Evaluation of the Abrasiveness of Dentifrices for Complete Dentures

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Abstract

Purpose: This study analyzed the surface roughness and weight loss in Plex Glass specimens caused by dentifrices, one conventional (Sorriso) and three specific for dentures.

Materials and Methods: Specimens (n = 6) of Plex Glass were divided into 5 groups including: negative control (water); positive control 1 (Sorriso) and 2 (Corega Brite); Experimental 1 (containing Chloramine T, antimicrobial agent); and Experimental 2 (containing Zonyl, detergent). Brushing was performed in a toothbrushing machine (Pepsodent) with a soft brush and a suspension of toothpaste and distilled water for 300 minutes, representing 6 years of brushing. Weight was measured initially and after the trial period; roughness was measured after the trial period only. The results of roughness and weight loss were analyzed using ANOVA and Tukey tests at 5%.

Results: The negative control (2.82 $\pm$ 4.41 mg) showed the lowest weight loss. Experimental 1 (13.62 $\pm$ 4.29 mg) and Experimental 2 (15.4 $\pm$ 5.80 mg) were equal statistically, and Sorriso (23.22 $\pm$ 7.23 mg) and Corega (28.83 $\pm$ 6.34 mg) produced the greatest weight loss. Concerning roughness, the negative control group (0.03 $\pm$ 0.01 μm) showed the lowest value. No significant differences were found between Corega (13.43 $\pm$ 1.65 μm), Experimental 1 (12.28 $\pm$ 0.85 μm), and Experimental 2 (10.68 $\pm$ 2.56 μm). The Sorriso toothpaste produced the greatest amount of surface roughness (19.15 $\pm$ 2.36 μm).

Conclusion: Of the tested dentifrices, the experimental preparations proved to be the least abrasive and resulted in the lowest weight loss after brushing of the acrylic. Based on these findings, the use of these experimental dentifrices is advocated. Further evaluation based on the ability of these preparations to remove biofilms is required.

Good denture hygiene is essential for denture users, particularly because it promotes biofilm removal and assists in control of oral diseases, increases the longevity of the prosthesis, and helps maintain the health of the patient. The mechanical removal of debris via the use of toothbrush, dentifrice, and water is a popular technique for denture cleansing.[1] This technique has the advantage of being simple, inexpensive, and effective in the removal of stains and organic deposits.[2] Disadvantages include difficulty of use, especially for patients with motor discoordination,[3,4] and the possibility of damage and wear to acrylic resin and denture liner after incorrect use.[5]

Dentifrices for dentures are basically composed of humectants, detergents, flavoring, thickeners, pigments, and an abrasive agent.[6] Surfactants and appropriate antimicrobials can also be used in the formulation. Fluorocarbon-based surfactants or fluorosurfactants are potential components for these formulations as they reduce surface tension similarly to conventional surfactants, but provide improved wetting, foaming, emulsifying, and detergency.[7]

These complex components can produce a variety of potential effects on the denture surface. Abrasion, for example, can increase biofilm retention.[8] The magnitude of surface abrasion caused by toothbrushing depends on the abrasiveness of the dentifrice used, bristle stiffness, toothbrushing technique, frequency of brushing, and hardness of the denture base material.[8] The degree of abrasion is important and is influenced by many properties of the abrasive such as chemical composition, crystalline structure, friability, solubility, concentration, hardness, size and shape of the particles, and compatibility with other ingredients in the dentifrice.[9,10] Taking into account that replacement of the dentures may need to be made within 5 to 7 years,[11] research on the development of new formulations for dentifrices appropriate for use with dentures is important and necessary.

The aims of this study were to evaluate the abrasiveness of two experimental dentifrice formulations compared with one dentifrice specific for complete dentures and one conventional dentifrice. The evaluation of abrasion involved quantitative weight-loss measurements from Plex Glass plates and measures of the roughness of the Plex Glass plates after brushing. The hypothesis tested was that acrylic weight loss and surface roughness would change after brushing and the extent of these changes would be dependent on the type of dentifrice used.

Material and methods

The materials used in this study are presented in Table 1. The chemical variables (density, pH, consistency, rheological measurements) of the experimental dentifrices were evaluated in an earlier report.[12]

Specimen preparation

The specimens were rectangular, measuring $90 \times 30 \times 4$ mm^3, and fabricated from acrylic plate (Plex Glass, polymethylmethacrylate, Day Brasil S.A., Ribeirão Preto, Brazil). The material used for the specimens is considered internationally acceptable for the analysis of dentifrice abrasiveness.[13,14] The 30 specimens, each identified with a number marking, were divided into five groups: control one (n = 6) with distilled water; and the four experimental groups with suspensions of Corega (n = 6), Sorriso (n = 6), Experimental Dentifrice 1 (n = 6) and Experimental Dentifrice 2 (n = 6). Before the brushing test, the specimens were immersed in distilled water at a temperature of 37°C to establish baseline values. The measurements of mass were carried out using an Ohaus electronic balance with a 0.1 mg and capacity of 210 g (Ohaus, Explorer, Pine Brook, NJ) daily, until obtaining stable mass. Prior to weighing, the specimens were removed from the water and dried using paper towels.

Brushing test

The brushing test was carried out using a toothbrushing machine in accordance with ISO/DTS 145692 specifications for wear testing (Mavtec Comércio Ltda., Ribeirão Preto, Brazil).[15] The machine allowed six specimens to be brushed simultaneously with a speed of 356 rpm. The course covered by the brush corresponds to 3.8 cm, and the load of the toothbrushing was standardized at 200 g.

The toothbrushes were cut at the neck and fixed by screws placed on the sides and the top of the support for the brush. The correct adjustment of these screws allowed the leveling of the appropriate brush. The type of toothbrush used in this study (Table 1) had a rounded end, uniform length, flexibility, and smooth bristles.

Suspensions for brushing were prepared with room temperature distilled water added to the pastes at a ratio of 1:1 (60 g of paste and 60 ml water, mixing until the suspension was homogeneous). The control group received distilled water at 23 ± 3°C and brushing.

Baseline values were recorded after immersion of specimens in distilled water and obtaining of constant mass. The specimens in each group were submitted to the brushing test for 300 minutes (106.8 cycles),[16] calculated to correspond to 6 years of normal brushing by a healthy patient. Brushes and suspension were replaced at 50-minute intervals, since leakage of the suspension was observed during the brushing test. After 300 minutes of brushing, the specimens in each group were removed from the suspension, washed, dried with a paper tissue, and weighed.

The values for roughness of the Plex Glass after brushing were obtained using a rugosimeter (Rug 0.3, Prazis, Buenos Aires, Argentina). Resolution was 0.01 μm, cut-off length was 0.8 mm, transverse length was 4.8 mm, and the stylus speed was 0.5 mm/sec. Three measurements were performed in the central area of each specimen, perpendicular to the brushing grooves at intervals of 5.0 mm, and the average reading was designated as the roughness (Ra) value for that specimen after the 300-minute toothbrushing period. Baseline roughness measurements were not determined since all specimens were derived from Plex Glass plate with a resin manufactured to an industrial standard. The surface of the Plex Glass was therefore of a constant high quality and uniformity in terms of

Table 1 Materials used

Materials	Components	Manufacturer
Experimental dentifrice 1	Hydroxyethylcellulose, glycerine, benzoic acid, methylparaben, sodium EDTA, chloramine-t, silica (sident 8), silica (sident 22 S), titanium dioxide, menthol and eucalyptol, distilled water	Ribeirão Preto Dental School, University of São Paulo, Ribeirão Preto, São Paulo, Brazil.
Experimental dentifrice 2	Hydroxyethylcellulose, glycerine, benzoic acid, methylparaben, sodium EDTA, fluorosurfactant (zonyl R), silica (sident 8), silica (sident 22 S), titanium dioxide, menthol and eucalyptol, distilled water	Ribeirão Preto Dental School, University of São Paulo, Ribeirão Preto, São Paulo, Brazil.
Corega Brite	Tetrapotassium, cocamidopropyl betaine, mentha piperita, saccharine, titanium dioxide, ammonia, menthol, anethol and eucalyptol	Stafford; Miller Ind. Ltd.; Rio de Janeiro, Brazil.
Sorriso	Sodium bicarbonate, calcium carbonate, sodium lauryl sulfate, sodium monofluorphosfate	Colgate-Palmolive Ind. Com. Ltd.; São Paulo, Brazil.
Brush	Colgate professional soft	Colgate-Palmolive Ind. Com. Ltd.; São Paulo, Brazil.

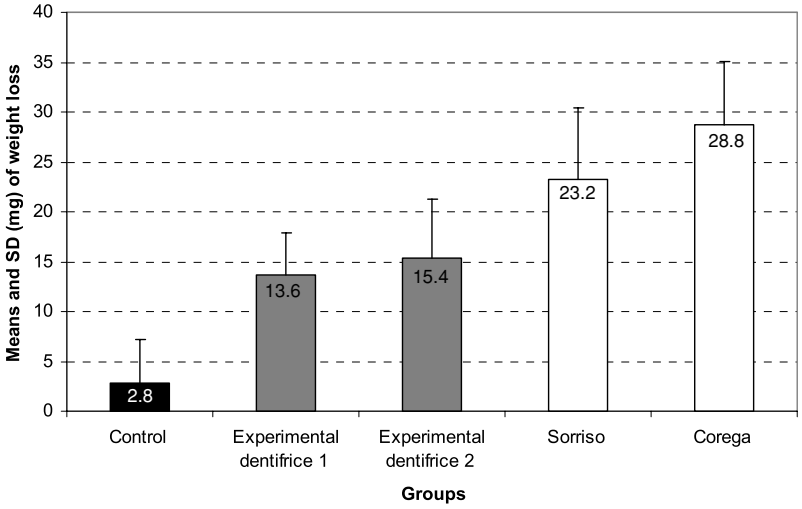

Figure 1 Means and standard deviation weight loss of specimens after brushing with groups of dentifrices. Columns with identical colors were not significantly different.

characteristics. The weight loss and roughness dates were subjected to ANOVA and Tukey tests ($p < 0.05$).

Results

The mean weight loss of specimens of each material after brushing is summarized in Figure 1. The ANOVA and Tukey tests ($p < 0.05$) indicated there was no significant difference in weight loss between Corega (28.83 $\pm$ 6.34 mg) and Sorriso (23.22 $\pm$ 7.23 mg), but the weight loss resulting from use of Corega was significantly higher than that from the experimental dentifrices (Experimental 1: 13.62 $\pm$ 4.29 mg; Experimental 2: 15.4 $\pm$ 5.80 mg). The control group (2.82 $\pm$ 4.41) showed the lowest weight loss.

Figure 2 shows the means for Ra analysis, with the negative control group (0.03 $\pm$ 0.01 μm) showing the lowest roughness ($p \leq 0.05$). The difference between Corega (13.43 $\pm$ 1.65 μm), Experimental 1 (12.28 $\pm$ 0.85 μm), and Experimental 2 (10.68 $\pm$ 2.56 μm) was not significant. The Sorriso dentifrice (19.15 $\pm$ 2.36 μm) caused the greatest amount of surface roughness.

Discussion

The most frequently used methods for analyzing the abrasiveness of dentifrices are weight alteration, Ra, radiation, and scanning electron microscopy. In this study, abrasiveness was analyzed by weight loss and surface roughness. Some researchers have considered that the best method would be a measure of the radioactive material, rather than weight loss, since the change of water content of the material affects this measure;[17] however, this limitation has been addressed by maintenance of the specimens in water until the mass remained the same after daily weighings.[18] The assessment of roughness was based on the arithmetic average deviation (Ra), which is the value of choice to test the roughness as a specification of ABNT (Brazilian Association of Technical Standards) and is more frequently used according to the NBR 6405.[19]

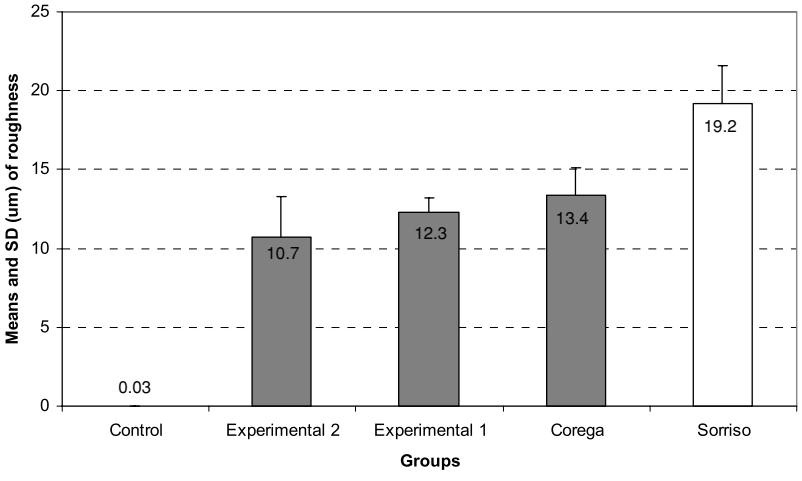

Figure 2 Means and standard deviation of dentifrice roughness of the specimens after brushing. Columns with identical colors were not significantly different.

The use of toothbrushing machines for the abrasiveness assays raises issues because the brushing is very vigorous, representing a difficult comparison with a patient's standard of toothbrushing;[1] however, many studies have concluded that there is concordance between clinical and laboratory studies.[20,21] Artificial toothbrushing in a machine is a simple method considered by ISO/DTS 145692 to be adequate for quantifying the abrasiveness of toothbrushing on acrylic resin.[2,22] In vivo studies to evaluate toothpaste abrasiveness have disadvantages including the time required and the inability to interpret the results in terms of the mechanisms responsible for generating wear because of the presence of many variables.[23]

The fact that the specimens are stationary in the machine may result in production of furrows on the surface of the specimen, resulting in more abrasion than would occur in vivo.[1] The two methods used in this study had previously been correlated, indicating their comparability.[13] In the present work all values obtained for roughness, except for the water control, were higher than this value. Ideally, a surface with the lowest possible roughness is recommended to reduce microorganism retention and prevent local infections and early denture deterioration.[24] The threshold surface roughness for bacterial retention is 0.2 μm.[25]

Many factors, such as the hardness of acrylic resin, the type of the abrasive agent, the shape and size of abrasive particles, the degree of dilution of the dentifrice, the type of toothbrush used, and the force applied on it, can affect the degree of abrasiveness in a substrate after toothbrushing.[6,25] This study used Sorriso dentifrice, a conventional dentifrice widely used in Brazil; Corega Brite, a specific dentifrice for prostheses; and two new dentifrices previously characterized via density, pH, consistency, and rheological features.[7] All factors that could affect the results were standardized so that only the differences between the dentifrices were crucial to the results. Specific toothpastes for complete dentures are presented as paste, and their final characteristics as a hygiene agent depend on the type and interaction of their components.[26] According to Tarbet et al,[27] low-abrasive toothpastes promote polishing of the surface of the prosthesis, thus making it less susceptible to biofilm accumulation.[7,14,28]

In accordance with ISO 8627,[29] a dentifrice is considered a low-abrasive one when the weight loss is less than 21 mg, a medium abrasive if weight loss is between 21 and 40 mg, and a highly abrasive one when the weight loss exceeds 41 mg. These measurements are recorded after 100 minutes of brushing with a load of 200 mg using bristles of medium hardness. With the caveat that 300 minutes of brushing was used in this study, the results here categorize the dentifrices Corega and Sorriso as being medium abrasive.

The dentifrice Corega promoted greater weight loss and lower roughness for the specimens compared to Sorriso. This can be explained by the abrasive properties of each dentifrice. Corega contains hard abrasive particles of sodium bicarbonate and silica, whereas Sorriso is composed of sodium carbonate, a water insoluble abrasive agent capable of causing weight loss and an increase in roughness. The experimental dentifrices contained only silica as an abrasive, which caused weight loss and roughness similar to Corega. Although some authors tend to link wear and roughness, previous results do not suggest that weight loss is closely linked to roughness, agreeing with the results of this study.[30] Weight loss can be mainly caused by the presence of silica, which does not necessarily result in elevated roughness due to the action of sodium bicarbonate. Silica is highly soluble in water and thus promotes polishing of the surface. The experimental dentifrices contain only silica as an abrasive, which caused lower weight loss, but similar roughness to Corega.

The same particle may produce larger and deeper grooves according to the force of brushing.[21] Studies using electronic microscopy have shown that the grooves made in acrylic resin by low-abrasive toothpaste have a regular shape and are less prone to retaining microorganisms and residues, similar to Corega Brite and the experimental dentifrices in this study.[31,32]

A toothbrush with soft bristles was chosen with the aim of preventing wear of the denture base or the artificial teeth, and because such brushes are readily available products, and also widely used by complete denture wearers. This is in accordance with some authors who suggest that stiff bristles that are flexible and made of nylon have low abrasivity.[13,33,34]

The suspension of the dentifrice and the water was made at a ratio of 1:1.[7] The brushes and the suspension were replaced every 50 minutes. With the replacement of the suspensions, the level of abrasion is probably higher because of the precipitation of the particles.[34]

The specimens brushed with the Sorriso toothpaste showed evidence of abrasion by the presence of grooves on the acrylic surfaces and loss of shine that was visibly detectable. This may have occurred because of the abrasiveness of the sodium bicarbonate particles.[7,22] The control group using water presented fewer furrows and no loss of polishing, as observed by Wictorin,[35] and only a small loss of weight in accordance with Vieira and Phillips,[36] who considered the brush alone as a cause of wear regardless of the toothpaste used. Dentifrices 1 and 2 show low abrasivity, and roughness and weight loss results were lower than the other dentifrices. There was no difference in the particles of Chloramine T (antimicrobial agent) and Zonyl (detergent) in terms of effect on roughness and weight loss. The major factor responsible for the differences in the degree of abrasiveness of the different dentifrices may be the shape of the abrasive particles.[7]

Conclusions

In a fairly extreme simulation of 6 years of use, all pastes tested produced a weight loss below the acceptable values for acrylic resin and a roughness beyond the acceptable values for acrylic resin. In relation to the properties evaluated, the use of experimental dentifrices could be indicated; however, it is important to also evaluate the clinical effectiveness of toothpaste in removing biofilm.

References

1. Sexton JC, Phillips RW: Studies on the effects of abrasives on acrylic resins. J Prost Dent 1951;1:454-456
2. Purnaveja S, Fletcher AM, Ritchie GM, et al: Compatibility of denture cleansers with some new self curing denture base materials. Biomaterials 1982;3:251-252

3. Abelson DC: Denture plaque and denture cleansers: review of the literature. Gerodontics 1985;1:202-206
4. Jagger, DC, Harrison A: Denture cleansing-the best approach. Br Dent J 1995;178:413-417
5. Haselden CA, Hobkirk JA, Pearson GJ, et al: A comparison between the wear resistances of three types of denture resin to three different dentifrices. J Oral Rehabil 1998;25:335-339
6. Lara EHG, Panzeri H: Study of the abrasiveness of basic dentifrices formulations. Rev Ciênc Farm São Paulo 1998;19:207-224
7. Panzeri H: Dentifrices evaluation II: shape and distribution of the abrasives particles. Odont Mod 1979;4:5-48
8. Harrison A. Wear of dental materials. Part 1: modes of wear. Dent Adver 1984;39:8-11
9. Davis WB: The cleaning, polishing and abrasion of teeth by dental products. Cosmetic Science 1978;1:39-81
10. De Boer P, Duinkerke ASH, Arends J: Influence of tooth paste particle size and tooth brush stiffness on dentine abrasion in vitro. Caries Res 1985;19:232-239
11. Zarb GA, Bolender CL, Carlsson GE: Boucher's Prosthodontic Treatment for Edentulous Patients (ed 11). St. Louis, MO, Mosby, 2000, 558p
12. Panzeri H, Lara EH, Lovato da Silva CH, et al: In vitro and clinical evaluation of specific dentifrices for complete denture hygiene. Gerodontology 2009;26:26-33
13. Wictorin L: Effect of toothbrushing on acrylic resin veneering material. II. Abrasive effect of selected dentifrices and toothbrushes. Acta Odont Scand 1972;30:383-395
14. Panzeri H, Lara EHG, Siéssere F, et al: Avaliação de dentifrícios II – forma e distribuição das partículas abrasivas. Odont Mod 1979;4:5-48
15. Richmond R, Macfarlane TV, McCord JF: An evaluation of the surface changes in PMMA biomaterial formulations as a result of toothbrush/dentifrice abrasion. Dent Mater 2004;20:124-132
16. Paranhos HFO, Freitas KM: Weight loss of five commercially available denture teeth after toothbrushing with three different dentifrices. J Appl Oral Sci 2006;14:242-246
17. Hefferren JJ: A laboratory method for assessment of dentifrice abrasivity. J Dent Res 1976;55:563-573
18. Aker JR: New composite resins: comparison of their resistance to toothbrush abrasion and characteristics of abrades surfaces. J Am Dent Assoc 1982;105:633-635
19. Brazilian Society of Techniques Standards: Roughness of surfaces: procedures. NBR 6405, 1988
20. Manly RS, Wiren J, Manly PJ, et al: A method for measurement of abrasion of dentin by toothbrush and dentifrice. J Dent Res 1965;44:533-540
21. Muhler JC, Stookey GK, Hassel TM: The development and evaluation of an improved denture cleaning and polishing paste. J Indiana Dent Assoc 1969;48:17-27
22. Murray ID, McCabe JF, Storer R: Abrasivity of denture cleaning pastes in vitro and in situ. Br Dent J 1986;161:137-141
23. Moore BK, Winkler MM, Ewoldsen N: Laboratory testing of light-cured glass ionomers as pit and fissure sealants. Gen Dent 1995;43:176-180
24. Ehrnford L: An abrasion test for composite resins. J Dent Res 1980;59:716-720
25. Oliveira LV, Mesquita MF, Henriques GE, et al: The effect of brushing on surface roughness of denture lining materials. J Prosthodont 2007;16:179-184
26. Salles AE, Macedo LD, Fernandes RA, et al: Comparative analysis of biofilm levels in complete upper and lower dentures after brushing associated with specific denture paste and neutral soap. Gerodontology 2007;24:217-223
27. Tarbet WJ, Axelrod S, Minkoff S, et al: Denture cleansing: a comparison of two methods. J Prosthet Dent 1984;51: 322-325
28. ADA. American National Standard: Specification n° 37 for dental abrasive powders. 1986, pp. 319-331
29. International Organization of Standardization (ISO): Specification n° 8627 for stiffness of the tufted area of tooth-brushes. 1987
30. Rios D, Honório HM, Araújo PA, et al: Wear and superficial roughness of glass ionomer cements used as sealants, after simulated toothbrushing. Pesqu Odontol Bras 2002;4:343-348
31. Harrison Z, Johnson A, Douglas CW: An in vitro study into the effect of a limited range of denture cleaners on surface roughness and removal of *Candida albicans* from conventional heat-cured acrylic resin denture base material. J Oral Rehabil 2004;31:460-467
32. Pipko DJ, el-Sadeek M: An in vitro investigation of abrasion and staining of dental resins. J Dent Res 1972;51:689-705
33. Harte DB, Manly RS: Four variables affecting magnitude of dentrifice abrasiveness. J Dent Res 1976;55:322-327
34. Freitas KM, Paranhos HFO: Weight loss of five commercially available denture teeth after toothbrushing with three different dentifrices. J Appl Oral Sci 2006;14:242-246
35. Wictorin L: Effect of toothbrushing on acrylic resin veneering material. I. A study of abrasion in vitro. Sven Tandlak Tidskr 1971;64:247-254
36. Vieira DF, Phillips RW: Influence of certain variables o the abrasion of acrylic resin veneering materials. J Prosthet Dent 1962;12:720-731