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Effect of Denture Cleansers on The Roughness of Heat-Or Auto Cured Denture Liners

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This study investigated the effect of short (24 h) and long term (6 months) exposure to a variety of commercially available denture cleanser solutions on the roughness of a variety of acrylic-and silicone-based resilient liners that were either heat-or auto-cured. The denture liners investigated were an acrylic-based heat-cured (Vertex Soft), acrylic-based auto-cured (Coe-Soft), a silicon-based heat-cured (Molloplast-B) and silicon-based auto-cured (Mollosil Plus) resilient liners. Cylindirical specimens (14 mm dia, 1 mm high) were made of each material, using 10 replications for each test condition. Immersion solutions consisted of distilled water (control) and those based on alcohol, chlorhexidine or an alkaline peroxide (dermacol, aqueous chlorhexidine, steradent) as a major active component. Specimens were fabricated according to manufacturer directions. Surface roughness were taken on all specimens at each time interval and then compared statisti-cally using four-way ANOVAs and Tukey HSD ($\alpha = 0.05$). The results of this study indicated that in comparison with distilled water, significant effect on the roughness of the specimens were found after immersion in all of the denture cleanser solutions at 24 h and at 6 months. Specimens immersed in alkaline peroxide showed higher and significant roughness changes than those immersed in other cleanser solutions. It was also determined that roughness of resilient liner materials increased with time and significantly higher roughness was recorded at 6 months for the auto-cured specimens compared with their heat-cured counterparts. The increasing roughness was greatest in acrylic-based, auto-cured resilient liner in all cleansers especially in alkaline peroxide, which suggests that the use of this resilient liner may not provide long-term clinical success.

Key Words: Resilient denture liners, Roughness, Denture cleanser, Curing type.

INTRODUCTION

Resilient denture liner materials are applied to the intaglio surface of dentures to achieve a more equal force distribution, to reduce localized pressure and to improve denture retention by engaging undercuts[1,2]. The most preferred property of resilient liners is resiliency, which is desired over a long period[3].

Resilient denture liners have been used in dentistry for more than a century. The earliest resilient liners were made from natural rubber. One of the first synthetic resins used as a resilient liner, a plasticized polyvinyl resin was developed[4] in 1945. Silicone-based materials were introduced[4] in 1958. Contemporary resilient liner materials can be divided into 2 groups: acrylic resin-based and silicone-based. Both groups are available in auto-polymerized or heat-polymerized forms[1,4]. Auto-polymerized resilient liner materials allow the dentist to intraorally reline a removable denture directly. This method is faster than the heat-polymerized (laboratory-processed) system and the patient is not without the prosthesis during the time required for the laboratory procedures[5]. However, it is difficult to produce liner materials of the optimum thickness with the auto-polymerized system[6]. The optimum thickness is *ca.* 2.4-3.0 mm which is needed to provide good shock absorption.

There are several problems associated with the use of resilient denture liners, including bond failure between the liner and denture base, porosity, poor tear strength, loss of softness and colonization by *Candida albicans*[2].

Gradual changes in oral tissues require complete or partial dentures to be relined to improve their adaptation to the supporting tissue. Although maintanence of appropriate denture hygiene is important, many denture wearers fail to maintain a satisfactory level of hygiene. Therefore a wide range of chemical denture cleansers are available to facilitate denture hygiene. These solutions not only control plaque on dentures but may also cause significant deterioration of resilient liners as well[7]. Effective denture plaque control is indispensable for clinical use of these materials, because bacterial and yeast plaque is a major factor in the etiology of denture stomatitis[7]. Inadequate cleaning by the patient leads to microbial growth on liner surfaces and denture stomatitis[8].

Two methods used to control plaque on the intaglio surface of resilient materials to prevent denture stomatitis are mechanical and chemical plaque control. Brushing is not advisable because it can damage the resilient liners. A chemical soaking technique is primarily the method of choice for geriatric patients and for those with poor motor function[9-12].

The solutions used for denture cleaning can be classified according to their chemical compositions as, alkaline peroxide, alkaline hypochlorites, acids, disinfectants, alcohol and enzymes[13]. The types of denture cleansers are known to be important in assessment of the incompatibility of cleansers with resilient liners. The selection of denture cleanser should be made to avoid or minimize changes in the properties of resilient materials[9]. Nikawa *et al.*[14] showed that various components of denture cleansers play important roles in the deterioration of resilient liners caused by cleansers.

The purpose of this study was to evaluate the effect of short and long term exposure of a variety of commercially available denture cleanser solutions or distilled water on the roughness of a heat-cured acrylic-based (HC-AB), an auto-cured acrylic-based (AC-AB), a heat-cured silicon-based (HC-SB) and an auto-cured silicon-based (AC-SB) resilient liner. The null hypothesis is that there is no effect of polymer and curing type of liner material, different cleanser solutions and storage time on roughness.

EXPERIMENTAL

The resilient liner materials and denture cleansers used in this study are listed in Table-1. For each resilient liner material, a total of 80 cylindrical-shaped wax (National Dental Dental Supplies Limited, Southport, England) specimens (14 mm in diameter and 1 mm in hight) were prepared in the appropriate brass mould. All wax specimens were invested in Type IV dental stone (Silky-Rock; Whip Mix Corp, Louisville, Ky) in the denture flasks (Hanau Engineering Inc, Buffalo, NY). After elimination of the wax, the resilient liner materials were mixed, packed into the flasks, trial packed and polymerized accoding to the manufacturers' instructions and uniform surface roughness produced by allowing polymerization to occur against the same glass surfaces.

TABLE-1
RESILIENT LINER MATERIALS AND DENTURE CLEANSERS USED

Denture cleanser		
Trade name	Chemistry	Manufacturer
Dermacol	Alcohol	Unident SA, Geneva, Switzerland
Aqueous chlorhexidine	Chlorhexidine	Hales Pharmaceutical Ltd, Wetherby, UK
Steradent	Alkaline peroxide	Reckitt&Colman.,Inc., Jull, UK
Distilled water	Control	

Resilient liner materials			
Trade name	Curing type	Polymer type	Manufacturer
Vertex Soft	Heat-cured	Acrylic-based	Dentimex, Zeist, Hoolond
Coe-Soft	Auto-cured	Acrylic-based	Coe Lab., Illinoi, USA
Molloplast-B	Heat-cured	Silicon-based	Detax, GmbH&Co.KG, Germany
Mollosil Plus	Auto-cured	Silicon-based	Detax, GmbH&Co.KG, Germany

For the HC-AB product polymerization, the powder-liquid ratio used was 2:1 and it was mixed for 1 min. Then, the flasks were placed under pressure in a standard flask press (No. 01001 Teledyne Hanau, Buffalo, NY) for 15 min and immersed in a water bath for 3 h at 70 °C, followed by 0.5 h at 100 °C. For AC-AB product polymerization, the powder-liquid ratio used was 1.5 g: 8 mL and it was mixed, placed in the flasks and the flasks were placed under pressure in a standard flask press for 15 min. For HC-SB product polymerization, it was placed in the flasks and the flasks were placed under pressure in a standard flask press for 15 min and then immersed in a water bath for 2 h at 100 °C. For AC-SB product polymerization, it was placed in flasks an the flasks were placed under pressure in a standard flask press for 0.5 h. After polymerization, all specimens were removed from the flask and trimmed with a sharp blade.

The change in surface roughness of resilient liners caused by chemical denture cleansers was tested under conditions representative of a normal overnight cleansing regime. Ten specimens of each material were immersed into the solution of each denture cleanser (Distilled water, Dermacol, Aqueous chlorhexidine, Steradent) for 8 h at 22 ± 2 °C, washed thoroughly with tap water and distilled water and immersed into distilled water for the remainder of the 24 h period at 37 °C. The process with preparation of fresh cleanser solution was continually repeated for 6 months and the surface roughness of each specimen was measured after 24 h and 6 months immersion.

Each specimen of the resilient liners was boxed using wax and then poured with the Die-Stone Peach (Modern Materials, South Bent, IN, USA) to make gypsum specimens for indirect measurement. After 1 h, the resilient liners removed, gypsum specimens were stored for 1 d at 22 ± 2 °C and 70 % humidity before measurement.

A linear variable differential transformer (LVDT) type contact instrument Surfcorder (Surfcorder SE3300, Kosaka Laboratory Ltd, Tokyo, Japan) was used as a measuring instrument. Two measurements were carried out for 10 specimens at 22 ± 2 °C and 70 % humidity and totally 20-points averaged roughness per product were calculated. The surface roughness was measured with a sample length of 0.8 mm from a 2.5 mm measuring length.

In total, 320 specimens were fabricated; 10 specimens for each test condition established from the 4 materials, 2 time periods and 4 solutions. No specimen was reused. The effects of test period, denture cleanser, curing type and polymer type on roughness of resilient liners were evaluated statistically using a four-way ANOVA, with significant effects followed up using Tukey's HSD test ($\alpha = 0.05$).

RESULTS AND DISCUSSION

Mean and standard deviation values of roughness of resilient materials immersed in the 4 treatments for 2 time intervals are shown in Table-2. From the four-way ANOVA, the main effect of dental cleansers was found to be significant ($p < 0.001$), as well as all of the main effects and all of the interactions. As indicated in Table-3, none of the interactions between dental cleansers and the other three factors approached significance ($p \geq 0.396$).

TABLE-2
MEANS VALUES AND STANDARD DEVIATIONS FOR ROUGHNESS (µm) OF RESILIENT LINER MATERIALS FOR EACH TREATMENT FOR 2 TIME INTERVALS (n = 10)

Resilient liners	Treatments	24 h	6 months
Vertex Soft	Distilled water	0.18 (0.03)	0.20 (0.02)
	Aqueous chlorhexidine	0.20 (0.03)	0.20 (0.03)
	Dermacol	0.22 (0.02)	0.24 (0.03)
	Steradent	0.24 (0.04)	0.26 (0.03)
Coe-Soft	Distilled water	0.22 (0.04)	0.24 (0.04)
	Aqueous chlorhexidine	0.24 (0.04)	0.25 (0.04)
	Dermacol	0.25 (0.05)	0.28 (0.05)
	Steradent	0.26 (0.05)	0.29 (0.06)
Molloplast-B	Distilled water	0.42 (0.02)	0.43 (0.02)
	Aqueous chlorhexidine	0.43 (0.02)	0.44 (0.03)
	Dermacol	0.45 (0.02)	0.47 (0.02)
	Steradent	0.46 (0.03)	0.48 (0.03)
Mollosil Plus	Distilled water	1.21 (0.03)	1.22 (0.03)
	Aqueous chlorhexidine	1.22 (0.03)	1.23 (0.03)
	Dermacol	1.23 (0.03)	1.23 (0.04)
	Steradent	1.23 (0.03)	1.25 (0.04)

TABLE-3
ANALYSIS OF VARIANCE FOR ROUGHNESS

Source	DF	SS	MS	F	P
Treatment	3	0.1	0.0	27.45	0.000
Time	1	0.0	0.0	17.74	0.000
Curing type	1	13.2	13.2	11929.54	0.000
Polymer type	1	28.9	28.9	26063.67	0.000
Curing type × polymer type	1	11.0	11.0	9945.04	0.000
Treatment × curing type	3	0.0	0.0	0.99	0.396
Treatment × polymer type	3	0.0	0.0	0.68	0.568
Time × curing type	1	0.0	0.0	0.35	0.557
Time × polymer type	1	0.0	0.0	0.62	0.431
Treatment × time	3	0.0	0.0	0.42	0.743
Treatment × time × curing type	3	0.0	0.0	0.17	0.919
Treatment × time × polymer type	3	0.0	0.0	0.07	0.974
Treatment × curing type × polymer type	3	0.0	0.0	0.20	0.894
Time × curing type × polymer type	1	0.0	0.0	0.24	0.627
Treatment × time × curing type × polymer type	3	0.0	0.0	0.16	0.924
Error	288	0.3	0.0		
Total	320	145.4			

Follow-up comparisons using Tukey's HSD showed significant differences between all pairs of the 4 denture cleansers (Table-4) except Dermacol and Steradent.

TABLE-4
PAIRWISE COMPARISONS AMONG LEVELS OF TREATMENT

Treatment	N	Subset		
		2	3	1
Distilled water	80	0.5133	–	–
Aqueous chlorhexidine	80	–	0.5269	–
Dermacol	80	–	–	0.5446
Steradent	80	–	–	0.5576

The results of the roughness test demonstrate that the roughness values of the Mollosil Plus was significantly higher than those of, Coe-Soft, Molloplast-B and Vertex Soft at both 24 h and 6 months ($p < 0.001$). The roughness of the SB resilient liners was greater than that of AB liners and the roughness of AC resilient liners was greater than that of HC liners for both the silicone- and acrylic resin-based groups. There were significant differences between Vertex Soft and Coe-Soft ($p < 0.001$) and between Molloplast-B and Mollosil Plus ($p < 0.001$) at both 24 h and 6 months.

When the results of 4 denture cleansers on each resilient liner are compared, the roughness values of resilient liners in Steradent was significantly higher than in Dermacol and aqueous Chlorhexidine, respectively for each resilient liner ($p < 0.001$).

The lowest roughness value was seen at 24 h and the greatest at 6 months for the 4 types of resilient liners tested. Significant increases in roughness values were observed for all 4 types of resilient liners in all cleanser solutions with time. The roughness of the resilient liner materials increased with time and the increase was significantly greater for the AB resilient liner materials than for the SB liner materials ($p < 0.001$); moreover, the increase was significantly greater for the AC resilient liner materials than the HC liners in all cleanser solutions ($p < 0.001$).

The results showed that the roughness of the resilient liner materials was increased in denture cleanser solutions compared with distilled water. This result is in agreement with those of others[14,15] who have reported that resilient liner materials can absorb water or lose soluble components, depending on their composition and the solution in which they are immersed. It is likely that the higher ionic concentration of potassium and sodium in denture cleansers compared to water[14,15] led to a higher release of soluble components.

Almost all resilient liners became rougher, to a greater or lesser extent, by the immersion into denture cleanser. Comprasion between the 3 denture cleansers tested in the present study showed that the increasing roughness was the most in alkaline peroxide solution, followed by alcohol based and chlorhexidine solution. The present results agree with those of others[15,16] who reported that alkaline solutions had a greater effect on roughness. The oxgenation occurring in alkaline peroxide solution is the damaging factor and affects the roughness property of resilient liners[17]. The contents of peroxide inhibit the polymerization of silicone materials[8,16]. This will be one of the reasons why peroxide causes the distortion of resilient liners. When peroxide is added to aqueous solutions, oxygen is liberated cleaning the surface of debris resulting in increasing roughness[18]. This study showed that the roughness of all the resilient liner materials increased with the duration of immersion in denture cleansers and significant differences were observed between denture cleansers and distilled water at 6 months. This finding is in agreement with others[17-19]. This results can be explained by the slow absorption of disinfecting chemicals into the resilient liner materials.

Comprasion between the polymer types tested in the present study showed that the Mollosil Plus liner had the greatest roughness compared with the other materials at 24 h after immersion. These results are similar with the report of Jin[16], who suggested that AC-SB resilient liner materials have the greatest roughness. The roughness of the Vertex Soft and Coe-Soft liners increased with the duration of immersion more than that of the acrylic products. The present results agree with those of others[6,7,20] who reported that water storage increased resilient liner roughness in AB products more than in SB products. Acrylic resin-based resilient liner materials contain plastizers which are responsible for softness of AB resilient liner materials. AB resilient liners undergo 2 processes when immersed in solution: the leaching of plasticizers and other soluble materials into the water and the absorption of water by the polymer. When the specimens were immersed in dentur cleanser, the loss of soluble components, such as the plasticizer, may have occurred leaving empty spaces or bubbles[20]. Probably, with time, these bubbles, responsible for the roughness, increased in size resulting in craters, resulting in high roughness values.

Comprasion between the curing types tested in the present study showed that the roughness of the Coe-Soft and Mollosil Plus liners increased with the duration of immersion more than the roughness of the Vertex Soft and Molloplast-B liners over the duration of this study. These findings agree with those of Aydin[21] and Kawano[2] who reported that the mechanical properties of AC resilient liners are affected more by immersion than are HC resilient liner materials. The roughness results may therefore have been influenced by material composition as well as curing mode.

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