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RESEARCH ARTICLE

The effect of various denture cleansers on porosity and discoloration level of acetal resin denture base

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ABSTRACT

Denture cleansing is one clinical parameter of successful denture wearing. This study aims to examine the effect of the type of denture cleanser on porosity and discoloration of acetal resin as a denture base. Twenty-four samples of acetal resin with 10 mm in diameter and 2 mm in thickness were divided into four groups. Porosity was measured using the wet and dry sample measurement method, and color value levels were measured using chroma meter for all samples. All of the samples were soaked into four types of denture cleanser: distilled water, alkaline peroxide tablets, 0.2% chlorhexidine gluconate, and 0.5% sodium hypochlorite for seven days, then the final porosity and color value level were assessed. The results showed that there were significant differences between groups in porosity and in color change of acetal resin ($p < 0.05$). Pearson's correlation test showed that there was a positive correlation between the porosity level and discoloration level of acetal resin ($p < 0.05$). The research discovered that the type of denture cleaner has a significant influence on the porosity and color change of acetal resin. Sodium hypochlorite has the highest porosity and color change when compared to other cleansing agents.

Keywords: acetal resin; denture base; denture cleanser; discoloration; porosity

INTRODUCTION

A denture base is a part of the denture that carries artificial teeth and rests on the soft tissues in the oral cavity. Denture base materials are particular biomaterials used for fabricating the denture base.[1] The most common denture base material is an acrylic resin that has been polymerized under heat. Polyamide (nylon), acetal resin, PEEK, epoxy, polycarbonate, and vinyl denture bases can be used as options for patients allergic to acrylic resin.[2] PEEK was first introduced in the early 1980s for engineering and industrial applications. Since 1998, PEEK has been used in biomedical applications and has become an alternative for implant, orthopedic components, and material for making maxillary obturators for patients with large oronasal defects. Acetal resins used in dentistry exhibit high flexibility, physical strength, heat and chemical resistance, exceedingly rare allergy response and show limited water sorption, and superior abrasion resistance.[3] Acetal resin is being used for esthetic purpose for denture base and clasps material, especially in individuals who are allergic to Co-Cr alloys as it has a property of biocompatibility. Many studies have been carried out to study resin properties, but to date there is little data about wear resistance, porosity, and discoloration of acetal resin materials.

Porosity on the denture base is undesirable because it can cause discoloration. Having a porous denture surface can decrease its flexural strength. Porous is caused by several factors such as manufacturing procedures in the laboratory, the ratio of powder and liquid mixtures, the pressing process, the material polymerization method, the cuvette cooling, and the polishing process.[4-5]

The denture base for aesthetic purposes must retain its color well to match the color

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of the gingiva.[6] Several causes might induce discoloration, including contamination of the material during the manufacturing process, the propensity of the material to absorb fluids, the presence of porosity on the surface of the material, and the habit of consuming and drinking food and beverages containing dyes.[7]

All denture wearers are urged to maintain oral and denture hygiene by frequently cleaning their dentures, regardless of the denture base material. Cleaning and disinfecting dentures are essential for maintaining dental health and are a criterion for the successful use of dentures.[8] Among the elderly and those with dementia or other impairments, chemical cleaning is a viable option.[9] On the base of how they function, denture cleansers can be categorized as alkaline peroxides, reducing solutions, chlorhexidine, mild dilute acids, effervescent agents, chelating agents, detergents, enzymes, and vinegar.[10-11] Ideally, denture cleaning agents should not cause changes in the mechanical properties of the denture base material.[12] Denture base qualities, such as color stability and flexural strength, can be altered by cleaning with chemicals or disinfectants.[13] This study aims to examine the effect of the type of denture cleanser on porosity and discoloration of acetal resin as a denture base.

MATERIALS AND METHODS

This is a laboratory experimental study. We used acetate resin materials (Bio Dentaplast, Breden UK), 0.2% chlorhexidine gluconate (Minosep, Ind), 0.5% sodium hypochlorite (Onemed, Ind), distilled water (Onelab, Ind), alkaline peroxide (Polident, GlaxoSmithKline), cartridge furnace and injector unit (Thermopress 400, Germany, acetal resin processing tools), and a chroma meter (Konica Minolta CR-400). Twenty-four samples of acetal resin with a diameter of 10 mm and a thickness of 2 mm were made by injection. All samples were divided into 4 groups. Group A was soaked in distilled water, group B in alkaline peroxide, group C in 0.2% chlorhexidine gluconate, and group D in 0.5% sodium hypochlorite. Soaking was carried out in a 200 mL solution for 7 days with the solution replaced every day.

The porosity of each sample was measured using the wet and dry sample measurement method. First, the test sample was weighed dry. Second, the samples were weighed after being soaked according to the soaking solution group for a day (24 hours) for 7 days. After obtaining the sample mass, the porosity percentage was calculated using the formula:[14]

The percentage of porosity of acrylic resin plates was determined in 2 (two) conditions:

1) The plate was weighed without submerging it in water (Wa)

2) The plate was weighed while submerged in water (Ww)

The values obtained will be included in the following equation:

$$Wa = g(dr–da)(Vsp–Vip) \quad [1]$$

$$Ww = g(dr-dw)(Vsp-Vip)+(da-dw)Vip \quad [2]$$

$$\% Porosity = Vip/Vsp\times100 \quad [3]$$

where:
Wa is sample weight in air
Ww is sample weight in water
g is gravitational constant (9.8066m/sec2)
dr is density of acrylic resin (1.198±0.01g/ml)
da is air density (1.23kg/m3)
dw is water density (1000kg/m3)
Vsp is sample volume
Vip is internal porosity volume

Color changes on each sample were measured using a chroma meter. The initial color of each sample was measured and recorded as the initial L*a*b value. After the sample was immersed in denture cleanser, the color was recorded as the final L*a*b value. Color change (ΔE) was calculated using the CIELAB method.

The category of color change was determined by converting color change data to NBS units. The surface topography of the sample was observed using a scanning electron microscope (SEM) after immersion in denture cleanser.

The data obtained from the calculation of porosity and color changes were each tested for normality using the Shapiro-Wilk test and

homogeneity test using the Levene's test. It was then continued with one-way ANOVA. To find out whether there was a significant difference between groups, post hoc LSD with a confidence level of 95% was used to analyze. Correlation analysis was used to see the relationship between porosity and color changes using Pearson's correlation analysis.

RESULTS

The effect of several denture cleaners on the porosity of acetal resin as a denture base was examined using a scanning electron microscope (SEM) with 5,000x magnification (Figure 1).

Observations using SEM showed that the surface topography of the samples in each treatment group varied. Acetal resin soaked in sodium hypochlorite had the highest porosity, followed by acetal resin soaked in chlorhexidine gluconate, and acetal resin treated with alkaline peroxide. Acetal resin soaked in distilled water showed the lowest porosity.

The sodium hypochlorite treatment group also had the highest average increase in porosity of acetal resin as a denture base, followed by the chlorhexidine gluconate treatment group, then the alkaline peroxide treatment group, and finally the distilled water control group, which had the lowest average increase in porosity (Table 1). The Shapiro-Wilk normality and Levene's test of homogeneity of variance yielded normal and homogeneous data distribution ($p > 0.05$). The

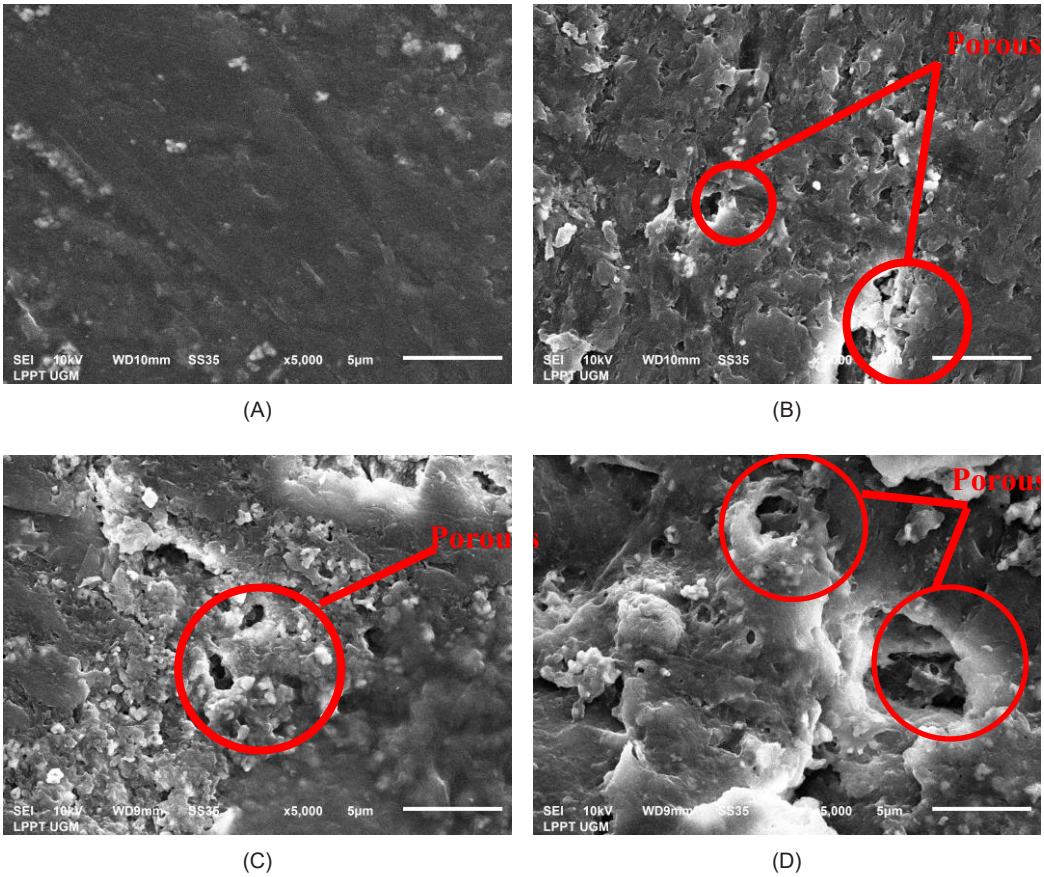

Figure 1. The SEM observation of the surface of a denture base

(Note: the circled area represents a porous on the surface of the acetal resin)
(A) distilled water;
(B) alkaline peroxide;
(C) chlorhexidine gluconate;
(D) sodium hypochlorite.

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Table 1. Mean and standard deviation of acetal resin porosity (%)

Treatment	Sample number (n)	mean± SD
Distilled water	6	3.006 ± 0.106
Alkaline Peroxide	6	3.064 ± 0.377
Chlorhexidine Gluconate	6	3.385 ± 0.300
Sodium Hypochlorite	6	3.646 ± 0.242

Note:
mean : Mean porosity
SD : Standard deviation

Table 2. One-Way ANOVA on acetal resin porosity

	Sum of squares	df	Mean square	F	Sig.
Between groups	1.601	3	0.534	7.045	0.002
Within groups	1.515	20	0.076		
Total	3.115	23			

Note:
df : degree of freedom
Sig. : probability

Table 3. Post Hoc LSD on acetal resin porosity

Treatment	Distilled water	Alkaline peroxide	Chlorhexidine gluconate	Sodium hypochlorite
Distilled water		-0.058	-0.379*	-0.640*
Alkaline Peroxide			-0.321*	-0.582*
Chlorhexidine Gluconate				-0.261*
Sodium Hypochlorite				

Note: * : significant differences ($p < 0.05$)

probability was 0.002 ($p < 0.05$) based on the results of the one-way analysis of variance (Table 2). Distilled water, alkaline peroxide, chlorhexidine gluconate, and sodium hypochlorite were found to have distinct effects on the porosity of acetal resin as a denture base.

The significance level between treatment groups was subsequently determined using the LSD post hoc test (Table 3). The results showed that there was a statistically significant difference in the porosity of the acetal resin between the distilled water and chlorhexidine gluconate treatment groups, the distilled water and sodium hypochlorite treatment groups, and the alkaline peroxide and sodium hypochlorite treatment groups. In contrast, there were no differences in the porosity of the acetal resin between the distilled water, alkaline peroxide, chlorhexidine gluconate, and sodium hypochlorite treatment groups.

The sodium hypochlorite treatment group had the highest average discoloration of acetal resin as a denture base, followed by the chlorhexidine gluconate treatment group, then the alkaline peroxide treatment group. Meanwhile, the distilled water control group had the lowest average discoloration (Table 4).

The probability was 0.002 ($p < 0.05$) based on the results of the one-way analysis of variance (Table 5). This indicated that distilled water, alkaline peroxide, chlorhexidine gluconate, and sodium hypochlorite discolored acetal resin as a denture base significantly.

Table 4. Mean and standard deviation of acetal resin discoloration (L*a*b)

Treatment	Sample number (n)	Mean ± SD
Distilled water	6	3.206 ± 0.241
Alkaline Peroxide	6	3.385 ± 0.602
Chlorhexidine Gluconate	6	3.966 ± 0.449
Sodium Hypochlorite	6	4.095 ± 0.172

Note :
Mean : Mean porosity
SD : Standard deviation

Table 5. One-Way ANOVA on acetal resin discoloration

	Sum of squares	df	Mean square	F	Sig.
Between groups	3.388	3	1.129	6.924	0.002
Within groups	3.262	20	0.163		
Total	6.650	23			

Note:
df : degree of freedom
Sig. : probability

Table 6. Post hoc LSD on acetal resin discoloration

Treatment	Distilled water	Alkaline peroxide	Chlorhexidine gluconate	Sodium hypochlorite
Distilled water		-0.178	-0.759*	-0.889*
Alkaline peroxide			-0.581*	-0.711*
Chlorhexidine gluconate				-0.130*
Sodium hypochlorite				

Note: * : significant differences ($p < 0$.

The significance level between treatment groups was then determined using the LSD post hoc test. Table 6 shows a statistically significant difference between the distilled water treatment group and the chlorhexidine gluconate treatment group, the distilled water treatment group and the sodium hypochlorite treatment group, and the alkaline peroxide treatment group and the chlorhexidine gluconate treatment group. This indicated that the color change of acetal resin differed significantly between the distilled water treatment group and the chlorhexidine gluconate treatment group, the distilled water treatment group and the sodium hypochlorite treatment group, and the alkaline peroxide treatment group and the chlorhexidine gluconate treatment group. There was no difference in discoloration between the distilled water treatment group, the alkaline peroxide treatment group, the chlorhexidine gluconate treatment group, and the sodium hypochlorite treatment group, according to these findings. Table 7 presents the correlation coefficient value used to classify the strength of the relationship between porosity and color change of acetal resin as a denture base. A positive relationship was observed between porosity and color change of acetal resin as a denture base ($p < 0.05$). The estimated correlation coefficient value of 0.443 may indicate a moderate relationship between porosity and changes in the color of acetal resin as a denture base.

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Table 7. Pearson correlation test results

	Porosity			Discoloration		
	Pearson correlation	Sig.	n	*Pearson correlation*	Sig.	n
Porosity	1		24	0.443*	0.03*	24
DIscoloration	0.443*	0.03*	24	1		24

Note : * : correlation ($p < 0.05$)

DISCUSSION

The results of this research showed that the type of denture cleanser affected the porosity of acetal resin as a denture base. The sodium hypochlorite treatment group had the highest average porosity, followed by the chlorhexidine gluconate treatment group, then the alkaline peroxide treatment group. The distilled water control group had the lowest average porosity. Statistical calculations showed significant differences in porosity between groups soaking in sodium hypochlorite, chlorhexidine gluconate, alkaline peroxide, and distilled water. Soaking in a denture cleaning agent has an impact on the porosity of the denture base because the active ingredients of the cleaning agent can weaken the surface of the acetal resin, resulting in the formation of porosity in the acetal resin. This is in accordance with the findings of previous research that active compounds in denture cleaning materials that come into contact with the denture base can weaken and dissolve the surface of the denture base, causing porosity on the surface of the denture base acrylic resin.[16]

Our findings showed that the porosity of the acetal resin differed significantly between the distilled water treatment group and the chlorhexidine gluconate treatment group, the distilled water treatment group and the sodium hypochlorite treatment group, and the alkaline peroxide treatment group and the sodium hypochlorite treatment group. The emergence of porosity in acetal resin might be due to alterations in bonding. This result is consistent with the findings of Arbeláez et al,[17] which showed a change in the surface topography of the denture base after immersion in denture cleanser chlorhexidine gluconate and sodium hypochlorite, which may have been caused by the release of the denture base's bond.

This research revealed that the type of denture cleanser affected the discoloration of acetal resin denture bases. The sodium hypochlorite treatment group had the greatest discoloration, followed by the chlorhexidine gluconate treatment group, the alkaline peroxide treatment group, and the distilled water control group. Statistical calculations showed that there were significant differences in changes in the coloration of acetal resin after immersion in sodium hypochlorite, chlorhexidine gluconate, peroxide base, and distilled water groups. The color change is likely due to chemical reactions and penetration of the dye contained in the cleaning agent, so soaking the denture in the cleaning solution can cause discoloration. This is in accordance with research conducted by Polyzois et al., immersing acetal resin in a denture cleaner which is a base peroxide and sodium hypochlorite can cause color changes in the acetal resin.[18]

We found a significant difference in discoloration of acetal resin between the distilled water treatment group and the chlorhexidine gluconate treatment group, the distilled water treatment group the sodium hypochlorite treatment group, the alkaline peroxide treatment group the chlorhexidine gluconate treatment group, and the alkaline peroxide treatment group alkaline peroxide to the sodium hypochlorite treatment group. Discoloration can be caused by a reaction between the acetal resin and denture cleanser which can oxidize the acetal resin. This is in accordance with research conducted by Polyzois et al which found that there was a significant discoloration of the denture base after immersion

in the denture cleanser chlorhexidine gluconate and sodium hypochlorite. This could be due to the strong oxidizing properties of this solution, where the oxygen released causes oxidation, resulting in a discoloration of the denture base.[19] The interaction of cations and anions of chlorine compounds in chlorhexidine gluconate solution causes discoloration of the denture base.[20]

We found a positive correlation between porosity and discoloration of acetal resin used as a denture base. The estimated correlation coefficient value of 0.443 suggested a moderate relationship between porosity and discoloration of acetal resin as a denture base. The porosity of acetal resin can facilitate dye penetration, resulting in discoloration. Absorption of denture cleaning solution via porosity results in the deposition of color pigments that are absorbed more than the material's reflected color.[21] This research was only carried out on the properties of porosity and color changes. Further research with more focus on other mechanical and physical properties is therefore necessary.

CONCLUSION

The type of denture cleaner has a significant influence on the porosity and color change of acetal resin. Sodium hypochlorite has the highest porosity and color change compared to other cleaning agents.

CONFLICT OF INTEREST

The authors declare no conflict of interest with the data contained in the manuscript.

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