BASIC SCIENCE RESEARCH

The Effect of Brushing on Surface Roughness of Denture Lining Materials

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Purpose: **The purpose of this study was to test the effect of brushing on surface roughness of two resilient liners (Luci Sof and Sofreliner) compared with an acrylic resin (QC 20).**

Materials and Methods: **Twenty specimens of each material were prepared (25 mm × 14 mm × 3 mm). Ten specimens served as controls and were stored in distilled water and not brushed. The remaining ten specimens were subjected to mechanical brushing, using an MSEt plus machine to simulate brushing at a rate of 5.0 strokes per second (30,000 cycles). Surface roughness measurements were recorded before and after brushing. Random samples were analyzed using scanning electron microscope. Data collected were analyzed by a two-way analysis of variance using material and treatment as variables, followed by Tukey's test ($\alpha = 0.05$).**

Results: **Initial surface roughness of materials indicated that QC 20 was the smoothest (0.13 μm), and Luci Sof the roughest (0.68 μm). Sofreliner had an intermediate value (0.31 μm). All materials were significantly different. Mechanical brushing significantly increased surface roughness in all the materials. Although there was no statistical difference between QC 20 and Luci Sof after mechanical brushing (0.88 and 1.00 μm, respectively), both differed significantly from Sofreliner (7.74 μm).**

Conclusion: **The two resilient liners and the acrylic resin became rougher, to a greater or lesser extent, when subjected to mechanical brushing.**

INDEX WORDS: complete dentures, resilient denture liner, acrylic resin, surface roughness, tooth brushing

EVEN THOUGH ACRYLIC RESIN IS commonly used for complete denture bases, patients often prefer resilient liners to conventional hard denture bases.[1] Treatment of atrophic ridge, bony undercuts, bruxism, and dentures opposing natural teeth requires the use of resilient lining materials to reduce and distribute stress on the denture bearing tissues; however, there are some disadvantages in using these materials. It has been shown that resilient liners are easily colonized by *Candida albicans*,[2] which may cause an oral pathologic condition known as denture stomatitis when associated with poor oral and denture hygiene.[3] Prosthetic cleansing that removes *C. albicans* is a necessary and important factor in preventing non-traumatic causes of denture stomatitis.[4] Consequently, one of the greatest disadvantages of resilient lining materials is the difficulty keeping them clean.[5,6]

Routine methods commonly used for denture cleaning include use of immersion cleansers and brushing.[6-9] The immersion denture cleansers may be classified as alkaline peroxides and hypochlorites, acids, disinfectants, and enzymes.[7] Ideally, these solutions should be effective in removing stains and deposits from the denture; they should be simple to use and be compatible with all denture base materials.[9,10] Although chemical denture cleansers have been considered an

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efficacious method for preventing *C. albicans* colonization and denture plaque formation,[12,13] a daily use of denture cleansers can affect the properties of denture acrylic resin and soft liners.[13,14] Thus, dentists should choose denture cleansers by taking into account the compatibility of denture cleansers with soft denture liners on both materials and biological aspects.

Brushing dentures with a toothbrush, dentifrice, and water is the most common alternative to chemical cleansing.[15] It is still questionable whether brushing causes abrasion of resilient lining materials.[5,16] Makila and Honka[5] found wear of soft denture liners subjected to brushing; however, Wright[1] and Schmidt and Smith[16] observed no evidence that soft liners are more difficult to clean than conventional dentures, neither was there any evidence of abrasion or wear of soft liners' surface. Since surface roughness can influence biofilm retention,[17] the purpose of this study was to investigate the effect of mechanical brushing on surface roughness of two resilient liners and one acrylic resin. The hypothesis tested was that brushing would not significantly affect surface properties of the resilient liners and acrylic resin.

Materials and Methods

The resilient liners and acrylic resin used in the present study, along with type of curing, batch number, and manufacturers, are shown in Table 1. Luci Sof was supplied in sheet form. Sofreliner was supplied in direct application cartridges, and QC 20 was supplied as a powder and liquid.

Specimen preparation and surface finish were carefully standardized. Twenty specimens of each material were prepared according to the manufacturers' directions and placed inside 24 mm × 14 mm × 3 mm rectangular silicone molds using either a spatula or an automix cartridge. To produce test surfaces of comparable smoothness, specimens were prepared against glass slides.

The glass slides were then incorporated in flasks using plaster. Luci Sof was processed by heating the flask in a water bath at 100°C for 2.5 hours. QC 20 was processed in a water bath at 100°C for 15 minutes. Sofreliner was processed at room temperature. Flasks were opened after polymerization. Specimens were then removed and stored in distilled water at 37°C for 24 hours.

Figure 1. Specimen in the mechanical brushing machine.

Ten specimens of each material served as controls. These specimens were stored in distilled water and not brushed. The test group was composed of the remaining ten specimens per material. The mechanical brushing assay was conducted on a brushing simulating machine (MSEt plus, São Carlos, São Paulo, Brazil), at a rate of approximately 5.0 strokes per second. Each test specimen was brushed for 30,000 strokes, which is equivalent to approximately 3 years of cleansing.[15] This machine is equipped with ten brush holders so that specimens could be brushed simultaneously. A fixed load of 300 g was applied to the toothbrush neck throughout the test. Brushes were free to move in a vertical direction (Fig 1). An extra soft bristle toothbrush (Reach, Johnson & Johnson, São José dos Campos, São Paulo, Brazil) with a round-tipped end and a calcium carbonate based dentifrice (Sorriso Dentes Brancos, Colgate Palmolive Company, São Bernardo dos Campo, São Paulo, Brazil) was used. Dentifrice paste/water slurries were prepared by mixing 4.6 g paste with 6 ml distilled water. A 0.3 ml of slurry was independently injected to specimens every minute during the 30,000 cycles.

Table 1. Materials Tested

Brand	*Material*	*Type of Curing*	*Batch Number*	*Manufacturer*
Luci Sof	Silicone liner	Heat	990726A	Dentsply International Inc., York, PA
Sofreliner	Silicone liner	Cold	U46973	Tokuyama Dental Corp., Tokyo, Japan
QC 20	Acrylic resin	Heat	57867	Dentsply Brazil Ltd., Petrópolis, RJ, Brazil

Table 2. Mean Surface Roughness (μm) ± Standard Deviation of Denture Materials ($n = 10$)

	Mean Surface Roughness (Ra)	
Material	*Control*	*Brushed*
Luci Sof	0.68 ± 0.25 a, A	1.00 ± 0.20 b, B
Sofreliner	0.31 ± 0.12 b, A	7.74 ± 1.16 a, B
QC 20	0.13 ± 0.05 c, A	0.88 ± 0.21 b, B

Means followed by the same lower case letter in a column and the same upper case letter in a row do not differ statistically by Tukey at a 5% probability level.

Surface roughness, Ra, was measured in micrometers (μm) with Surfcorder SE 1700 (Kozaka Industry, Kozaka, Japan) at 2.4 precision of measure after the profilometer was calibrated with a calibration specimen (Model SS-N S94 Ra 3.0 μm no. 20138, Kosaka Laboratory, Tokyo, Japan). The cut-off value was set at 0.8 and 0.5 mm/s.[18] Statistical calculation of surface roughness was performed using an average of three surface roughness measurements taken parallel to the long axis at the central segment of each specimen.[19]

One specimen was randomly selected from each group and visually examined by an observer. These specimens were then covered with gold in a sputter-coater (Denton Vaccum Desk II, Denton Vacuum Inc., Denton, TX) and viewed with a scanning electron microscope (SEM) (JSM 5600 PV, JEOL, Tokyo, Japan) at an accelerating voltage of 15 kV at 50× magnification for qualitative descriptive purposes. Sputter-coating for SEM observation damaged specimens so that further evaluation was impossible.

Surface roughness data were analyzed with a two-way analysis of variance using material and treatment as variables, followed by Tukey's test ($\alpha = 0.05$).

Results

Mean surface roughness of control specimens was significantly different, increasing from smoothest to roughest in the following order: QC 20 (0.13 μm), Sofreliner (0.31 μm), and Luci Sof (0.68 μm) ($p = 0.0010$). Although mechanical brushing significantly increased surface roughness in all specimens, QC 20 and Luci Sof (0.88 and 1.00 μm, respectively) did not differ significantly from one another. On the other hand, these two materials were significantly different from Sofreliner (7.74 μm) ($p = 0.0014$) (Table 2).

Macroscopic Examination

Macroscopic examination of brushed Luci Sof and QC 20 specimens presented no apparent material wear. On the other hand, Sofreliner specimens demonstrated varying degrees of wear, in the form of grooves running parallel to the length of the specimen.

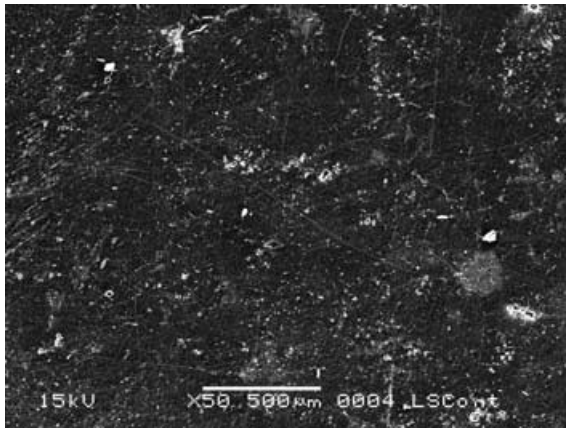

Figure 2. SEM view of Luci Sof, control specimen (original magnification ×50).

SEM Examination

Photomicrographs (50× magnification) of one control and one brushed specimen per group were taken (Figs 2–7). Brushed specimens demonstrated a series of grooves in the long axis of the specimen. The grooves were more pronounced in Sofreliner specimens than in the other materials (Fig 5).

Discussion

Intrinsic characteristics of resilient lining material on denture fit enable the shape of the

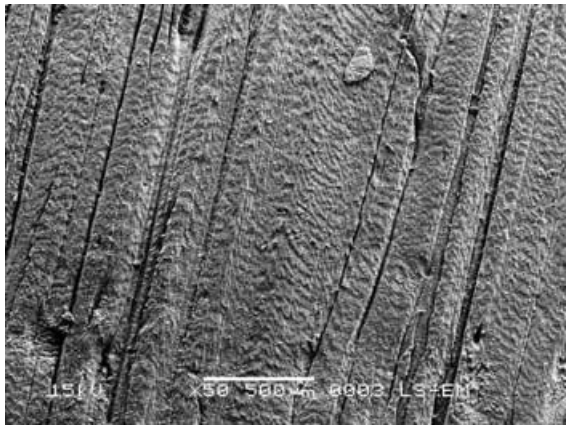

Figure 3. SEM view of Luci Sof, brushed specimen (original magnification ×50).

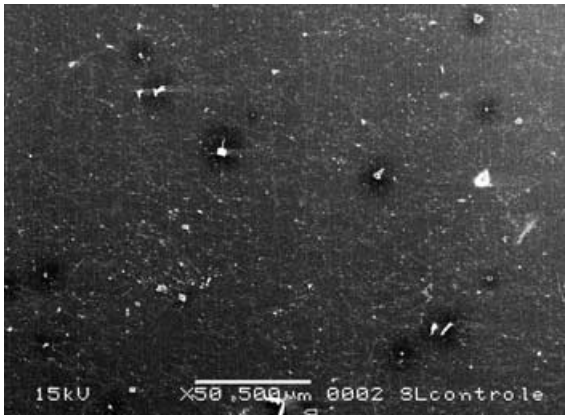

Figure 4. SEM view of Sofreliner, control specimen (original magnification ×50).

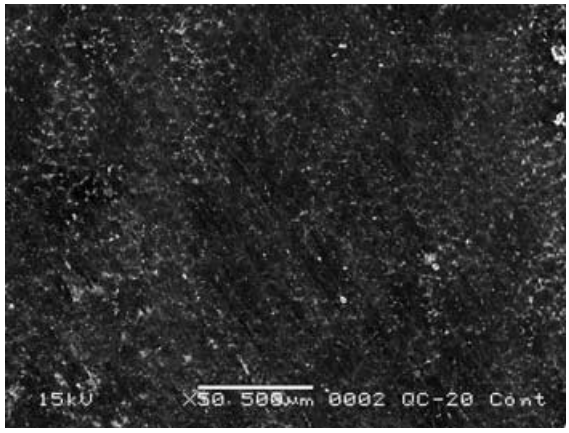

Figure 6. SEM view of QC 20, control specimen (original magnification ×50).

prosthetic base to change in response to functional loads; consequently, resilient lining materials help distribute functional load evenly across the entire denture bearing area, impeding stress from concentrating in any single location.[23] However, possible drawbacks include easy colonization by *C. albicans* and difficulty in keeping the prosthesis clean.

Surface roughness of denture materials is important, as it affects the oral health of tissues in direct contact with a denture. Rough surfaces like bridges, implant abutments, and denture bases accumulate and retain more dental plaque than smooth surfaces.[20] Once bacteria join to irregular surfaces and other stagnation sites, they can survive for a long period of time. A rough surface may protect bacteria from natural removal forces and even from oral hygiene methods. Ideally, a surface with the lowest possible roughness is recommended to reduce microorganism retention and prevent local infections and early denture deterioration.[21] The threshold surface roughness for bacterial retention is 0.2 μm.[17] Surface roughness below this value does not help reduce bacterial accumulation. On the other hand, surface roughness greater than 0.2 μm produces increased plaque accumulation.[17] A review of the literature failed to produce any studies associating surface roughness with mechanical brushing of resilient denture liners; consequently, only indirect comparisons are possible.

The present study was carried out to assess whether brushing affects the surfaces of resilient lining materials. Both the resilient liners and

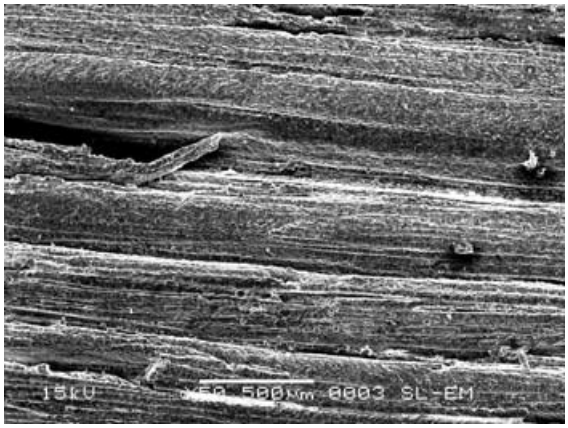

Figure 5. SEM view of Sofreliner, brushed specimen (original magnification ×50).

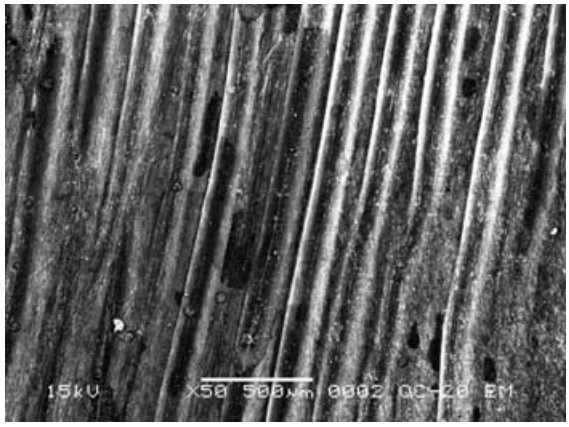

Figure 7. SEM view of QC 20, brushed specimen (original magnification ×50).

the acrylic resin became rougher, to a greater or lesser extent, when subjected to mechanical brushing. Results demonstrated that Sofreliner was less resistant than Luci Sof and QC 20. Although both resilient liners tested in the present study are classified as silicone-based materials, the results might have been affected by material composition and polymerization mode. Luci Sof is a poly(dimethylsiloxane)-based, heat-cured material, and Sofreliner is a poly(methylmethacrylate) and polyorganosiloxane chemical-cured material. The higher conversion of heat-curing materials[22] helps make this material more resistant to brushing.

Dentists consider immersion cleansers as an efficacious aid in preventing denture plaque formation,[17,18] and patients prefer this cleansing method due to its preparation ease.[24] However, daily use of these solutions can affect physical properties of denture materials.[14,26-28] Consequently, a clinician should consider the cleanser's compatibility with the resilient liner when choosing a denture cleanser.[14,28] Brushing dentures with toothbrush, dentifrice, and water is a popular cleansing technique[15] that has proven to be quite effective in removing plaque deposits.[26] It is uncertain whether abrasion of resilient lining materials by brushing is a significant problem. Schmidt and Smith[16] reported no evidence of abrasion in their clinical study of resilient liners. On the other hand, Makila and Honka[5] reported wear of this material within a period of 30 months.

Surface roughness of denture materials is clinically important because it can influence biofilm retention,[17] since an increase in roughness may encourage microbial colonization. However, interactions between protein coats, resilient material, and *C. albicans* have been found to be important factors in in vivo *Candida* colonization.[2] In the present study, brushing significantly increased surface roughness. It is probable, but not demonstrated, that brushing could have a similar effect clinically, although other factors such as the presence of saliva during polymerization, tissue irregularities, and microbial factors might affect the results as well. Poor denture hygiene is cited as a local etiological factor in denture stomatitis;[7,10] consequently, efficient denture cleaning is important for lifelong good oral health.

In the present study, crack lines were apparent in SEM photomicrographs of all materials, which corroborates Loney et al.[29] Either SEM processing helped produce the cracks, or they are normally present on the surface of these materials. SEM photomicrographs after mechanical brushing demonstrated channel-like grooves running along the long axis of the specimen. Brushed Sofreliner specimens not only presented the greatest Ra values, but also the most pronounced grooves.

Although laboratory studies simulate clinical conditions, testing environments are never exactly the same. Since there were no significant differences between brushed Luci Sof and QC 20 specimens, clinicians could recommend an extra soft bristle toothbrush for this resilient liner. On the other hand, denture cleansers, such as alkaline hypochlorite, should be recommended for cleaning Sofreliner. The fact that only two resilient liners of the many products available on the market were evaluated is another limitation of this study.

Conclusions

Considering the limitations of this study, the following conclusions were drawn:

1. Non-brushed (control) specimens were significantly different from one another with mean values being 0.13 μm for QC 20, 0.31 μm for Sofreliner, and 0.68 μm for Luci Sof.
2. There was no statistical difference in roughness between QC 20 (0.88 μm) and Luci Sof (1.00 μm) after mechanical brushing; however, these materials differed significantly from Sofreliner (7.74 μm), which was rougher.
3. Mechanical brushing significantly increased surface roughness in all materials tested.

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