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In Vitro Assessment of the Abrasion Resistance of Two Types of Artificial Teeth Submitted to Brushing

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Keywords
Complete denture; toothbrushing; tooth abrasion; artificial teeth.

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Abstract

Purpose: To assess the effect of brushing with different solutions on the abrasion resistance of two types of acrylic resin teeth.

Materials and Methods: Maxillary premolars from two types of acrylic teeth (Biotone and Biotone IPN) were divided into six groups (n = 12), according to the solution used during brushing: distilled water (control), coconut soap, or dentifrice. A mechanical brushing machine was used to simulate approximately 1 year of brushing (11,000 strokes). The weight loss (WL) of teeth was obtained from the difference between the initial (IW) and final weight (FW) of each specimen, and the mean of percentage of weight loss (PWL) was calculated for each group. Data were analyzed using the Kruskal-Wallis test, followed by Bonferroni's post-test comparison ($\alpha = 0.05$).

Results: A statistically significant difference was found for the factor solution ($p < 0.001$). Brushing using dentifrice caused the highest values of weight loss (–0.50%), in comparison with the groups brushed with coconut soap (0.00%) or distilled water (0.00%).

Conclusions: For both types of artificial teeth, brushing with dentifrice produced higher abrasion than brushing with coconut soap or water.

Acrylic resin artificial teeth are the most common form of removable prostheses due to several advantages, such as a better bond to the denture base, improved esthetics, and ease of adjustment.[1] However, resin teeth have the disadvantage of low resistance to abrasion and higher fracture susceptibility.[2] Acrylic resin teeth have shown some improvements with claims of increased wear resistance, better esthetics, and more convenient curing methods.[3,4] The composition of acrylic resin polymer teeth is essentially polymethyl methacrylate (PMMA) beads and color pigments in a crosslinked polymer matrix.[5] Interpenetrated polymer network (IPN) teeth are produced by blending together two or more existing polymers that have compatible networks, which form permanent entanglements and owe their improved properties to synergism of the networks.[5] These highly crosslinked denture teeth were developed for their desirable properties, such as fracture resistance, abrasion resistance, and stain resistance.[1,4]

The abrasion resistance of artificial teeth is related to the longevity of the prosthesis and is important in the maintenance of occlusal vertical dimension.[2] Consequently, it can have the following negative effects: craniofacial disorders, reduced chewing efficiency, masticatory muscle fatigue, increased patient discomfort, and impaired esthetics.[2,6] Weight loss and surface roughness are the most common methods of analyzing abrasion resistance.[7] Low resistance to abrasion wear of acrylic resin teeth can be considered an undesirable feature, since the level of roughness of a resin can affect biofilm adhesion and staining, contributing to the rate of microbial colonization of prosthesis surfaces and oral pathologies, such as denture stomatitis.[8]

Brushing is the most common cleansing method employed with dentures[9,10] and is associated with surface abrasion of denture base materials and acrylic resin teeth.[7,11] According to Harrison et al,[12] the magnitude of surface abrasion caused by brushing teeth depends on the abrasiveness of the dentifrice used, bristle stiffness, the brushing technique, the frequency of brushing, and the hardness of the denture base material.

Several studies have indicated that most denture wearers use some kind of toothpaste to clean their dentures.[9,13] The complex composition of cleaning pastes with their abrasives, humectants, detergents, and flavoring, has a variety of potential effects on the denture surface, such as a loss of surface

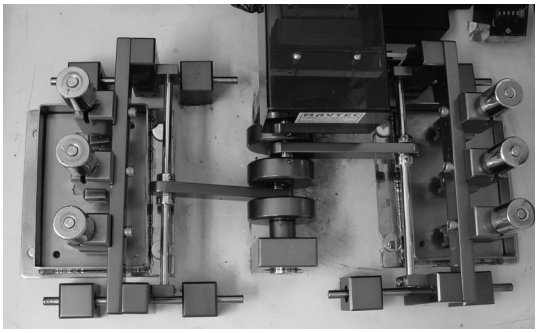

Figure 1 Toothbrushing machine used in the study.

polishing and roughness, and also facilitates the adherence of biofilm and the staining of acrylic resin.[12] An alternative would be the use of a nonabrasive detergent, such as a soap associated with denture brushing. The low cost and ease of access to soap are factors motivating its use.[14] Moreover, brushing associated with neutral soap is effective in controlling biofilm and has been widely accepted by denture wearers.[14]

Studies related to the effects of brushing teeth with different solutions on the properties of acrylic resin teeth are relatively scarce.[15-17] Further studies must be conducted to assist dentists in choosing artificial teeth for the fabrication of partial and complete dentures.

The null hypothesis of this study was that the abrasion resistance of two types of artificial teeth would not be affected by brushing with different solutions. Thus, the aim of the present study was to assess the effect of brushing with different solutions on the abrasion resistance of two types of acrylic resin artificial teeth.

Materials and methods

The specimens were maxillary premolars from two types of acrylic resin artificial teeth (Biotone and Biotone IPN; Dentsply Ind. Com. Ltda. Petrópolis, Brazil). Six groups were formed ($n = 12$) according to the type of artificial tooth and solution used during the brushing cycles, as follows: Biotone/distilled water (G1); Biotone/coconut soap (G2); Biotone/dentifrice (G3); Biotone IPN/distilled water (G4); Biotone IPN/coconut soap (G5); and Biotone IPN/dentifrice (G6).

First, the ridge lap surface of each denture tooth was reduced using 320-, 400-, and 600-grit silicon carbide paper (Norton, Saint-Gobain Abrasivos Ltd., Vinhedo, Brazil) in a polishing machine (Arotec Ind. e Com. Ltd., Cotia, Brazil) at 300 rpm to obtain a flat surface. This flat surface was obtained to fit the acrylic teeth to the brushing machine, as described below. Afterwards, the artificial teeth were stored in water at 37°C for 7 days.[16,18] After storage, the specimens were cleaned for 1 minute in an ultrasonic bath with deionized water containing 1% detergent and then dried with absorbing paper. The specimens were then weighed on an analytical scale with an accuracy of 0.001 g (AB 204-S, Mettler Toledo Ind. e Com., São Paulo, Brazil) to record the initial weight (IW).[16,18]

A mechanical brushing machine equipped with five soft nylon-bristled toothbrushes (Colgate; Colgate-Palmolive, São Bernardo do Campo, Brazil) was used for tooth brushing cycles

Figure 2 Silicone-acrylic tooth sets fabricated from the stainless steel mold.

Figure 3 Silicone-acrylic tooth set positioned on the brushing machine.

(Fig 1). To fit the acrylic teeth properly to the brushing machine, a stainless steel mold with internal cavities measuring $40 \times 10 \times 2$ mm^3 was used to fabricate patterns in high-viscosity silicone (Zetalabor; Zhermack S.p.A., Badia Polesine, Rovigo, Italy) (Fig 2). The silicone-acrylic tooth sets were then carefully removed from the stainless steel mold and fitted to the testing machine. Thus, the brushing cycles were performed with the cusps and marginal ridge areas exposed to abrasion (Fig 3).

The specimens and water/coconut soap (Ufe; Rosatex Produtos Saneantes Ltda, Guarulhos, Brazil) or water/dentifrice solutions (Colgate-Palmolive) were placed in pans. A sufficient volume of solution (mass ratio of 1:1) was used to cover the specimens. Distilled water was used as the control group for each type of tooth.

The machine was set to brush at a rate of 60 reciprocal strokes per minute, and to provide a 200-g vertical load on each specimen.[12,16,19] The specimens were then brushed with a total of 11,000 strokes, which is representative of approximately 1 year of brushing.[11] Each brush was replaced every 2750 cycles, which corresponds to 3 months of use.

After the brushing test, the artificial teeth were separated from the silicone patterns, thoroughly rinsed, blotted dry with soft tissue paper as previously described, and weighed again on an analytical scale to record the final weight (FW). The weight loss (WL) of denture teeth was obtained from the difference between the FW and the IW of each specimen, and a mean was obtained for each group. In addition, the percentage of weight loss was calculated for each group, according to the formula: $\%PWL = WL \times 100/IW$.

Data were statistically analyzed by the comparison of the means of percentage of weight loss (PWL) for each experimental condition. The analysis of the PWL was performed using

Table 1 Means (standard deviations) of initial weight (IW), final weight (FW), weight loss (WL), and percentage of weight loss (PWL) for each group

Group	IW (g)	FW (g)	WL (g)	PWL (%)
Biotone/distilled water	0.184 (±0.018)	0.184 (±0.018)	−0.001 (±0.001)	−0.283 (±0.389)
Biotone/coconut soap	0.191 (±0.020)	0.190 (±0.019)	−0.001 (±0.001)	−0.256 (±0.270)
Biotone/dentifrice	0.192 (±0.016)	0.191 (±0.016)	−0.001 (±0.001)	−0.651 (±0.448)
Biotone IPN/distilled water	0.196 (±0.021)	0.196 (±0.020)	0.000 (±0.001)	−0.112 (±0.387)
Biotone IPN/coconut soap	0.196 (±0.016)	0.196 (±0.016)	0.000 (±0.000)	−0.091 (±0.203)
Biotone IPN/dentifrice	0.199 (±0.017)	0.197 (±0.018)	−0.002 (±0.002)	−0.932 (±1.004)

Note: Negative values represent the weight loss decrease.

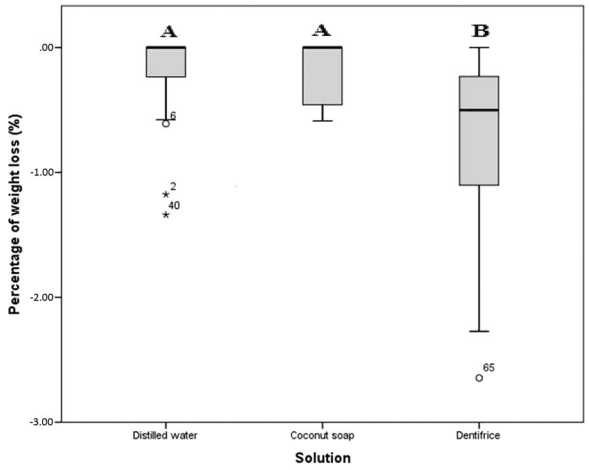

Figure 4 Box graph of percentage of weight loss (%), according to the solution used during brushing, irrespective of the type of tooth (Bonferroni's test, $p < 0.05$). Different capital letters mean statistical difference among the groups.

the Kruskal-Wallis test for nonparametric variables, considering the factors type of tooth, solution, and the combination tooth × solution. The type of tooth was analyzed with two levels and the type of solution with three levels. All data were analyzed with PASW Statistics (v.18; SPSS Inc., Chicago, IL), with the significance level set at $\alpha = 0.05$.

Results

A description of the mean values of initial weight (IW), final weight (FW), weight loss (WL), and percentage of weight loss (PWL) for each group is shown in Table 1. The Kruskal-Wallis test detected a statistically significant difference for the factor *solution* ($p < 0.001$). No difference was detected for the factor *tooth* ($p = 0.05$) and for the combination of the factors *tooth* × *solution* ($p = 0.765$). Multiple nonparametric comparisons were performed using the Bonferroni's post hoc test to identify the statistical difference among the groups (Fig 4). Brushing using dentifrice caused the highest values of weight loss (–0.50%), in comparison with the groups brushed with coconut soap (0.00%) or distilled water (0.00%), irrespective of the type of tooth.

Discussion

A study of the physical properties of artificial teeth is important, since these properties are related to the longevity of the prosthesis and esthetics.[17] The null hypothesis of this study (the abrasion resistance of two types of artificial teeth would not be affected by brushing with different solutions) was rejected.

Weight loss, which can be affected by the abrasion caused by brushing, was used to measure the abrasion resistance of acrylic resin artificial teeth.[16,20] The results showed that brushing with dentifrice decreased the abrasion resistance of the two types of artificial teeth assessed, since the weight loss values were significantly higher in these groups, representing greater wear. A number of studies have reported that brushing with commercially available dentifrices can be potentially harmful to the material used to fabricate prostheses, causing tooth wear and abrasion of these materials.[7,16,21]

Dentifrices are basically composed of humectants, detergents, flavoring, thickeners, pigments, and abrasive agents, such as silica and calcium carbonate.[7,16] In this study, the experimental dentifrice used presents calcium carbonate in its composition as abrasive particles. It could be hypothesized that these particles were responsible for the highest values of weight loss obtained, irrespective of the type of tooth, in comparison with the groups of teeth brushed with coconut soap or distilled water.

Coconut soap is essentially composed of coconut oil, sodium hydroxide, sodium chloride, water, coadjutant, antioxidant, and glycerin. It is a natural, biodegradable and antibacterial soap.[22] It has been stated that coconut soap is a nonabrasive product and should be used in denture cleansing,[22,23] In addition, coconut soap has been effective in association with sodium hypochlorite in controlling denture biofilm.[22] Our results demonstrated that brushing with coconut soap produced the lowest weight loss, similar to the control group (distilled water), for both teeth evaluated.

Abrasive agents are used to remove biofilm and stains on natural teeth and prostheses surfaces effectively.[21] Shigli[24] reported that complete denture wearers should not use dentifrices to brush their dentures, because most of them contain an abrasive material that will wear away the surface of the acrylic resin.[25] It reinforces that any debris should be removed by brushing with a soft brush, soap, and cold water.[14,22]

The results of this study must also be highlighted in relation to the type of denture tooth. Biotone teeth are essentially composed of macromolecules of PMMA linearly arranged in two layers and color pigments in a polymeric matrix.[5] IPN teeth

are defined as a combination of two polymers in a network form, at least one of which is synthesized and crosslinked in the immediate presence of the other.[5] Crosslinked denture teeth should exhibit desirable properties, such as greater fracture resistance, abrasion resistance, and stain resistance.[1] Although these different features must be considered, the results of this study showed that weight loss was similar for both of the teeth assessed. These findings are in agreement with Freitas and Paranhos[16] and Khan et al,[25] who also found no difference in abrasiveness between teeth with different compositions when submitted to brushing.

In this study, a period equivalent to 1 year of manual brushing was simulated for all groups assessed. Artificial brushing could be considered as a limitation of this study because it is vigorous and more abrasive than manual brushing.[16] However, considering the consensus in the dental literature that complete dentures must be replaced every 5 to 7 years,[26] the results of this study could help ensure that denture wearers are properly educated regarding the methods employed when cleaning their denture teeth, as well as the need for regular replacement of their dentures. In addition, the results of this study could also help dentists and laboratory technicians to choose artificial teeth with suitable properties.

Another limitation of this in vitro study was the fact that only two types of artificial teeth, two solutions, and one type of brush were tested. Future in vitro and in vivo studies are suggested to assess other materials and physical properties, since new findings may contribute to the choice of artificial teeth, as well as providing proper denture hygiene instructions for denture wearers.

Conclusion

Within the limitations of this study, it is possible to conclude that brushing with dentifrice produced higher abrasion than brushing with coconut soap or water, regardless of the type of artificial tooth. It could be suggested that brushing the dentures using coconut soap would be an effective method for the maintenance and longevity of artificial teeth.

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