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ORIGINAL ARTICLE

Integrity of the Interface Between Denture Base and Soft Liner: A Scanning Electron Microscopic Study

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Abstract Aims and objectives of the study was to study the integrity of the interface between the denture base and the soft liner when the thickness of the soft liner was 0.5, 1.0 and 2.0 mm, and to study the integrity of the soft liner and denture base interface as influenced by aging process. 80 rectangular based specimens were fabricated using heat cured acrylic resin. The heat cured component of the specimen was fabricated from stainless steel template form by compression molding technique. Different thickness of silicone soft layer component was added to heat cured acrylic resin component of the specimen following the manufacturer's instructions to fabricate the group A, group B, group C and group D specimens. All the specimens were subjected to the same finishing and polishing procedures. The group A specimens was immediately scanned in scanning electron microscope after processing. A thermo statically controlled artificial saliva bath designed to maintain the temperature between 38 ± 4°C was used to simulate the oral condition and to age the group B, group C and group D specimens for 3 months after which they were subjected to scanning under a scanning electron microscope. All the aged specimens demonstrated two types of failures namely adhesive which occurred along the bond interface between the soft liner and the acrylic resin and adhesive and cohesive type of failure which occurred not only at the interface but also within the soft liner material itself. When the data was subjected to ANOVA, the group A specimens showed statistical significance with group B ($P = 0.006$), group C ($P = 0.007$) and group D specimens ($P = 0.004$), the level of significance being ($P < 0.05$). However, there was no statistical significance between group B and C ($P = 0.98$), group C and D specimens ($P = 0.52$), group B and D specimens ($P = 0.70$), the level of significance being ($P < 0.05$). Based on the results, statistical analysis of the results and within the limitations of this in vitro study the following conclusions can be drawn: The thickness of the liner did not show a statistically significant rate of failure on the integrity of the interface between the denture base resin and the soft liner and aging conditions simulating the clinical environment showed a statistically significant rate of failure on the integrity of the interface between the denture base resin and the soft liner.

Keywords Silicone soft liner · Failure at the interface · Integrity of the interface · Aging the specimens · Scanning electron microscope · Study of the bond failure · Adhesive and cohesive failure

Introduction

The development of silicone based soft liners to be used with acrylic resin denture bases is a breakthrough in the clinical management of edentulous patients. However, despite using an adhesive to bond the soft liner to the resin denture base, observations reveal that failure occurs at the interface. A review of literature reveals that not many studies have been performed to document this, particularly after aging which occurs clinically. Several authors have

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reported that the bond between the RTV silicone liner and the denture base resin is weaker compared to that of HTV silicone liner. These results in edge bond failure when RTV liner is employed [1–5].

This failure results when the soft lining material swells due to water sorption leading to stress build up between the bonding surfaces or when the viscoelastic properties of the materials change. The material becomes brittle and transfers the external load to the bonding area thus leading to bond failure [1, 6, 7]. This weakened bond between the silicone reliner and denture base resin encourages the ingress of oral fluids and microorganisms at their junction and leads to staining and compromised denture hygiene.

Evidence based dentistry demands that investigations are to be designed to study such failures in clinical situations. The application of research methodologies to investigate this in clinical studies is difficult, time dependent leading to the attrition of the sample [8]. This invitro study was designed to overcome the problems of a clinical study and also to study the nature of the bond failure using scanning electron microscope simulating the oral environment as closely as possible.

Materials and Methods

Methodology

Source of the Materials

The materials for the study were sourced from commercially marketed products, the details of which are presented in Table 1.

Details of the Specimens

All the 80 specimens employed in this study had the standardized 2 mm thickness of acrylic resin component with the thickness of the soft liner component added upon it being varied.

The specimens were grouped as follows:

(a) Group A—2 mm thickness of soft liner
(b) Group B—2.0 mm thickness of soft liner
(c) Group C—1.0 mm thickness of soft liner
(d) Group D—0.5 mm thickness of soft liner

Specimens in all the groups except for Group A were subjected to aging process for duration of 3 months.

Fabrication of the Specimens

The specimens were fabricated using standardized stainless steel templates.

Details of the Template

Three stainless-steel templates of following dimensions were used for preparing specimens.

(a) Stainless steel template 1 of dimensions 30 × 10 × 2.0 mm^3
(b) Stainless steel template 2 of dimensions 30 ×10 × 1.0 mm^3
(c) Stainless steel template 3 of dimensions 30 × 10 × 0.5 mm^3

Preparation of Heat Cured Acrylic Component of the Specimens

The heat cured PMMA component of all the 80 specimens were fabricated using the stainless steel template 1. The stainless steel templates were invested in dental flasks. Then the two halves of flasks were separated and the templates were removed. Wax patterns of the mold space were formed. The flasks were closed and the mold space was obtained by dewaxing to simulate conventional processing procedure. Heat cured acrylic was packed into the mould space and processed using compression mould technique adapting 169°F for 3 h and boiling for 1 h curing cycle. Thus, processed specimens were subjected to dry and wet sandpaper finishing and were polished with pumice.

Table 1 Materials used in this study

Sl no	Type of material	Lot no	Composition	Manufacturer
1	Trevelon HI	TH 050101 Exp: 12-2006	Heat polymerized PMMA resin	TREVELON
2	GC-reline soft	0412241 Exp: 12-2009	Auto polymerized silicone liner	GC CORPORATION TOKYO JAPAN
3	Artificial saliva Wet mouth	C05003 Exp: 8-2008	Sodium carboxy methyl cellulose and glycerin	ICPA Health Products LTD, INDIA

Bonding of the Soft Liner upon the Heat Cured Acrylic Component of the Specimens

The heat cured acrylic resin component of the specimens was again invested in dental flasks and control group specimens with 2 mm thickness of soft liner were fabricated using the stainless steel template 1. The templates were flasked along with the acrylic component of the specimens taking care to ensure that the templates did not stray away from the acrylic component of the specimens. The two halves of the flasks were separated and the stainless steel template was removed for creating mould space for the auto polymerizing silicone soft liner. The heat cured acrylic component of the specimen was coated with a primer using a hair brush both of which were supplied by the manufacturer. The soft liner was mixed in paper pad using equal amounts of catalyst and base pastes according to the manufacturer's instructions. Thus, mixed soft liner was applied to the primer treated heat cured acrylic component of the specimen and was processed using compression molding technique. Similarly group A, group B and group C experimental specimens were prepared using stainless steel templates 1, 2 and 3 respectively. Thus, prepared specimens were finished using a special type of rotary instrument supplied by the manufacturer (Fig. 1).

Aging of the Experimental Specimens

All the experimental specimens were then aged for three months in a thermostatically controlled artificial salivary bath which maintained temperature in the range of 37 ± 4°C. The specimens were alternatively soaked completely in artificial saliva and water for about 16 h and 8 h respectively for a period of 3 months to simulate clinical conditions of wearing the removable prosthesis for 16 h a day and keeping the prosthesis in water for 8 h to provide rest to the oral mucosal tissues (Fig. 2).

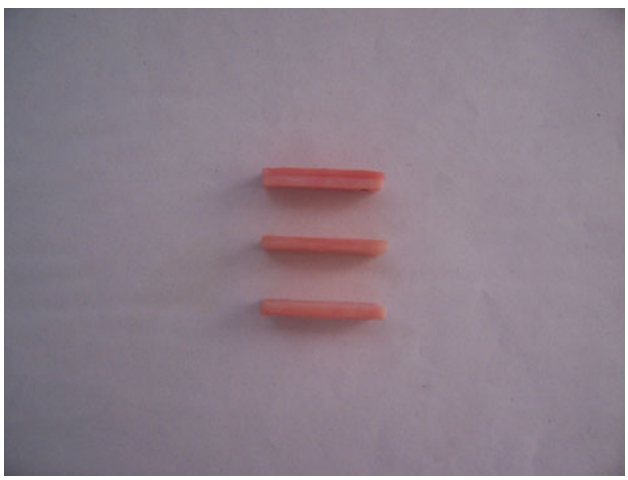


Fig. 1 Acrylic specimens with soft liner material bonded to them

Fig. 2 Experimental specimens immersed in artificial saliva

Preparation of Samples for SEM Study

Specimens requiring to be studied under SEM should be made electro conductive. In order to make the specimens electro conductive, all the specimens used in this study were sputter coated with the help of sputter coating machine before subjecting them to scanning in a scanning electron microscope.

Scanning of the Specimens

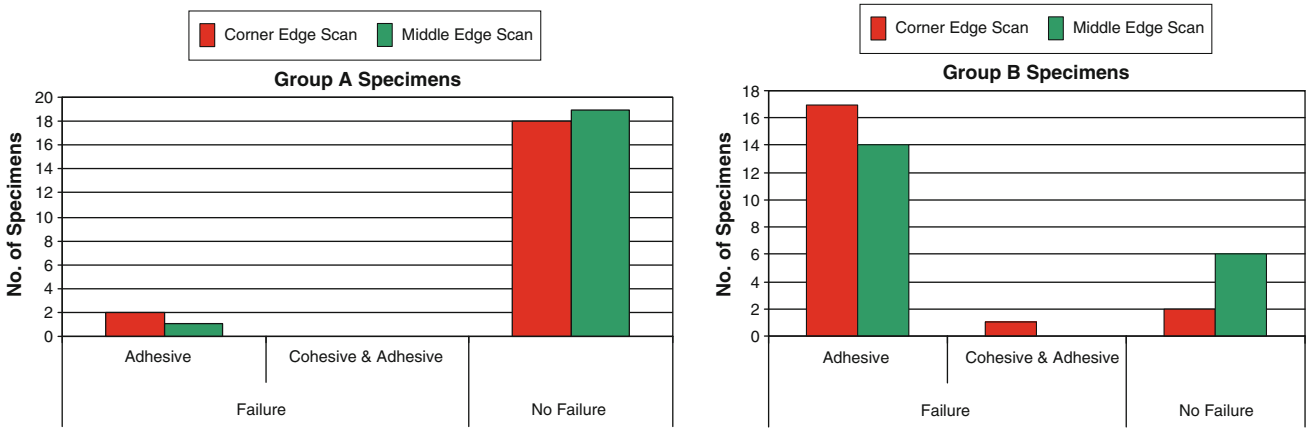
Two scans were obtained for each of the specimens to study the integrity of the interface between the denture base and the soft liner, one each at the corner edge and the middle edge of the specimen at 20 kV and using a standard magnification of 100 μm in a scanning electron microscope (Graphs 1, 2).

Results

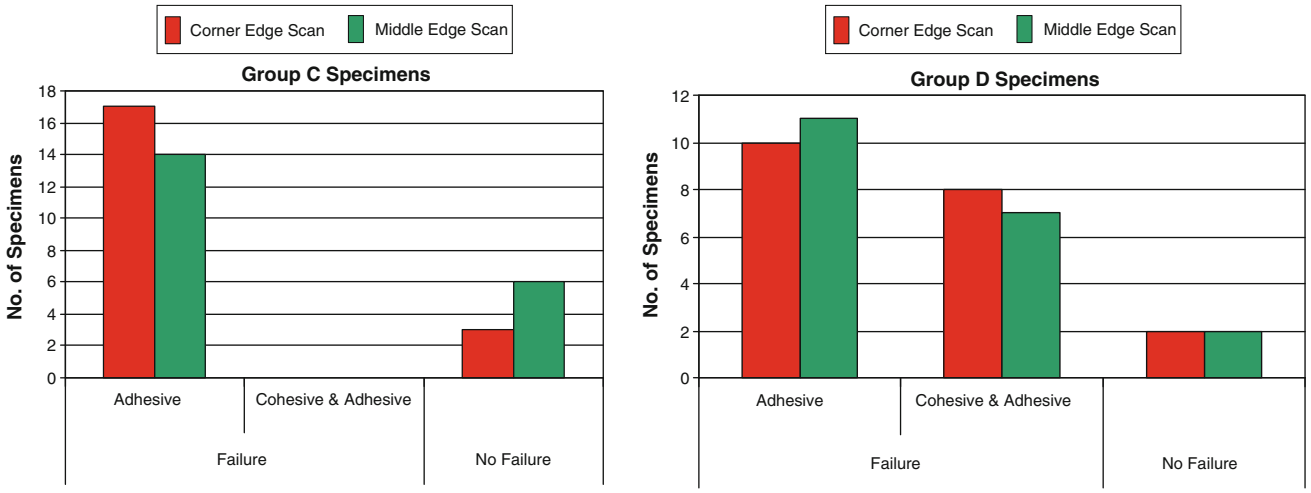
The results of the study on the integrity on the interface between the denture base and the soft liner in group A consisting of 20 specimens reveled that adhesive failure occurred in only two specimens in the corner edge scan and one specimen showed adhesive failure in the middle edge scan (Table 2) while other specimens exhibited no failure (Fig. 3). The data obtained was subjected to ANOVA and was found to be statistically significant when compared with different group specimens at ($P = 0.003$), the level of significance being ($P < 0.05$).

Table 2 Types of failures observed under SEM for different groups

Sl no	Specimen group	Corner edge scan			Middle edge scan		
		Failure		No failure	Failure		No failure
		Adhesive	Adhesive and cohesive		Adhesive	Adhesive and cohesive	
1	A	2	0	18	1	0	19
2	B	17	1	2	14	0	6
3	C	17	0	3	14	0	6
4	D	10	8	2	11	7	2



Graph 1 Graphical representation of types of failures observed in Group A and B specimens



Graph 2 Graphical representation of types of failures observed in Group C and D specimens

Table 3 One-way ANOVA (analysis of variance)

	Sum of squares	df	Mean square	*F*	Sig.
Between groups	3917.054	3	1305.685	30.150	0.003*
Within groups	173.228	4	43.307		
Total	4090. 282	7			

* The mean difference is significant at the 0.05 level

However, there was no statistical significance between group B and C, group B and D, group C and D specimens (Table 3).

Discussion

Uniform thickness of 2 mm of soft liner on the tissue surface of the denture is recommended by the manufacturer

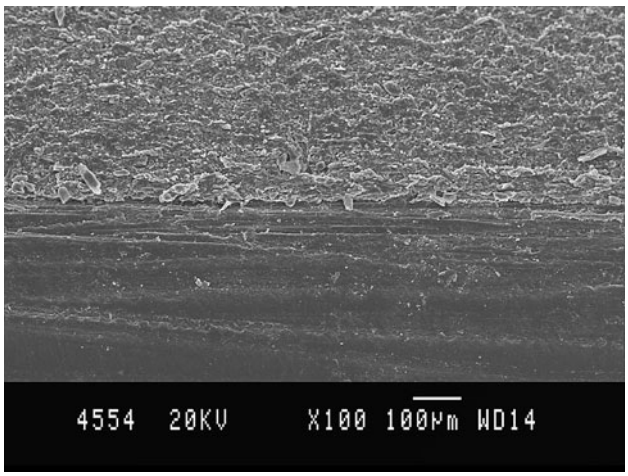


Fig. 3 SEM photograph of Group A specimen

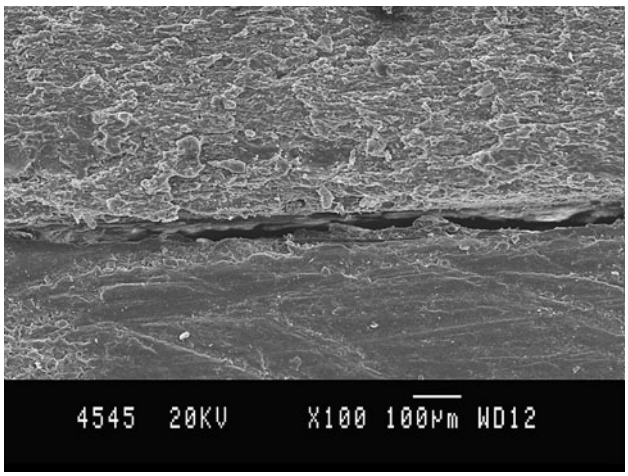


Fig. 4 SEM photograph of Group B specimen

and several authors [4, 9, 10] to provide adequate cushioning effect. Clinically it is very difficult to obtain a uniform space of 2 mm thickness on the tissue surface of the dentures. Despite making every effort to provide uniform thickness of 2 mm for the soft lining material there will be many areas of the denture which will have varying thickness of soft lining material. This was the reason why different thickness of soft liner upon denture base component was taken into account in this study.

The materials and methodology for this study was chosen with care to standardize and simulate the clinical and laboratory procedures. The acrylic component of the specimens was fabricated using stainless steel templates to prevent the errors that could be incorporated by using only wax. The thickness of the soft liner to be bonded with the acrylic component of the specimen was also standardized using stainless steel templates.

Failure of bond in silicone soft liners has been attributed to the sorption of fluids by the silicone material. Increased sorption leads to stresses at the bond interface leading to both adhesive and cohesive failures [1, 2, 6, 9]. Very few studies have investigated into the influence of the normal aging process on the bond strength and failure analysis between the silicone soft liner and the acrylic denture base. Hence this study was designed to test the specimens under artificial saliva rather than water and by employing real time weathering conditions rather than accelerated weathering to simulate the clinical conditions.

From the results of this study it is evident that the failure of the bond between the acrylic resin and the silicone soft liner is probably due to the inherent physical properties of the materials and due to the sorption of the liquid. Failures with RTV silicone liner can be of purely adhesive or a combination of adhesive and cohesive as shown in this study and also as described by several authors [3, 10–12]. It is also evident that varying the thickness of the soft liner and swaying away from the manufacturer's instructions of maintaining uniform thickness of 2 mm of soft liner does not influence the rate of bond failure significantly. Sectioning and examining the bond failures at intermediate sites like middle edges well beyond the boundaries of periphery can throw light on the extent of failure from the periphery and if independent bond failures can occur away from the margins.

When the failure is genuinely adhesive in nature as observed in group-B and group-C specimens (Figs. 4, 5), it is most probably due to the inability of the adhesive to adapt to the substrate, such that no interaction at the molecular level is possible which can be observed between the silicone and the acrylic [11] or due to high level of water sorption by the liner inducing stress concentrations in the adhesive or at the interface [13]. Adhesive -cohesive failure especially in RTV silicone liner can be attributed to the thickness of the liner being employed as thin sections of

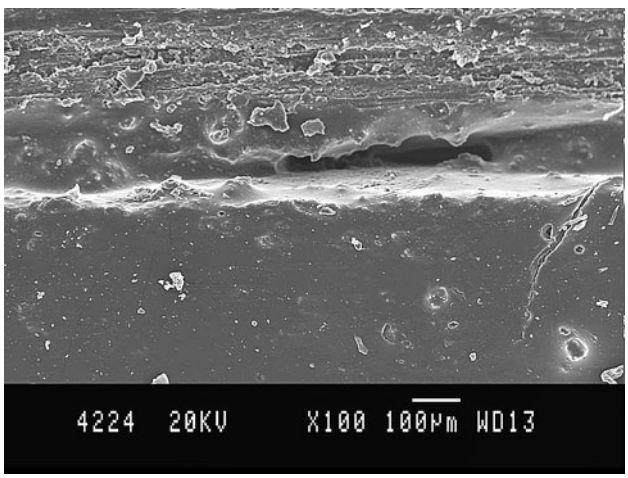


Fig. 5 SEM photograph of Group C specimen

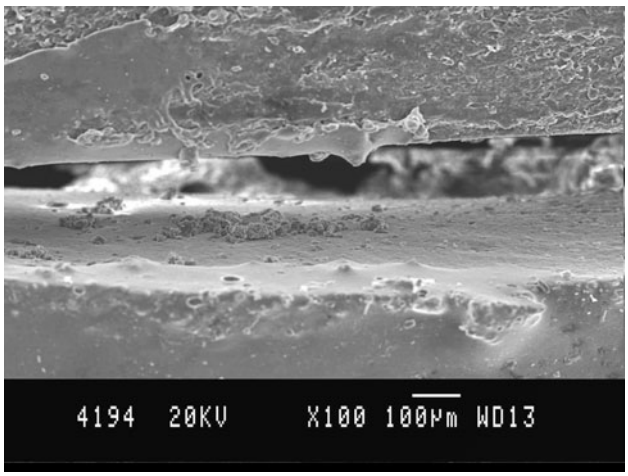


Fig. 6 SEM photograph of Group D specimen

liner usually tend to peel cohesively [14] which was exhibited by group-D specimens (Fig. 6).

The silicone materials remain permanently soft and have good elastic properties and retain their shape after setting despite being subjected to masticatory loads. Those products described as *cold curing acrylic materials are in fact temporary soft lining materials.* These materials harden within a period of a few weeks or at best a few months and cannot therefore be seriously considered as permanent soft lining since they would require regular replacement. Although the cold –curing silicones are cured at room temperature and are called chair side reliners, they are generally processed in the laboratory. The room temperature polymerizing silicone though called as chair side reliner should not be processed in the mouth because significant quantities of acetic acid are liberated during processing [3, 15].

Scanning electron microscopy [6, 8]' provides a better alternative for this purpose as it provides three dimensional images of the surface topography of the specimens.

The chair side liner employed in this study was aged for 3 months which was in accordance to the manufacturer's instructions and was also based upon the results of a prospective study [16].

Conclusions

Based on the results, statistical analysis of the results and within the limitations of this.

In vitro study the following conclusions can be drawn:

(a) The thickness of the liner did not show a statistically significant rate of failure on the integrity of the interface between the denture base resin and the soft liner

(b) Aging conditions simulating the clinical environment showed a statistically significant rate of failure on the integrity of the interface between the denture base resin and the soft liner

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