

Effects of various denture cleansers on surface roughness of hard permanent relined resins

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The aim of this study was to investigate the influence of denture cleansers on surface roughness (Ra, μm) of two hard permanent relined resins and a conventional acrylic denture base resin. Fifty specimens of each material, measuring 10 mm×2 mm were randomly divided into 1 control and 4 experimental subgroups ($n=10$). Surface roughness values were measured using profilometer before and after immersion in distilled water and in 4 different denture cleansers for 8 h for 140 days. The Kruskal Wallis and Wilcoxon Signed Ranks tests were used for comparison among groups with a significance level of $\alpha=0.05$. Immersion in denture cleansers significantly increased the surface roughness of relined resins and the difference among the cleansers was statistically significant ($p=0.059$). Denture cleansers can cause significant surface roughness alterations on hard permanent relined resins and denture base resin where their effect may differ according to the selected resin material.

Keywords: Denture base, Denture cleanser, Hard permanent relined, Surface roughness

INTRODUCTION

Proper denture plaque control and its importance for the long term health of oral tissues is very well documented in the literature by various clinical and microbiological studies¹⁻⁶. Inadequate denture hygiene may contribute to biofilm formation on the tissue bearing surface of the prostheses which engender opportunistic oral infections such as denture stomatitis¹.

Various protocols have been proposed for denture disinfection. Brushing with dentifrices or ultrasonic treatment are commonly used mechanical methods for the elimination of biofilm on denture surfaces^{7,8}. Where there is a lack of motor coordination, especially in elderly patients who comprise the majority of denture wearers, immersion in chemical cleansers should be adjunctively used with mechanical methods⁹.

Denture cleansers can be classified as: alkaline peroxides, acids, disinfecting agents and enzymes^{4,10,11}. They should effectively inactivate microorganisms without causing an adverse effect on the surface of the denture material¹²⁻¹⁴.

The influence of different denture cleansers on the surface roughness of denture base acrylic resins has been investigated¹⁵⁻¹⁷. Peracini *et al.*¹⁸ reported that alkaline peroxide effervescent denture cleansers significantly increased the surface roughness of heat-polymerized acrylic resin and they should be used with caution. In their crossover *in vivo* study, Lima *et al.*¹⁹ verified the increased roughness of microwave polymerized base acrylic resins after treatment with enzymatic and sodium hypochlorite solutions.

Dentures may require direct relining as the residual ridge reduces over an indefinite period of time, particularly when fabrication of a new denture is contraindicated due to the health status of geriatric

individuals. Direct relining with hard permanent relined resins offers an opportunity for correcting an adaptation problem at the clinic in a relatively short time when compared to laboratory relining^{20,21}.

Relined materials can be colonized by microorganisms due to their porous and micro-retentive surface characteristics²²⁻²⁴. The results of *in vitro* studies revealed that smoother surfaces retain fewer cells whereas rough surfaces promote the adhesion of microorganisms²⁵⁻²⁸. The influence of various denture cleansers on the surfaces of denture base and soft relined resins have been reported by several studies whereas there are only a limited number of studies which have evaluated the effect of denture cleansers on the surface roughness of hard permanent relined resins²⁶⁻²⁹.

The purpose of this study was to analyze the influence of denture cleansers on surface roughness (Ra, μm) of 2 hard permanent relined resins and a conventional acrylic denture base resin. The research hypothesis was that denture cleansers may increase surface roughness of denture base and hard permanent relined resins.

MATERIALS AND METHODS

Two commercial hard permanent relined resins having different compositions were selected to evaluate the influence of denture cleansers on surface roughness. Table 1 and Table 2 list the resins and denture cleansers used in this study. Cylindrical wax (Cavex Set Up Regular, Cavex, Haarlem, The Netherlands) patterns in dimensions of 10 mm×2 mm were prepared using a custom made metal mold and invested in metallic flasks. After wax elimination, the powder and liquid of the denture base acrylic resin were mixed according to the manufacturer's instructions. Resin dough was inserted into the molds and packed. After polymerization for

Table 1 Heat polymerizing denture base resin and hard chairside reline resins used in this study

Product/Type	Manufacturer	Lot Number	Powder/ Liquid Ratio	Composition		Polimerization Condition
				Powder	Liquid	
New Truliner Hard permanent reline resin	Bosworth Company, Illinois, USA	0810-522	15 mL/7.6 mL	PEMA BPO TiO ₂ Cd Pigments	Alkyl methacrylate Alkyl phythlate n,n DmPT	15 min at room temperature
UfiGel Hard Hard permanent reline resin	Voco, Cuxhaven, Germany	1028020	3 mL/1 mL	PEMA	1.6 HDMA	10 min at room temperature
Meliodent Heat-polimerized acrylic resin	Heraeus Kulzer, Hanau, Germany	012259	35 g/14 mL	PMMA Benzoyl Peroxide	MMA EGDMA	90 min at 73°C and then 100°C boiling water for 30 min

PEMA; polyethyl methacrylate, BPO; benzoyl peroxide, TiO₂; titanium-dioxide, Cd; cadmium, DMPT; dimethyl-p-toluidine, 1.6-HDMA; 1.6-hexanediol dimethacrylate, PMMA; polymethyl methacrylate, MMA; methyl methacrylate, EGDMA; ethylene glycol dimethacrylate.

Table 2 Denture cleansers used in this study

Product	Type	Manufacturer	Composition	Lot Number
Corega Tabs	Effervescent Tablet	Glaxo Smith Kline, Brentford, UK	Sodium carbonate, Sodium perborate, Sodium bicarbonate, Citric acid, Potassium monopersulfate compound, Sodium benzoate, Polyethylene glycol 8000 NF, VP/VA S 630 Copolymer, Sodium lauryl sulfoacetate, Proteolytic enzyme, Peppermint oil.	5T0943
Protefix	Effervescent Tablet	Queisser Pharma, Flensburg, Germany	Sodium perborate and enzyme, Sodium bicarbonate, Potassium caroate, Sodium perborate, Citric acid, Sodium lauryl sulphate, CI 73105, Aroma.	002091
Fitty Dent	Effervescent Tablet	Fittydent International, Pinkafeld, Austria	Sodium perborate, Sodium bicarbonate, Potassium monopersulfate, Trisodium phosphate, PEG-240, Sulphamic acid, PVP, TAED, Silica, Sodium Methyl Oleoyl Taurate, Cellulose-Lactose, Color C.I. 42090, Aroma.	10112014
Curaprox	Citric acid-based solution	Curaprox UK, Huntingdon, UK	Water, Alkylethersulfate, Citric acid, Eucalyptus oil, Methylbromo glutaronitrile phenoxyethanol.	105-0806

90 min at 73°C and then 100°C boiling water for 30 min, under pressure in a thermostatically controlled water bath (Ivomat IP3, Ivoclar Vivadent, Schaan, Lichtenstein). Specimens were bench cooled for 2 h and excess resin was trimmed with a tungsten steel bur (CX 79, Jota, Rüthi, Switzerland) using a handpiece at low speed. The specimens were visually inspected and those with voids or porosity were discarded.

The powder and liquid of the hard permanent reline resins were mixed according to the manufacturer's instructions. Resin mixture poured a fluorocarbon resin matrix and a flat glass plate was placed above the matrix. The specimens were polymerized under pressure for 10 min at room temperature. The glass plate was separated

after the resin was polymerized and specimens were immersed in water for the time recommended by the manufacturers. The surfaces of denture base acrylic and hard permanent reline resin specimens selected for the measurements were finished with progressively finer grades using 150, 360 and 500-grit abrasive papers (Silicon carbide abrasive paper, UGR, China) and polished with a slurry pumice. Fifty specimens for each material were randomly distributed into 1 control and 4 test subgroups and each subgroup consisted of 10 specimens. Initial surface roughness measurements of denture base acrylic and hard permanent reline resin specimens were made after being stored in distilled water at 37±1°C, for 48 h for residual monomer elimination²⁹.

The 3 effervescent denture cleansers were prepared by adding one tablet to 200 mL of warm tap water ($40\pm 2^\circ\text{C}$) according to the manufacturer's instructions¹⁸⁾. For preparation of citric acid-based solution type cleanser a concentrated form of denture cleanser was added to the manufacturer's denture box (Curaprox Denture Box BDC 110, Curaprox UK, Huntingdon, UK) until the bottom of the box was covered. Later on, by adding 200 mL of tap water ($40\pm 2^\circ\text{C}$) to the concentration, an experimental solution was prepared. Specimens were marked with identifying numbers. The 10 specimens of each subgroup were immersed at the same time in the individual denture box for 8 h with the surface to be measured facing upward, ensuring that the solution covered all specimens¹⁸⁾. Specimens immersed in distilled water served as the control group. Between the immersion procedures, specimens were kept in distilled water at room temperature ($23\pm 2^\circ\text{C}$) for 16 h. Each day, fresh denture cleanser solution was prepared and the process continuously repeated for 140 days²²⁾.

A profilometer (Mitutoyo Surf Test SJ 201 P/M; Mitutoyo Corp, Kanagawa, Japan) was used for evaluation of surface roughness (Ra, μm) of the specimens before and after immersion procedures. A diamond stylus (tip radius, 5 μm) was moved across the surface under a constant load of 0.75 mN with a range of 350 μm and speed of 0.5 mm/s to measure the roughness profile value in micrometers. The instrument was calibrated using a standard precision reference specimen. For each specimen, three traces were recorded at three different locations in different positions (parallel, perpendicular and oblique) giving nine tracings per specimen. The average of nine mean surface roughness measurements

was accepted as the score for each specimen. Initial roughness values were subtracted from the roughness values after immersion to obtain the ΔRa values, which were then entered into a spreadsheet for calculating descriptive statistics. For surface characterization, one representative specimen from each group with Ra values close to the mean values were selected. The specimen was coated with gold and examined under a scanning electron microscope (SEM), (LEO 440, Electron Microscopy Ltd, Cambridge, USA).

A power analysis was done to determine the number of specimens required in each experimental subgroup. For the accepted surface roughness parameter, a 0.8 power and 0.05 alpha error probability, and the minimum number of specimens required in each subgroup was determined as $n=10$. During the assessment of the data obtained in the study, Statistical Package for Social Sciences (SPSS 18, IBM Corp., New York, USA) for Windows 15.0 was used for statistical analysis. Conformity of the parameters to the normal distribution was assessed by a Kolmogorov-Smirnov test. A Kruskal Wallis test was used for the intergroup comparisons of parameters without normal distribution and a Mann Whitney U test was used for the determination of the group causing a difference. Wilcoxon Signed Ranks test was used for the in-group comparisons. Significance was evaluated at a level of $p<0.05$.

RESULTS

The mean surface roughness values are presented in Table 3. Immersion of specimens in 4 denture cleansers, significantly increased the surface roughness values of

Table 3 Mean surface roughness values (Ra, μm) and standard deviations (SD) of materials evaluated

Product		Denture cleansers					* <i>p</i>
		Protefix	Fitty dent	Corega	Curaprox	Distilled water	
		Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	
New Truliner	Before	1.91 \pm (1.06)	2.37 \pm (1.23)	2.44 \pm (1.25)	1.17 \pm (0.10)	2.56 \pm (0.85)	0.625
	After	2.11 \pm (1.17)	2.56 \pm (1.22)	2.57 \pm (1.28)	1.25 \pm (0.08)	2.63 \pm (0.85)	0.662
	Difference	0.20 \pm (0.16) ^a	0.19 \pm (0.12) ^a	0.13 \pm (0.03) ^a	0.08 \pm (0.03) ^b	0.06 \pm (0.03) ^{b,c}	0.033*
	** <i>p</i>	0.005**	0.011*	0.005**	0.018*	0.005**	—
Meliodent	Before	0.38 \pm (0.32)	0.30 \pm (0.13)	0.35 \pm (0.28)	0.49 \pm (0.45)	0.21 \pm (0.09)	0.998
	After	0.45 \pm (0.36)	0.36 \pm (0.12)	0.41 \pm (0.28)	0.54 \pm (0.46)	0.25 \pm (0.06)	0.948
	Difference	0.06 \pm (0.05)	0.06 \pm (0.04)	0.06 \pm (0.03)	0.05 \pm (0.04)	0.04 \pm (0.01)	0.765
	** <i>p</i>	0.018*	0.005**	0.007**	0.012*	0.027*	—
UfiGel Hard	Before	0.82 \pm (0.38)	0.74 \pm (0.41)	0.62 \pm (0.36)	0.92 \pm (0.45)	1.25 \pm (0.67)	0.137
	After	0.95 \pm (0.42)	0.84 \pm (0.45)	0.68 \pm (0.21)	0.96 \pm (0.44)	1.28 \pm (0.68)	0.318
	Difference	0.13 \pm (0.08)	0.10 \pm (0.03)	0.06 \pm (0.01)	0.04 \pm (0.02)	0.02 \pm (0.001)	0.478
	** <i>p</i>	0.005**	0.008**	0.043*	0.008**	0.008**	—

+ Kruskal Wallis Test ** Wilcoxon sign test

* $p<0.05$ ** $p<0.01$

The same superscript indicates statistically insignificant difference.

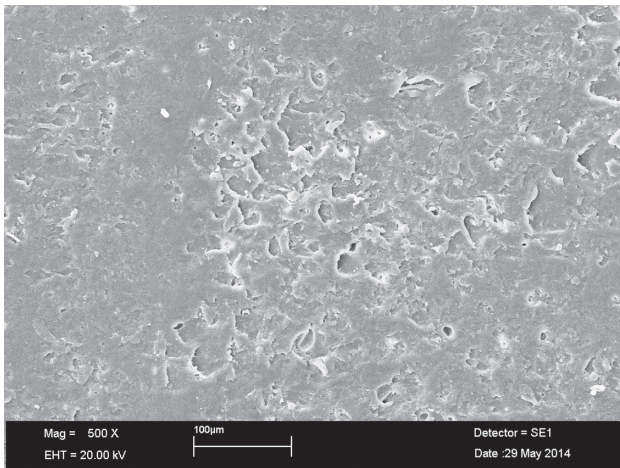


Fig. 1 Representative SEM micrograph of New Truliner specimen immersed in Protefix with the highest mean surface roughness value.

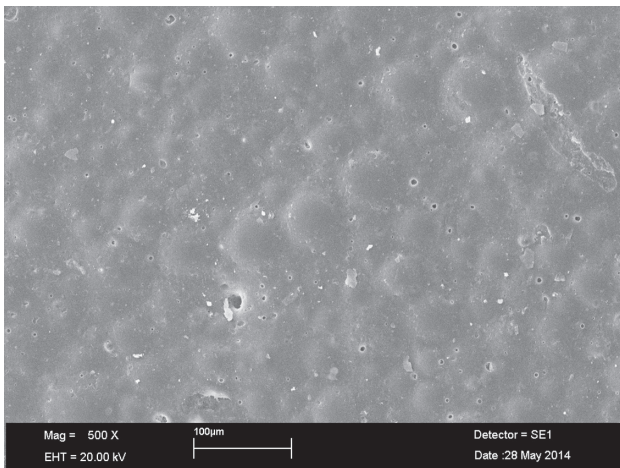


Fig. 2 Representative SEM micrograph of UfiGel Hard specimen immersed in Protefix with the highest mean surface roughness value.

both hard permanent reline resins, and denture base acrylic resin ($p < 0.05$). The amount of increase in surface roughness of New Truliner was significantly higher than Ufi Gel Hard and Meliodent ($p < 0.01$) (Table 3). Regarding the final surface roughness of New Truliner, the effect of 3 effervescent tablets was statistically higher than solution type denture cleanser and distilled water respectively ($p < 0.05$). The difference between the 3 effervescent tablets was insignificant ($p > 0.05$) (Table 3). Regarding final surface roughness of UfiGel Hard and Meliodent, treatment with the effervescent tablets resulted in higher surface roughness values when compared to solution type cleanser and distilled water but their effect was statistically insignificant ($p > 0.05$). Distilled water increased surface roughness of

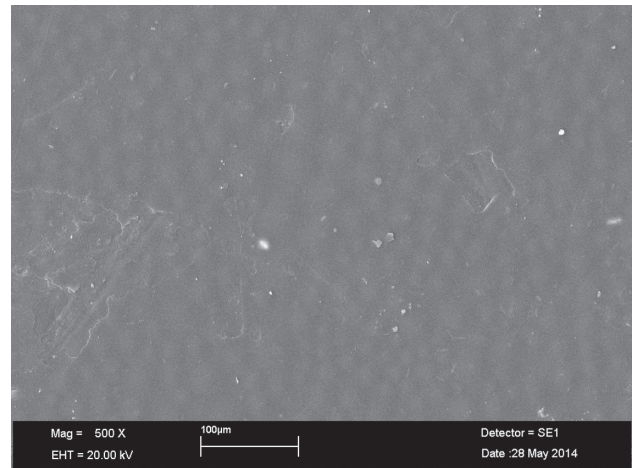


Fig. 3 Representative SEM micrograph of Meliodent specimen immersed in Corega with the highest mean surface roughness value.

all materials investigated but its effect was statistically insignificant ($p > 0.05$) (Table 3). For all resin materials evaluated, the amount of change in surface roughness was below $0.2 \mu\text{m}$. Figures 1–3 display representative SEM micrographs of the specimens with the highest mean surface roughness values, immersed in different denture cleansing solutions.

DISCUSSION

The hypothesis that denture cleansers may increase the surface roughness of a denture base and hard permanent reline resins was accepted. Three sodium perborate denture cleansers in effervescent tablet form and a citric acid-based cleanser in solution form which are commonly used on the local market were included in the study. The results showed a significant change in surface roughness of both hard permanent relining resins and denture base acrylic resin after treatment with denture cleansers.

The effervescent tablets are classified as chemical soak-type products. Sodium-perborate transforms to an alkaline peroxide solution by decomposing to form sodium metaborate, hydrogen peroxide and nascent oxygen when hydrated¹¹. This peroxide solution subsequently releases oxygen thereby enabling a mechanical cleaning by the oxygen bubbles in addition to the chemical cleaning^{10,11}. The increase in surface roughness observed after chemical disinfection may have been a result of active oxygen released by hydrogen peroxide and oxygen liberating solution at a certain soaking temperature in the present study¹⁴. The acid-based cleanser presented lower roughness values than three effervescent type cleansers which may be attributed to different amount of peroxide and lack of mechanical cleaning mechanism that effervescent type cleansers contain. The results of the present study were in accordance with *in vitro* studies. Machado *et al.*¹⁴ evaluated surface roughness

and the hardness of denture base acrylic and reline resins after repeated disinfection procedures. After 7 days of immersion in sodium perborate, the roughness of two hard permanent relining resins and denture base resin increased significantly over specimens immersed in distilled water for the same period. Peracini *et al.*¹⁸⁾ also compared the effect of two sodium perborate tablets on surface roughness of heat polymerized acrylic resin and reported significantly increased surface roughness when compared to distilled water.

In the present study, distilled water increased the surface roughness of all materials investigated. Commercially available tissue conditioners generally contain approximately 5 to 20 wt% ethanol (EtOH)¹²⁾. However, it has been reported that EtOH is lost within 24 h after the material is immersed in water, whereas the loss of ester plasticizer ranges from 0.03 to 8.70 mg/g within 14 days¹²⁾. Thus the loss of initial softness and surface integrity over time may be caused by leaching out of the components contained in the liquids, especially EtOH, differences in osmotic pressure and water absorption²²⁾. Water absorption may further cause dimensional instability and fatigue which can lead to crack formation in acrylic resins.

The amount of change in surface roughness values of the studied resins were as follows: New Truliner>Ufigel Hard>Meliodent (Table 3). In autopolymerizing resins, due to low degree of methacrylate conversion achieved by the chemical activator, not all of the monomer is converted to polymer and residual monomer has been shown to adversely affect the surface properties of acrylic resins. In denture base resin, polymerization by heating enables molecule movements necessary to form long chains in the polymer resulting a more rigid polymerized network²¹⁾. Higher surface roughness values of New Truliner may be related to differences in levels of residual monomer in surface layer of autopolymerized resin and the composition of the resin^{12,14)}. The particle size of polymer powders, viscosity just after mixing the powder and liquid and the powder-liquid ratio of the reline resins might also have affected surface roughness²²⁾.

Another contributing factor could be the differences in the chemical composition of the cleansers (Table 2). When effervescent type cleansers dissolved in water, the released oxygen, high concentrations of sodium and potassium ions, as well as the presence of citric acid might be collectively affecting the surface roughness of the hard permanent reline resins. However, the percentage of these components is not known to the end user.

Surface irregularities associated with the microporous structure of denture liners provide a larger environment for biofilm formation^{14,24)}. The threshold surface roughness value for bacterial accumulation was reported as 0.2 μm by Bollen *et al.*¹⁶⁾. Under experimental conditions used in this study, the amount of change in surface roughness values of all resin materials was lower than the proposed 0.2 μm threshold limit. In their *in vitro* study, Machado *et al.*¹⁴⁾

suggest that rougher specimen surface after disinfection may not always render the surface more prone to the adhesion of microorganisms. Therefore, the amount of increase in surface roughness may be assumed clinically insignificant. This assumption must be validated by further *in-vivo* and *in-vitro* microbiological studies focused on biofilm recolonization.

The limitations of this study were considered as follows: there were only two hard permanent relining resins, two chemical type denture cleansers and one type of disinfection method evaluated. Furthermore, factors such as saliva, masticatory force and thermal cycling, which are considered to have an effect on surface conditions for reline resins, should also be evaluated. The effect of variations in solution temperature and period of immersion might be considered for future studies which may provide a more thorough evaluation of how the surface roughness of hard permanent relining resins are affected by these variables.

CONCLUSIONS

Within the limitations of this *in vitro* study, the following conclusions were drawn:

1. The surface roughness of hard permanent reline resins and the denture base resin tested were affected by immersion in denture cleansers.
2. Immersion in effervescent type cleansers significantly increased the surface roughness of hard permanent reline resin where their effect may differ according to the selected resin material.

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