each group (n=10) of specimens were stored in water at 37°C for 1 day, 1 week and 1 month.

For the tensile bond strength testing, ASI Instron universal testing machine [Figure 1] was used. For GROUP A TO C, specimens were placed under tension until failure in a universal testing machine [Figure 2] with a crosshead speed of 20 mm/min. Bond strength of the specimen was recorded in megapascals (MPa).

The difference in the bond strengths of each resilient liner material was determined for the 3 test periods and were evaluated statistically using a 2-way ANOVA and the Tukey HSD post hoc test. All statistical testing was performed at a preset alpha level of 0.05.

RESULTS

There were significant interactions between materials and time periods with respect to bond strength as shown by the 2-way ANOVA [Table 1]. Mean value and standard deviation values of bond strength of resilient liner materials for the three time intervals are given in [Table 2]. There were significant differences in bond strength between the materials at each time period [Table 2]. The results of the bond strength test demonstrated that the mean bond strength values (SD) of the heat-polymerized resilient liner after 1 day 3.12(±0.46) Mpa was significantly ($P<0.05$) greater than those of autopolymerized liners 0.40(±0.05) MPa; 1.74(±0.55) MPa in both the acrylic resin and silicone-based groups, respectively. Considering each material separately, the differences in bond strength with respect to time are also shown in [Table 1]. For super soft, there were significant differences in bond strength values between 1 day, 1 week and 1 month [Table 3]. For Coe-Soft there were significant differences between 1 day, 1 week and 1 month. For GC-super soft also, there was a significant difference between 1 day, 1 week and I month [Table 4]. The highest bond strength was observed for specimens stored in water for 24 hours, followed by specimens stored for 1 week. The bond strength values of the specimens became lower as the storage time increased. The lowest bond strength values for all resilient liner materials were observed after 1 months of storage. With respect to the different types of material, the reduction was greater in the autopolymerized versus heat-polymerized resilient liner materials. The mean bond strength (SD) of acrylic resin-based resilient liners 3.12(±0.46) MPa was significantly greater than that of silicone 1.20(±0.41) MPa and acrylic based liners 0.45(±0.18) MPa in both heat and autopolymerized category after 1 day. The change in bond strength over time for the acrylic resin-based resilient liner materials was greater than that of the silicone-based liners materials within both the heat and autopolymerized groups.

There are significant difference in pair wise comparison of groups and time periods with respect to bond strength values as shown by Tukey HSD post hoc test [Table 4]. In Super Soft group, the bond strength values at 5% level ($p<0.05$) was significantly higher for all storage periods as compared to COE-Soft and GC-Reline soft liner with different follow-ups. In COE-Soft group, the bond strength values for all storage periods at 5% level ($p<0.05$) was significantly smaller as compared to Super Soft and GC-Reline group with different follow-ups. Whereas in GC-Reline group, the bond strength values at 5% level ($p<0.05$) was significantly higher as compared to COE-Soft but lower when compared to Super Soft group for all storage periods with different follow-ups.

Table 1: Two-way ANOVA results for comparison of bond strength values between groups and time

SV	DF	SS	MSS	F-value	P-value
Main effects					
Group	2	99.7793	49.8896	234.3461	0.0000*
Time	2	9.6972	4.8486	22.7752	0.0000*
2-way interactions					
Group x time	4	5.0357	1.2589	5.9136	0.0003*
Error	81	17.2440	0.2129		
Total	89	131.7561			

*p<0.05

Table 2: Mean (SD) values of tensile bond strength (MPa) of resilient liner materials for 3 time intervals (n=10) in three groups.

Group	Super-soft (heat cure acrylic liner)		COE-Soft (self cure acrylic liner)		GC-Super soft (self cure silicone)	
Summary	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
1 Day	3.12	±0.46	0.40	±0.05	1.74	±0.55
1 Week	3.48	±0.97	0.28	±0.08	1.74	±0.50
1 Month	2.02	±0.39	0.21	±0.03	1.07	±0.19

Table 3: Comparison of 1day, 1week and 1 month values in each group with tensile bond strength by paired t-test.

Group	Time	Mean	Std.Dv.	Mean Diff.	SD Diff.	Paired t-value	p-value
Super-soft	1 Day	3.1160	0.4634				
	1 Week	3.4800	0.9739	-0.3640	1.2392	-0.9289	0.3772
	1 Day	3.1160	0.4634				
	1 Month	2.0200	0.3882	1.0960	0.5999	5.7775	0.0003*
	1 Week	3.4800	0.9739				
	1 Month	2.0200	0.3882	1.4600	0.9834	4.6948	0.0011*
COE-Soft	1 Day	0.3990	0.0489				
	1 Week	0.2760	0.0778	0.1230	0.0849	4.5836	0.0013*
	1 Day	0.3990	0.0489				
	1 Month	0.2070	0.0254	0.1920	0.0603	10.0635	0.0000*
	1 Week	0.2760	0.0778				
	1 Month	0.2070	0.0254	0.0690	0.0837	2.6061	0.0285*
GC-Super soft	1 Day	1.7400	0.5502				
	1 Week	1.7400	0.5038	0.0000	0.8769	0.0000	1.0000
	1 Day	1.7400	0.5502				
	1 Month	1.0700	0.1914	0.6700	0.5131	4.1290	0.0026*
	1 Week	1.7400	0.5038				
	1 Month	1.0700	0.1914	0.6700	0.5408	3.9180	0.0035*

*p<0.05

Table 4: Pair wise comparison of groups and time periods with respect to bond strength values by Tukey HSD post hoc test.

Group x time	Super-soft 1 day	Super-soft 1 week	Super-soft 1 month	COE-Soft 1 day	COE-Soft 1 week	COE-Soft 1 month	GC-Super Soft 1 day	GC-Super Soft 1 week	GC-Super Soft 1 month
Mean	3.11600	3.4800	2.0200	0.39900	0.27600	0.20700	1.7400	1.7400	1.0700
Super-soft 1 day	-								
Super-soft 1 week	P=0.7051	-							
Super-soft 1 month	P=0.0002*	P=0.0001*	-						
COE-Soft 1 day	P=0.0001*	P=0.0001*	P=0.0001*	-					
COE-Soft 1 week	P=0.0001*	P=0.0001*	P=0.0001*	P=0.9996	-				
COE-Soft 1 month	P=0.0001*	P=0.0001*	P=0.0001*	P=0.9906	P=1.0000	-			
GC-Super Soft 1 day	P=0.0001*	P=0.0001*	P=0.9103	P=0.0001*	P=0.0001*	P=0.0001*	-		
GC-Super Soft 1 week	P=0.0001*	P=0.0001*	P=0.9103	P=0.0001*	P=0.0001*	P=0.0001*	P=1.0000	-	
GC-Super Soft 1 month	P=0.0001*	P=0.0001*	P=0.0006*	P=0.0420*	P=0.0070*	P=0.0024**	P=0.0426	P=0.0426*	-

*p<0.05

Figure 1: ASI Instron universal testing machine.

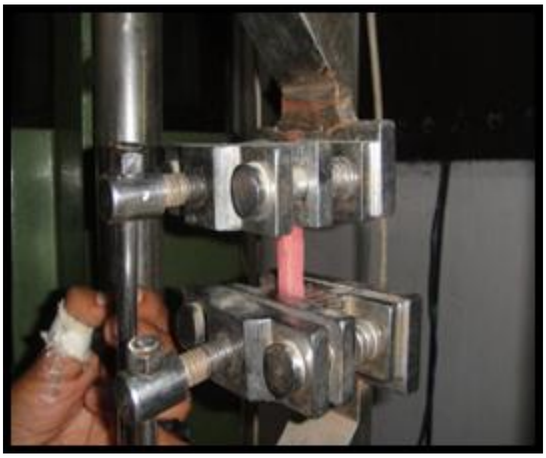

Figure 2: Specimens were placed under tension until failure in a universal testing machine.

DISCUSSION

Soft denture liners are used for edentulous patients to cushion functional forces. The influence of the thickness of temporary soft lining on masticatory function-including the maximum bite force, chewing time, and chewing frequency of test food samples has been studied previously.[3] Acrylic resin-based resilient liner materials generally consist of methacrylate based polymers and monomers. These materials undergo leaching of plasticizers, which results in increasing hardness over the time. Silicone-based resilient liner materials are similar in composition to silicone-type impression materials, so no plasticizer is necessary to produce a softening effect with this material.[4] Sufficient bond strength (4.5 kg/cm²) between the soft denture lining and the acrylic resin denture base material is required to avoid interfacial separation at the denture borders.[10] Ideally, the soft denture liners should bond sufficiently well to PMMA denture base resin to avoid failure of the interface during the service life of the prosthesis.[5] The bond strength of soft denture liners to PMMA denture base resin is weak and when the separation takes place, the localized area may become unhygienic and nonfunctional.[5] Leaching of plasticizer leas to the physical and mechanical properties of the materials change with time in the patient’s mouth. Softness is primarily affected by the leaching out of plasticizer with a consequent hardening of the material, limiting its usefulness.[6]

In this study, the bond strength and hardness of three resilient denture liners was determined by a tensile test, and softness of the resilient denture liners was measured as resistance to indentation in a material for the three test periods. These tests apply different forces than those to which the resilient denture lining materials are subjected clinically. The definitive heat-polymerized acrylic resin-based Super Soft liner had the greatest bond strength compared with the other materials at 24 hours, because the chemical composition of Super Soft is similar to that of the PMMA denture base polymer. Related to similar chemical compositions, a chemical bond is formed between the acrylic resin-based liners and the PMMA denture base polymer. Since silicone liners have little or no chemical bond to PMMA, an adhesive is needed to bond the liner to the polymerized denture base. Consequently, the bond strength of silicone denture base liners depends on the tensile strength of the liner materials, as well as the adhesive used. The chemical composition and immersion time affected both the bond strength and hardness of the resilient denture liners examined. The interim autopolymerized acrylic resin-based Coe-Soft liner has a similar chemical composition to PMMA, but it demonstrated the lowest bond strength at day one. This result indicated that heat polymerized liners have a greater bond strength than autopolymerized products. This may have been due to the mode of polymerization of this resilient liner material. The bond strength values of all the resilient liner materials were lower with increasing duration of immersion. These results agree with those of other investigators, who suggested that water storage reduced resilient liner bond strength. The lower bond strength may result from the swelling and stress formation at the bond interface, or from a change in the viscoelastic properties of the liner, rendering the material stiffer and better able to transmit external loads to the bond site.4 The acrylic resin-based liners demonstrated a greater reduction in bonding strength values compared to the silicone products during the 6 month immersion test. Moreover, the bond strength values of autopolymerized products showed greater reduction than those of heat-polymerized materials over the course of the current study. These findings agree with those of Mese.[5]

The results of the present investigation support a common trend reported in previous studies namely, heat-polymerized silicone based resilient liners have more optimal properties.[7,8] Heat polymerized acrylic resin-based resilient liners have good properties initially, but deteriorate with long-term use, and autopolymerized resilient liners have a useful, but limited role.

CONCLUSION

Within the limitations of this study, following conclusion can been drawn:

1) The Super soft liner had higher bond strength than either processed COE Soft and GC Reline soft materials.
2) Autopolymerized silicone resilient liner has increased bond strength than autopolymerized acrylic liner but the bond strength and of autopolymerized silicone liner was less than heat cure acrylic resilient liner.
3) However; autopolymerized acrylic liner has lowest bond strength than heat cure acrylic liner and autopolymerized silicone resilient liner.

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