Effects of brushing with abrasive dentifrices containing various materials on the surface roughness of acrylic resins

I P A Ramadhan¹, M Damiyanti¹ and S Triaminingsih¹*

¹Department of Dental Materials, Faculty of Dentistry, Universitas Indonesia, Jakarta, 10430, Indonesia

Email: ami_permana@yahoo.com

Abstract. The aim of this study was to analyze the effects of brushing base dentures with various toothpastes. Heat-cured acrylic resin specimens were divided into three groups and were brushed with dentifrices containing silica, silica + calcium carbonate, and silica + calcium carbonate + perlite for 22 min to represent one year of brushing. The surface roughnesses of the base dentures were then determined and compared using paired t-tests and Kruskall–Wallis tests. These analyses showed that more complex abrasive materials result in the greater surface roughness of acrylic dentures.

1. Introduction
Dentures that are placed in direct contact with various types of food, saliva, and flora in oral cavities require regular cleaning to avoid plaque retention and bacteria colonization. Plaque on denture bases can cause various complications in oral cavities, including papilla inflammation, candidiasis, and denture stomatitis infections [1].

Brushing with toothpastes can eliminate plaque, although abrasive additives can increase the roughnesses of denture base surfaces, thus leading to greater risks of bacterial colonization and plaque accumulation [1]. The degrees of roughness on denture base surfaces have been associated with bacteria colonization, microorganism attachment, biofilm development, and parasitic colonization [2]. In a previous study, various brands of toothpaste containing abrasive silica and combinations of silica and calcium carbonate with different levels of roughness were compared in abrasivity tests [3]. The authors concluded that not all types of toothpaste are safe to use on dentures because they are too abrasive.

Common abrasive materials that are added to toothpastes include silica, calcium carbonate, and perlite. Toothpastes that contain silica only are generally gel-type toothpastes, such as Close-Up, whereas toothpastes that contain calcium carbonate generally also contain silica and are marketed as white paste types, such as Pepsodent Regular. Perlite is added to toothpastes that are designed to remove stains, such as Pepsodent Whitening. These three toothpastes have differing abrasive material complexities. More complex abrasive materials in toothpastes lead to greater mechanical forces and the increased roughnesses...
of brushed surfaces, thus leading to elevated risks of plaque retention and oral cavity complications, such as denture stomatitis [1,3].

On the basis of the differences in complexity of abrasive materials in three toothpastes, we compared the resulting surface roughnesses of acrylic resin plates to inform consumer choices regarding toothpastes.

2. Methods
Laboratory experiments were performed using 24 specimens of heat-polymerized acrylic resins divided into a control group and 3 treatment groups with 6 specimens each. The treatment groups were brushed with toothpastes containing the following abrasive agents: silica, silica + calcium carbonate, and silica + calcium carbonate + perlite. Resin specimens with diameters of 12.5 mm and thicknesses of greater than 2 mm were soaked in aquadest for 48 h after the resin specimens processed using cuvettes and polished with suspensions containing 1 μm alumina particles for 90 s [4,5]. Initial roughness values were estimated using a surface roughness device, and specimens were then brushed using a Pierrot electric toothbrush with various toothpastes for 22 min to represent one year of brushing under conditions of normal human use [6]. Surface roughness values were then estimated again.

Prior to making statistical comparisons, data were assessed using Saphiro–Wilk normality tests and Levene homogeneity tests. Changes in roughness values from before and after brushing were identified using the paired t-tests, and differences between means of treatment groups were identified using Kruskal–Wallis comparative test. Differences were considered significant when p < 0.05 (α = 0.05).

3. Results
The analyses of surface roughness values (Figure 1) using Kruskal–Wallis tests showed significant differences between all treatment groups (p < 0.05), and paired t-tests showed that all treatments increased the surface roughness significantly (p < 0.05).

![Figure 1](image_url)

**Figure 1.** Comparison of surface roughness values of acrylic resin specimens before and after brushing with aquadest (control) or dentifrices containing silica, silica + sodium carbonate, and silica + sodium carbonate + perlite.
4. Discussion
Increasing the roughnesses of acrylic resin surfaces reflects abrasive wear from particles that are harder than the surface material [7]. Therefore, the present acrylic resin specimens became rougher after brushing with toothpastes containing harder abrasive agents, likely reflecting the relative frictional forces of abrasive additives. The abrasive properties of toothpaste additives were previously described in terms of material hardness, microstructures, particle size and shape [6].

In our acrylic resins samples, brushing with aquadest only (control group) changed the surface roughness value by 0.101 μm, thus indicating that the present acrylic resin surfaces are abraded by toothbrush bristles in the absence of dentifrices, as shown previously [8]. Changes in surface roughness values were significantly greater after brushing with dentifrices containing abrasive materials compared with the control group. In agreement, Kusumaningtyas (1999) previously showed increases in the surface roughness values of dentures due to brushing alone [9].

The present data also show that changes in roughness values increase with the numbers of abrasive agents in toothpastes, and silica containing toothpaste led to increases in surface roughness values of 0.203 μm, double that in the control group. Silica particles have a hardness of 7 on the Mohs hardness scale and the relatively large particle sizes of about 8–10 μm produce sufficient mechanical effects to scratch acrylic resin surfaces. Because minimum retention of plaque on dentures has been associated with roughness values of >0.2 μm, the presence of silica in toothpastes may lead to roughness that exceeds this value [6]. Therefore, abrasive materials in toothpastes may be negatively indicated for dentures and may increase bacteria and plaque retention [6].

Brushing of acrylic resin dentures with dentifrices containing silica and calcium carbonate and silica, calcium carbonate, and perlite led to changes in surface roughness values of 0.313 and 0.663 μm, respectively, and these values differed significantly from those in the silica only treatment group. Similarly, Sorgini et al., (2012) showed greater roughness values following brushing with silica and calcium carbonate than those after brushing with silica only [3].

These data indicate that the calcium carbonate enhances the abrasive quality of toothpastes, although the silica and silica + calcium carbonate toothpastes used in the present study were gel-, and paste-types, respectively. Because gel-type toothpastes are more viscous than paste types, abrasive particles may move more freely and cause greater abrasion than those in gel-type toothpastes. In addition, differences in surface roughness values may reflect particle size distributions, which differ between abrasive materials. Moreover, toothpastes containing silica only are more homogeneous than toothpastes containing silica and calcium carbonate.

Although silica remains the dominant toothpaste additive and is harder than calcium carbonate, the latter also provides calcium and lowers plaque pH [10]. The concentration of silica was the same in the first two toothpastes of this study, silica and calcium carbonate form similar particles, with irregular shapes and the predominance of cylindrical shapes with the sharp angles. Thus, particle shapes and sizes are unlikely contributors to the differences in roughness values following brushing with these two toothpastes.

Brushing of acrylic denture surfaces with toothpaste containing silica, calcium carbonate, and perlite led to marked changes in roughness values. Perlite comprises comparatively large particles of about 20–25 μm with sharp edges that produce greater mechanical effects than those of silica and calcium carbonate particles. Although silica concentrations were the same between the first two toothpastes, silica and calcium carbonate concentrations were different in the perlite (0.7%) containing toothpaste, potentially contributing to the abrasive qualities and ensuing roughness values. However, Lutz, et al. (1993) showed that perlite-associated changes in roughness were greater than those of other types of abrasive materials,
further suggesting that perlite is the dominant influence on roughnesses following brushing with this toothpaste [11].

Taken together, the present data indicate that dentures need to be cleaned with toothpastes that contain fewer abrasive ingredients to minimize the formation of abrasions that encourage bacteria and plaque retention, and to protect against the emergence of denture stomatitis. Hence, alternative denture cleaning approaches, such as the soaking method with cleaning tablets or brushing using liquid soap that does not contain abrasive agents, are recommended.

5. Conclusion
Abrasive materials in toothpastes increase the surface roughnesses of acrylic resins. Moreover, more complex abrasive materials produce larger surface roughness. Hence, dentures may be better cleaned using dentifrices that lack abrasive additives.

References
[1] Pattanaik S, Vikas B V J, Pattanaik B, Sahu S and Lodam S 2010 Denture Stomatitis: A Literature Review. JIAOMR. 22 136-140.
[2] Al-Rifaiy M Q 2010 The effect of mechanical and chemical polishing techniques on the surface roughness of denture base acrylic resins. Saudi Dent. J. 22 13-17.
[3] Sorgini D B, Silva-Lovato C H, Souza R F, Davi L R and Paranhos H D 2012 Abrasiveness of arguments cogently and Specific Denture-Cleansing Dentifrices. Braz. Dent. J. 23 154-159.
[4] The International Organization for Standardization ISO 2211. Dentistry - Denture Base Polymers Second Edition 1988-11-01. Switzerland.
[5] Bassam A H, Alaa E A and Wael A R 2008 Effect of different dental materials on the surface roughness of acrylic resin (A comparative in vitro study). MDJ. 5.
[6] Harrison Z, Johnson A and Douglas C W 2004 An in Vitro Study Into the effect of a Limited Range of Denture Cleaner on Surface Roughness and removal of Candida Albicans from arguments cogently Heat-Cured Acrylic Resin Denture Base Material. J. Oral Rehabil. 31 460-467.
[7] O’Brien W J 2002 Dental Materials and Their Selection 3rd. Quintessence Publishing Co, Inc. p.76-89,156-158.
[8] Aminian R et al. 2008 In Vitro Evaluation of Toothbrushing Abrasion by 4 Standard Toothbrushes. Research Journal of Medical Sciences 2 128-132.
[9] Kusumaningtyas E 1999 The influence of the cleaning agents and Long Penyikatan against the softness of the surface of the plates of Acrylic resin. (Jakarta: The Faculty of Dentistry University of Indonesia)
[10] Roberson T M, Herald H and Swift Jr. E 2002 Studervant's Art and Science of Operative Dentistry Fourth Edition. Mosby.
[11] Lutz F, Sener B, Imfeld T, Barbakow F and Schüpbach P 1993 Comparison of the efficacy of prophylaxis pastes with arguments cogently abrasives or a new self-adjusting abrasive. Quintessence Int. 24.