Acta Scientiarum
http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-8648
Doi: 10.4025/actascihealthsci.v47i1.68071

Evaluation of the bristle characteristics and effects of denture brushes on acrylic resin

Ana Emanuela Cisne de Lima[1], Carolina Noronha Ferraz de Arruda[2*], Daniel Zuluaga Goyeneche[1], Viviane de Cássia Oliveira[1], Ana Paula Macedo[2], Cláudia Helena Silva-Lovato[1]and Helena de Freitas Oliveira Paranhos[1]

[1]Departamento de Materiais Dentários e Prótese Dentária, Faculdade de Odontologia de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto, São Paulo, Brasil. [2]Departamento de Prótese Dentária, Faculdade de Odontologia, Universidade do Estado do Rio de Janeiro, Boulevard 28 de Setembro, 157, 20551-030, Rio de Janeiro, Rio de Janeiro, Brasil. *Author for correspondence. E-mail: carolina.arruda@uerj.br

ABSTRACT. Specific denture brushes were evaluated in regards to characteristics of the bristles (thickness, bristle ends, and deterioration) and their effects (mass variation, surface roughness, and gloss) on acrylic resin after simulated brushing periods of 3 (T1), 6 (T2), and 12 months (T3). For their effects on acrylic resin, specimens were randomly distributed (n = 13): BI: Bitufo; CB: Curaprox; PP: Prosthesisplus; CO: Condor; OB: Oral B; OF: Orafix; and Control: Curaprox 5460. The specific brushes CO and OF showed higher values for thickness (larger side) (T0 to T3) and OF (smaller side) (T0). Results for both sides of bristle-ends showed (T0 to T3) flat or slanted bristles, indicating unacceptability in 69.4% to 85.1% of bristles. Results related to degradation showed bristles with progressive flat or oblique wear over time. For mass loss in dentures, there was gain in mass from T1 to T3 and mass gain over time for OB (T2). For surface roughness, there were no significant differences between all factors (p>0.001). For gloss, OB (T1 and T3) showed higher values. It was concluded that there is a lack of standardization of the characteristic of specific denture brushes. Despite the progressive wear of the bristles over time, Curaprox, Próteseplus, Condor, Oral B, and Orafix can be indicated for routine hygiene of denture wearers since they were not able to damage the acrylic resin.

Keywords: complete denture; physical properties; denture cleansers; acrylic resin; brush.

Received on May 02, 2023.
Accepted on September 09, 2024.

Introduction

Hygiene products for use by denture wearers must be effective and harmless to the materials of the prosthetic device (Council on Dental Materials, Equipment and Instruments, 1983). Brushing is the method most used for routine denture hygiene (Peracini et al., 2010; Gajwani-Jain et al., 2015; Papadiochou & Polyzois, 2017), and can be performed alone or used with chemical agents, as there are advantages of effectiveness against organic deposits and low cost (Sorgini et al., 2012; Sorgini et al., 2015).

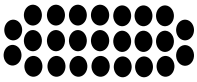
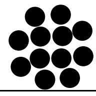
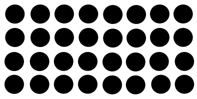
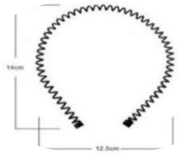
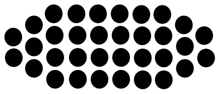
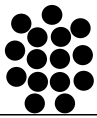
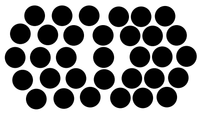
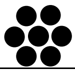
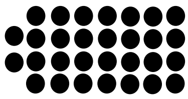
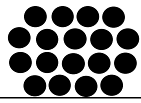
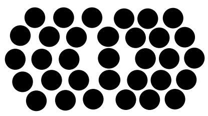
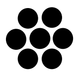
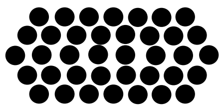
However, abrasion is a factor that may interfere with some properties of the acrylic resin, such as the surface roughness (Freitas & Paranhos, 2006; Journal of the American Dental Association. [JADA], 2007; Sorgini et al., 2012, 2015; Santos et al., 2021). This depends on the characteristics of the toothbrush bristles, dentifrice abrasiveness, brushing frequency and technique, force applied during brushing, and the hardness of the substrate being brushed (Panzeri et al. 2009; Sorgini et al., 2015; Freitas-Pontes et al., 2016; Santos et al.. 2021). Dentifrice abrasiveness and hardness of the substrates are highlighted in different studies, showing the need for the use of specific dentifrices (Silva & Paranhos, 2006; Panzeri et al., 2009; Sorgini et al., 2012, Sorgini et al., 2015; Freitas-Pontes et al., 2016; Santos et al., 2021).

Furthermore, previous studies have shown the benefits of using specific brushes for the hygiene of complete dentures (Silva & Paranhos, 2006; Fernandes et al., 2007), in the control of denture biofilm and oral health maintenance (Peracini et al., 2017; Badaró et al., 2020; Arruda et al., 2021). However, studies regarding the occurrence of adverse effects of specific brushes on the components of materials used to manufacture dental prosthetic devices are scarce. Therefore, the aim of this study was to evaluate the characteristics of bristles of different specific brushes commonly indicated to complete dentures wearers for performing routine oral hygiene and the bristles effects on acrylic resin after time intervals of 03, 06, and 12 months of simulated mechanical brushing. The null hypothesis tested was that all the specific brushes tested would promote an effect differing from that of the brushes indicated for hygiene of natural teeth.

Material and methods

Table 1 shows both types of brushes evaluated. A total of seven groups (n = 13) were evaluated, six groups of specific denture brushes and one toothbrush for natural teeth (control).

Table 1. Specifications of evaluated brushes.

Groups	Brushes	Manufacturer	Number of tufts/bristles per tuft	Tuft distribution
Specific brushes	1.Bitufo (BI)	Coty Brazil Comércio Ltda	BS: 25/17-19 MS: 12/16-18	BS:  MS: 
	2.Curaprox – Brush (CB)	CuradenSwiss of Brazil Ltda	BS: 32/38 MS: 13 bows/ 105 bristles	BS:   MS:
	3.Condor (CO)	Copyright © Condor	BS: 34/15-16 MS: 15/15-16	BS:  MS: 
	4.Proteseplus (PP)	Dentalclean	BS: 33/58-68 MS: 7/20	BS:  MS: 
	5. Oral-B (OB)	Procter & Gamble	BS: 30/42-48 MS: 18/50	BS:  MS: 
	6.Orafix (OF)	Orafix - Dr. Fresh. Inc	BS: 33/27-30 MS: 7/27-30	BS:  MS: 
Control	Curaprox– 5460 (CP)	CuradenSwiss of Brazil Ltda	BS: 38/140-143	BS/MS: 

Legend: BS - Larger side; MS - Smaller side

Specimen fabrication

Plexiglass acrylic matrices (90 mm X 30 mm X 3 mm) (Plex Glass, Day Brasil S.A., Ribeirao Preto, SP, Brazil) were included (Jon, Jon Industria Brasileira, Sao Paulo, SP, Brazil) in plaster type III and IV (Herodent, Vigodent S/A Ind. Com., Rio de Janeiro, Brazil). After disinclusion of the matrices, the acrylic resin (Classico, Classico Ltda, Sao Paulo, SP, Brazil) was manipulated and polymerized (Termocicler 100, Oficina de Precisao do Campus USP/RP, Ribeirao Preto, Sao Paulo, Brazil), according to the manufacturer's instructions.

The excess was trimmed, and specimens were stored in distilled water at 37 °C for 50 ± 2 h to eliminate the residual monomer.Then, each specimen was polished (Arotec, Cotia, São Paulo, SP, Brazil) with 180/320/400/600/1200-grit paper (Norton, Guarulhos, SP, Brazil). One of the flat faces of each specimen was polished with a polishing cloth (Fortel, São Paulo, SP, Brazil) and calcium carbonate water solution (Branco Rio, Rio Claro, SP, Brazil), as well as VIPI bril polishing stick (VIPI, Pirassununga, Sao Paulo, Brazil). The specimens were weighed on electronic analytical scales (Precision of the scale: 0.0001g) (Metler Toledo GMbH, Laboratory & Weighing Technologies, Greifensee, Switzerland), immersed in distilled water at 37°C, and weighed every three days until a stable wet mass was obtained. Subsequently the specimens were rinsed in water for 15 seconds, sonicated with distilled water and neutral detergent for 1 minute, dried with absorbent paper, and after 1 minute, weighed again to determine the initial mass.

Brushing simulation

The brushing test simulation was performed (Mavtec Comercio Ltda., Ribeirao Preto, SP, Brazil) according to ISO/DTS 145692 (International Organization for Standardization. [ISO], 1987), with a 200g load at a speed of 356 cycles per minute and trajectory of 3.8 cm. The toothbrush handles and a single bristle were removed with a carborundum disc (Dentorium Products Inc., Farmingdale, NY, USA) before attaching the brush to the brushing machine. The specimens were brushed with distilled water (10 mL; 23 ± 3°C) until the simulation of three periods was completed: T1) 03 months (12.5 min - 4,450 cycles); T2) 06 months (25 min - 8,900 cycles); and T3) 12 months (50 min - 17,800 cycles) (Sorgini et al., 2012, 2015). The brushes were analyzed for bristle characteristics (thickness, bristle ends, and degradation) and effects on the acrylic resin (abrasiveness, surface roughness, and gloss).

Bristle characteristics

One brush of each group was randomly selected at T1, T2, and T3. The bristles were evaluated for thickness, bristle ends, and degradation. For thickness and bristle ends, 09 bristles were analyzed (03 from the central area and 06 from the peripheral area) from the larger side, and were submitted to the brushing test (times 1, 2, and 3). In addition, both sides (larger and smaller) were evaluated before the brushing test simulation (T0). For degradation, 01 bristle of the central area of the larger side was analyzed (T0, T1, T2, and T3).

For thickness and bristle ends, the bristles were individually positioned on a microscopy plate (Olen, Ribeirao Preto, SP, Brazil), fixed (3M, Scotch, Fixa Forte), and analyzed under a stereomicroscope (Nikon Stereomicroscope, SMZ 800, NIKON, Kawasaki, Kanagawa, Japan) and the NIS Elements for basic Research Software was used (NIKON, Kawasaki, Kanagawa, Japan). For thickness, 03 measurements were made of each bristle (anchoring, center, and tip) and a mean was then obtained. For the bristle ends, the bristles were classified as "Acceptable" or "Not Acceptable", according to the classification of Silverstone & Featherstone (1988). Therefore, according to the geometry shown, the free ends of the bristles were classified as acceptable (without capacity to cause abrasion) and not acceptable (with capacity to cause abrasion). For degradation, the bristles were sputter-coated with a gold-palladium (ratio 4:1) for 120 seconds and were analyzed by scanning electron microscopy (SEMXL30 Field EmissionGun Microscope, Philips, Eindhoven, The Netherlands).

Bristle effects on acrylic resin

Abrasiveness, surface roughness, and surface gloss were evaluated at T1, T2, and T3.

For assessing abrasiveness, the Gravimetric Method was used, and the mass loss (ML) was calculated: ML1 = m1-m0; ML2 = m2-m0, and ML3 = m3-m0. Surface roughness (SR) was evaluated (Surftest SJ-201P, Mitutoyo Corporation, Kawasaki, Japan), according to SR1 = r1- r0; SR2 = r2- r0; and SR3 = r3- r0. Surface gloss (SG) was evaluated (Micro-gloss 45o, BYK-Gardner GmbH, Wesel, Germany), and the changes were calculated: SG1 = b1- b0; SG2 = b2- b0; and SG3 = b3- b0.

Statistical analysis

The data of bristle ends and their degradation were considered qualitative. Data of bristle thickness and effects on the acrylic resin (mass loss, surface roughness, and gloss of the specimens) were considered quantitative.

The quantitative data were analyzed for normality by the Shapiro-Wilk test (IBM Corp, Armonk, NY, USA). The thickness data at T0 (bristles on both sides of the brush) showed normal distribution, so two-way ANOVA, followed by the Tukey post-test with Bonferroni adjustment ($\alpha = 0.05$) was used. For the other time intervals, non-normal distribution of the data was found relative to thickness (T1, T2, and T3), mass variation, surface roughness, and gloss, therefore, a nonparametric analysis followed by Friedman-Conover post-test with Benjamini-Hochberg adjustment ($\alpha = 0.05$) was used (R Foundation for Statistical Computing).

Results

For thickness, the factors "brush", "time" and interaction "brush vs time" were significant ($p < 0.001$). Comparisons of the Means are shown in Figure 1.

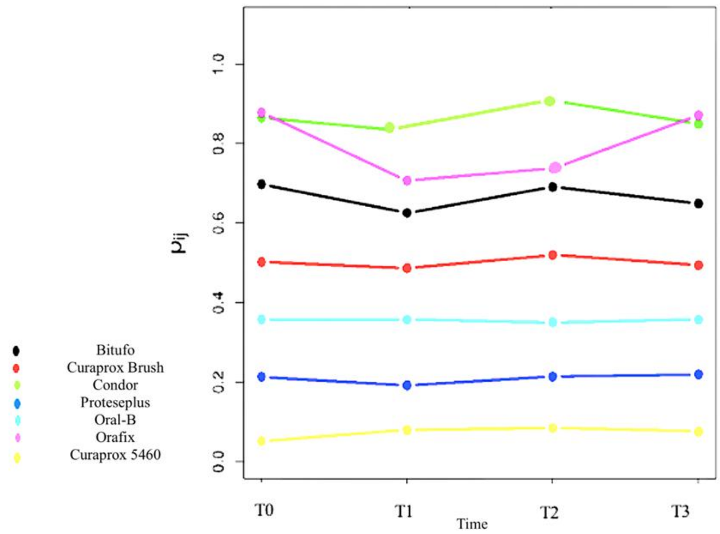


Figure 1. Mean values of bristle thickness at T0, T1, T2, and, T3. Different capital letters indicate statistically significant differences for the same brush in different times tested ($p < 0.05$). Different lowercase letters indicate statistically significant differences for brushes in the same tested time ($p < 0.05$).

When the brushes were compared at all times (T0 to T3), the specific brushes showed higher values than the control group, with the lowest values for PP and the highest for CO and OF. When comparing the time, only OF showed significant changes, with reduced bristle thickness at T1 and intermediate values at T2.

For comparison of both sides of the specific brushes in T0, the side ($p < 0.001$), brush ($p < 0.001$), and interaction "side vs brush" ($p < 0.001$) were significant. Comparisons of means are shown in (Table 2). For comparison of the brushes on the smaller side, the Control Group and PP showed the lowest thickness values, followed by OB, BI, CO, and OF, which had the highest values. When the two sides of the same brush were compared, there was a difference only for the Control Group and Condor, with lower thickness values for the smaller side.

Table 2. Specific brushes – Means of bristle thickness values (mm) (smaller side) and comparison between sides (larger and smaller).

Side	Brushes	Mean± Standard Deviation (Median)
Smaller	Bitufo	0.320± 0.003 (0.320)^{Ac}
	Curaprox brush	0.205± 0.003 (0.206)^{Ba}
	Condor	0.337± 0.036(0.343)^{Bcd}
	Proteseplus	0.214± 0.006 (0.215)^{Aa}
	Oral-B	0.259± 0.011 (0.257)^{Ab}
	Orafix	0.356± 0.018 (0.345)^{Ad}
Larger	Bitufo	0.322± 0.004 (0.322)^{Ad}
	Curaprox brush	0.278± 0.006 (0.281)^{Ac}
	Condor	0.365± 0.018 (0.358)^{Ae}
	Proteseplus	0.214± 0.006 (0.215)^{Aa}
	Oral-B	0.259± 0.007 (0.261)^{Ab}
	Orafix	0.364± 0.020 (0.371)^{Ae}

Different lower case letters indicate statistically significant differences for brushes for the smaller side ($p<0.05$). Different capital letters indicate statistically significant differences between both sides ($p < 0.05$).

The Table 3 shows the acceptability for bristle ends. For the experimental brushes, of the 108 bristles analyzed at T0, 75 (69.4%) were rated as unacceptable; and, of the 54 bristles analyzed at each subsequent time interval, these numbers were 41 (75.9%) at T1, 40 (74%) at T2, and 46 (85.1%) at T3.

Table 3. Acceptability ratings of the extremities of the total number of bristles.

	TIMES											
	T0						T1		T2		T3	
Sides	LARGER		SMALLER		TOTAL		LARGER		LARGER		LARGER	
Brushes	A	U	A	U	A	U	A	U	A	U	A	U
BI	2	7	4	5	6	12	1	8	2	7	4	5
CB	0	9	1	8	1	17	1	8	3	6	0	9
CO	8	1	4	5	12	6	6	3	4	5	3	6
PP	4	5	1	8	5	13	4	5	5	4	0	9
OB	1	8	3	6	4	14	1	8	0	9	1	8
OF	3	6	2	7	5	13	0	9	0	9	0	9
CONTROL	4	5	-	-	4	5	4	5	3	6	4	5

A: Acceptable; U: Unacceptable.

The Figure 2 shows the SEM images (magnification 300X) of the bristle ends before (T0) and after (T1 to T3) the brushing test.

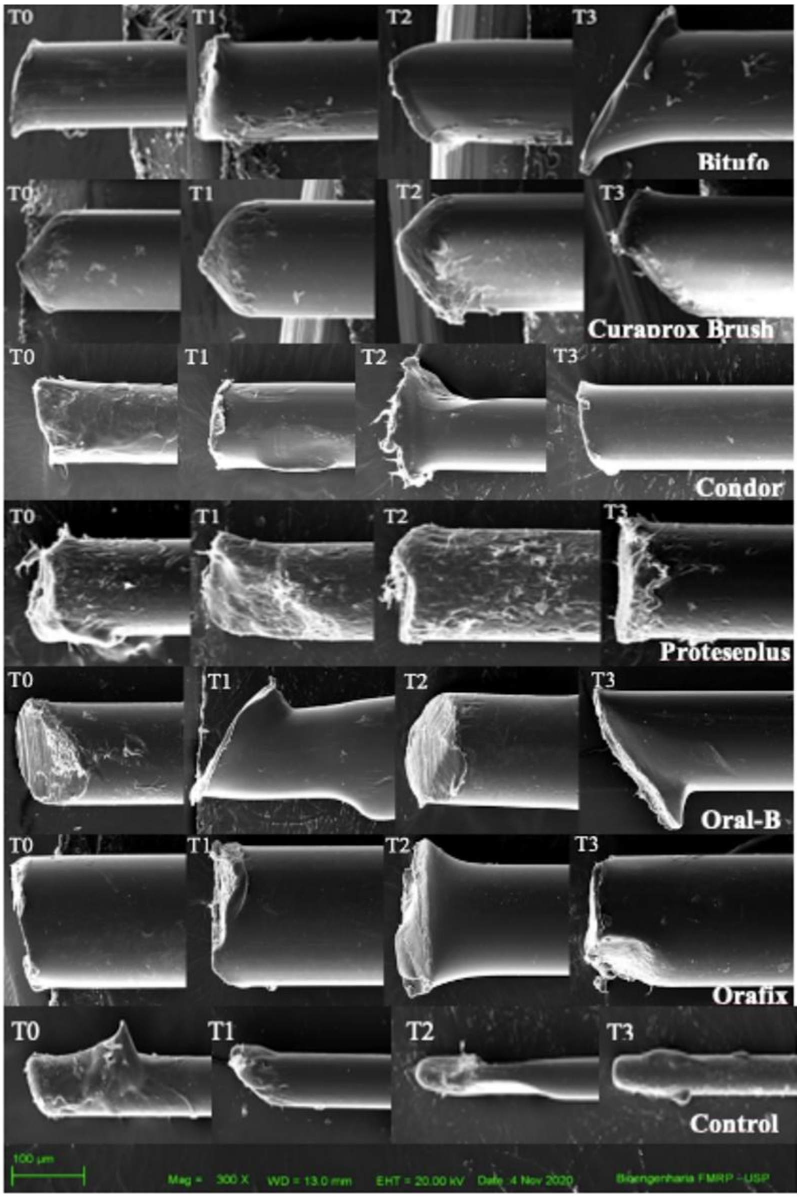


Figure 2. Scanning electron microscopy (SEM) images of the bristles.

The degradation results indicated that the initial aspects of the bristle ends varied widely, with flat, pointed and rounded ends, with or without irregularities. For all brushes, when compared with T0, there was progressive bristle wear over time, showing a little wear at T1, increased wear at T2, and marked wear at T3. All bristle ends showed wear in a flat or oblique shape.

For the mass loss, the factors of brush, time, and the interaction "brush vs time" were significant ($p < 0.001$). The results of mean comparison are shown in (Figure 3).

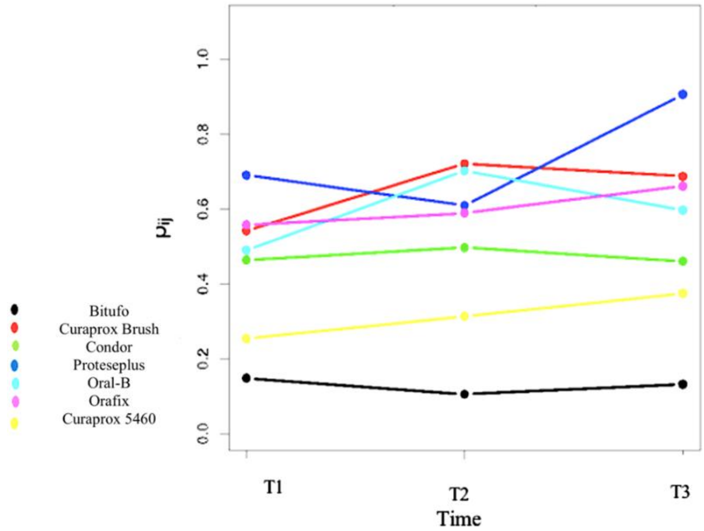


Figure 3. Mean values of mass variation - Times T0 to T3.

When the brushes were compared at T1 and T2, Bitufo was similar to the Control Group causing loss of mass in dentures, while the others differed from the control by showing gain of mass. At T3, all brushes differed from the Control, with loss of mass for the Bitufo brush and gain of mass for the other brushes, with higher values for Proteseplus. When the time was compared, there was a significant difference for Oral-B, with gains in mass at T2 and intermediate values at T3, when compared with T1.

The Figure 4 shows variation in surface roughness, in which no statistically significant differences ($p > 0.001$) were found for the factors of brush ($p = 0.319$), time ($p = 0.116$), and the interaction "brush vs time" ($p = 0.562$).

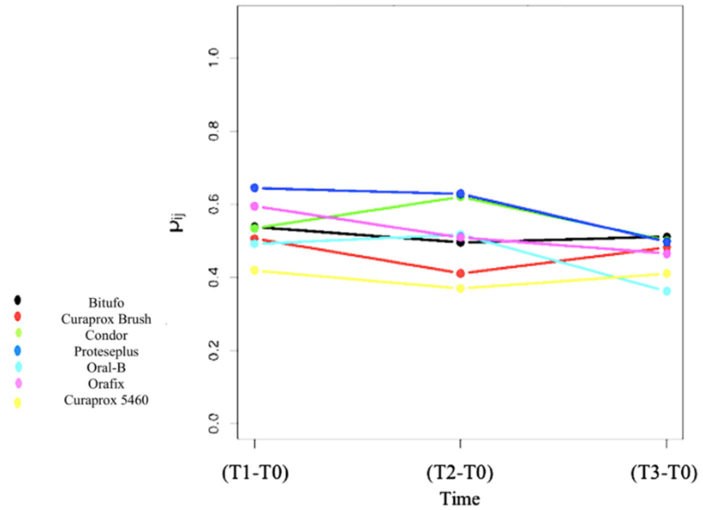


Figure 4. Surface roughness variation (ΔRa) - Times T0 to T3.

The Table 4 shows gloss data. There were statistically significant differences for the factor of time and for the interaction "brush vs time" ($p < 0.001$).When the brushes were compared, there were no differences at T0 and T2. At T1, Oral B increased gloss, while in the Control Group gloss decreased. The other groups were similar to the Control. At T3, Oral-B differed from Control, with an increase in gloss, while Bitufo, Condor, and Orafix showed decreased gloss. Curaprox brush and Proteseplus were similar to the Control Group and did not differ. At T1, except for Control Group, all Groups showed increased gloss. At T2, there was an increase in gloss for Condor, Oral B, and Orafix, which showed higher values. At T3, Bitufo, Condor, Oral B, Orafix, and Control showed similar results and increased gloss.

Table 4. Gloss variation (GU) Mean Values - Times T0 to T3.

Time	Brushes	95% Confidence Interval (minimum-maximum)
T0 (Initial)	BI	22.07; 28.42 (19.20; 33.30)
	CB	24.49; 30.64 (20.90; 33.40)
	CO	21.76; 30.62 (18.20; 35.90)
	PP	21.16; 27.11 (20.20; 31.00)
	OB	22.78; 30.04 (16.50; 32.90)
	OF	21.62; 28.36 (18.90; 33.40)
	CP (Control)	23.13; 29.95 (20.70; 33.80)
T1 (3 months)	BI	37.11; 43.15 (34.00; 45.10)
	CB	36.34; 39.37 (33.60; 40.20)
	CO	39.17; 42.77 (37.40; 45.30)
	PP	39.62; 43.89 (37.80; 45.60)
	OB	40.35; 44.07 (38.60; 46.30)
	OF	38.47; 43.26 (33.00; 43.50)
	CP (Control)	38.40; 43.91 (36.40; 47.50)
T2 (6 months)	BI	40.41; 43.35 (38.90; 44.40)
	CB	39.84; 43.31 (39.20; 44.70)
	CO	39.70; 43.77 (38.40; 45.90)
	PP	41.03; 44.24 (39.90; 46.50)
	OB	42.20; 45.22 (39.70; 47.20)
	OF	41.91; 44.73 (38.70; 45.00)
	CP (Control)	40.83; 45.35 (38.60; 47.30)
T3 (1 year)	BI	42.68; 44.92 (41.70; 45.70)
	CB	41.75; 44.11 (41.20; 45.60)
	CO	40.82; 43.98 (39.30; 46.30)
	PP	42.30; 45.74 (40.20; 47.80)
	OB	44.43; 46.70 (43.50; 48.20)
	OF	43.18; 45.44 (42.00; 46.60)
	CP (Control)	42.19; 46.09 (39.80; 48.40)

BI: Bitufo; CB: Curaprox brush; CO: Condor; PP: Próteseplus; OB: Oral B; OF: Orafix; CP: Curaprox 5460.Different lower case letters indicate statistically significant difference for brushes ($p < 0.05$).Different capital letters indicate statistically significant difference between times ($p < 0.05$).

Discussion

Brushing is the method of performing oral hygiene most used by denture wearers (Peracini et al., 2010; Papadiochou & Polyzois, 2017). However, there are no norms or guides that indicate the best characteristics of brushes, and the extent to which they can interfere in the durability of oral rehabilitation, acrylic resin, or in control of biofilm (Council on Dental Materials, Equipment and Instruments, 1983; Journal of the American Dental Association. [JADA], 2007; Gajwani-Jain et al., 2015).

Therefore, in this study, denture brush characteristics and their effects on acrylic resin were evaluated. Brushes were selected according to those used in previous clinical studies (Paranhos et al., 2007; Fernandes et al., 2007; Panzeri et al., 2009; Freitas-Pontes et al., 2016; Peracini et al., 2017; Badaró et al., 2020; Arruda et al., 2021). The results showed that the null hypothesis was rejected since there was a difference between the specific brush brands with respect to the properties evaluated.

Brushes can be classified as ultra-soft, soft, medium, and hard, by correlating the thickness and length of the bristles, or as extra hard or extra soft (JADA, 2007).The brushes tested showed great variation in the number of tufts, bristles, and geometric configurations, and only three had a bristle hardness classification, i.e. Condor and Proteseplus (hard) and Control Group (ultra-soft).

The results showed higher thickness values for the specific brushes tested than for the Control Group (T0 to T3). For the larger side, the lowest values were observed for Proteseplus (hard) (0.211 mm to 0.216 mm), which did not differ statistically over time. The highest values (T0 to T3) were found for Condor (hard) (highest value at T2: 0.371 mm), for which the variation in values over time was also not significant, and Orafix (highest value at T3: 0.365 mm), which showed a significant reduction in thickness at T1 when compared with

T0, with a recovery of values at T3. On the smaller side, the lowest values occurred for Curaprox-Brush (0.205 mm) and Proteseplus (0.214 mm), followed by Oral-B (0.259 mm), Bitufo (0.320 mm), Condor (0.337 mm), and Orafix (0.356 mm), which showed the highest values.

Thus, a difference was observed between brushes regarding bristle thickness for both sides, and it could be inferred that there was a variation in the degree of bristle hardness. In the present study, there was no significant difference between the brushes, therefore, the authors assume that all of them can be routinely used in hygiene programs.

Although the results of removing unsightly debris from dental prostheses are visible, the cleaning methods are not discernible. Consequently, many hygiene products are still overlooked or discarded by a large number of patients and oral health specialists. This has led to the unfortunate substitution of hygiene products that reduce the clinical useful life of dentures.

However, there was no significant variation in the bristle thickness values over time, showing that brushing did not change this property of the bristles. When both sides of the same brush were compared, there was a difference only for the Curaprox and Condor brushes, with lower values for the smaller side (0.205 mm and 0.337 mm, respectively). The specific dentures brushes should have more rigid and longer bristles than conventional toothbrushes and to avoid abrasion of the acrylic resin they should be flexible and soft, with uniform diameters and lengths (JADA, 2007).

Brushes should have bristles with rounded free ends, without sharp or jagged edges (JADA, 2007), and this was a criterion for rating their acceptability (Aravind Raaj et al., 2018). Studies have described anatomical conformations of denture brushes, but have not considered bristle ends (André et al., 2011). Although there are no specific standards for the bristle ends of denture brushes, they should be uniform and have rounded tips (JADA, 2007).The results showed that except for the Condor, all brushes showed a significant number of bristles without rounded and uniform edges, which is not acceptable. This lack of standardization of bristle ends also occurs with toothbrushes, which do not meet acceptable quality criteria or those of the ADA specifications (Aravind Raaj et al., 2018).

There was a correlation between analyses of the bristle ends and degradation, as the initial aspects of the bristle ends were shown to be widely varied for all brushes. There was progressive bristle wear over time, with ends that were observed to be flat, as well as flattened, sloping, pointed, or heterogeneous shapes. Studies on abrasion of acrylic resin have shown great variation in bristle wear of toothbrushes after 60 minutes and three months (Tan & Daly, 2002) of brushing. Our results for denture brushes showed irregularities with use and this observation is an important factor in analyzing the lifespan of brushes.

Specific brushes for dentures must not be abrasive to the constituent materials of prosthetic devices since deterioration of the denture surface makes it more susceptible to biofilm deposition (Freitas-Ponte et al., 2016). Studies on the abrasive effects of toothbrush bristles on acrylic resin substrates have drawn attention to the necessity of using soft bristles, which are natural (soft or medium) and homogeneous in diameter (Wictorin, 1972). Dyer et al. (2001) evaluated six brands of toothbrushes and showed that soft brushes, associated with toothpaste, produced greater abrasion due to the ability of the bristles to grasp the toothpaste. Thus, the abrasive particles retained on the ends of the bristles predispose the acrylic resin to the chemical influence of the toothpaste, favoring abrasion by brushing. In regard to specific brushes, Freitas-Pontes et al. (2016) found no differences between Bitufo and Medic Denture brushes in relation to abrasiveness against heat-polymerizable resins when simulating 1 to 3 years of brushing with water. The authors observed significant resin mass loss, with mean values of 1.83 mg (01 year) to 3.78 mg (03 years), indicating abrasion occurred even with water brushing, but this loss was minimal when compared with the loss observed with the use of toothpaste.

The Bitufo brush caused a loss of mass in all the time intervals evaluated, demonstrating a greater abrasive potential. This brush had fewer bristles than the others; however, its bristles were thicker than those of the brush in the control group and both Condor and Orafix brushes, all of which did not cause loss of mass. Thus, the abrasion generated by Bitufo may be related to other characteristics of the bristles, such as length and flexibility, properties not analyzed in this study. The gain in mass observed for the others can be justified by water absorption, since acrylic absorbs or loses liquid depending on the solution used. Moreover, the longer the immersion time, the greater the exchange and influence of the solution on the material property (Sorgini et al., 2015). Studies have shown that brushing with soft-bristle toothbrushes and water entailed minimal or no abrasiveness of acrylic resin (Freitas & Paranhos, 2006); Panzeri et al., 2009); Sorgini et al., 2012, 2015; Santos et al., 2021). The results found here were relevant, as they showed that these brushes did not cause loss of acrylic resin mass, even with the presence of different shapes, number of tufts and bristles, as well as varying thickness values. When the times were compared, there was a difference only for the Oral-B brush, with mass gain at T2 and intermediate values at T3, when compared with T1.

Surface roughness is an important property of acrylic resin since it interferes with biofilm deposition (Fernandes et al., 2007; Paranhos et al., 2007). Studies with toothbrushes have indicated that changes in resin roughness are mainly related to the type of brush and auxiliary sanitizing agent used, and to a lesser extent to brushing time (Sorgini et al., 2012; Freitas-Pontes et al., 2016). Thus, relative to mass loss, studies have shown minimal or no changes in the roughness of acrylic resin at different brushing time intervals (Sorgini et al., 2012; Santos et al., 2021).As far as specific brushes are concerned, studies are scarce, and Freitas-Pontes et al. (2016) found no changes in the roughness of thermally activated acrylic resins after using the Bitufo and Medic Denture brushes associated with water in periods of 1, 2 and 3 years of brushing, with minimum and maximum values of 0.05 μm and 0.19 μm, respectively (mean of 0.14 μm). The results obtained in this study are relevant, since for all brushes the values were below 0.2 μm, thus preventing biofilm accumulation on the acrylic resin (Zissis et al., 2000). Findings similar to those of other studies (Sorgini et al., 2012; Freitas-Pontes et al., 2016), showed there was no increase in surface roughness over time.

In relation to gloss, there was no difference between brushes at T0 and T2; and a significant increase in values for Oral B at T1 and T3, indicating a greater polishing action, and to a lesser extent for the Bitufo, Condor and Orafix brushes at T3. Loss of gloss has been associated with causal factors of acrylic resin abrasion, such as the use of hard-bristled brushes, toothpastes, and prolonged brushing times (Dyer et al., 2001). An increase in gloss was observed over time, indicating greater polishing effect, except for Curaprox brush (T1 and T3), Bitufo (T2), Proteseplus (T2 and T3), and Orafix (T3), but without great variations in the mean values obtained at the end of the experiment. This was an interesting result, since the more polished the resin surface was, the greater the resistance to abrasion and the greater the longevity of the prosthesis (Sorgini et al., 2012, 2015).

A limitation of this study was that the bristles of both sides of the brushes were not evaluated over time. Although the results showed similarity between the sides regarding thickness for most of the brands analyzed, specific analysis of the smaller side is important since both sides are used during brushing. Another important limitation was the analysis of bristle thickness only. Therefore, future studies should cover bristles on both sides of the prosthetic brushes, as well as other bristle characteristics such as length and flexibility. These studies should include different commercial brands of brushes, as well as other properties of acrylic resins, such as flexural strength and hardness. Such evaluations, taken together, would enable elucidation of the relationship between bristle characteristics, efficacy, and absence of deleterious effects on the materials of which the dental prosthetic appliance is fabricated.

Conclusion

It was possible to conclude that the specific denture brushes Curaprox, Próteseplus, Condor, Oral B, and Orafix did not alter significantly the acrylic resin in complete dentures and may be use in denture hygiene routine by denture wearers.

References

André, R. F. G., Andrade, I. M. D., Silva-Lovato, C. H., Paranhos, H. D. F. O., Pimenta, F. C., & Ito, I. Y. (2011). Prevalence of mutans streptococci isolated from complete dentures and their susceptibility to mouthrinses. *Brazilian Dental Journal*, *22*(1), 62-67. DOI: https://doi.org/10.1590/s0103-64402011000100011

Aravind Raaj, V., Muthu, J., Pratebha, B., Saravanakumar, R., Vineela, K., & Sakthi Devi, S. (2018) Light Microscopic Analysis of Toothbrush Bristle End Morphology - An In Vitro Study. *Acta Scientific Dental Sciences, 2*(7), 84–88.

Arruda, C. N. F., Salles, M. M., Oliveira, V. C., Macedo, A. P., Silva-Lovato, C. H., & Paranhos, H. F. (2021). Using denture cleansers to control biofilm from dentures and brushes: a randomized crossover clinical trial. *The International Journal of Prosthodontics, 34*(3), 291–299. https://doi.org/10.11607/ijp.6665

Badaró, M. M., Bueno, F. L., Arnez, R. M., Oliveira, V. C., Macedo, A. P., Souza, R. F., Paranhos, H. F. O., & Silva-Lovato, C. H. (2020). The effects of three disinfection protocols on Candida spp., denture stomatitis, and biofilm: A parallel group randomized controlled trial. *The Journal of Prosthetic Dentistry, 124*(6), 690–698. https://doi.org/10.1016/j.prosdent.2019.09.024

Council on Dental Materials, Instruments, and Equipment. (1983). Denture cleansers. *The Journal of the American Dental Association*, *106*(1), 77-79. https://doi.org/10.14219/jada.archive.1983.0001

Fernandes, R. A. G., Lovato-Silva, C. H., Paranhos, H. F. O., & Ito, I. Y. (2007). Efficacy of three denture brushes on biofilm removal from complete dentures. *Journal of Applied Oral Science*, *15*(1), 39-43. https://doi.org/10.1590/s1678-77572007000100009

Freitas, K. M., & Paranhos, H. F. O. (2006). Weight loss of five commercially available denture teeth after toothbrushing with three different dentifrices. *Journal of Applied Oral Science*, *14*(4), 242. https://doi.org/10.1590/s1678-77572006000400006

Freitas Pontes, K. M., Holanda, J. C., Fonteles, C. S., Barros Pontes, C., Silva, C. H. L., & Paranhos, H.F.O. (2016). Effect of toothbrushes and denture brushes on heat-polymerized acrylic resins. *Gen Dent*, *64*(1), 49-53. PMID: 26742168

Gajwani-Jain, S., Magdum, D., Karagir, A., & Pharane, P. (2015). Denture cleansers: A review. *IOSR Journal of Dental and Medical Sciences*, *1*(14), 94-6. https://doi.org/10.9790/0853-14249496

International Organization for Standardization. [ISO].(1987). Dentistry. *Stiffness of the tufted area of toothbrushes, ISO 8627*. ICS: 97.170

Journal of the American Dental Association [JADA]. (2007). A look at toothbrushes. *The Journal of the American Dental Association, 138(9), 1288*.

Panzeri, H., Lara, E. H., Paranhos, H. F., Lovato Silva, C. H., Souza, R. F., Souza Gugelmin, M. C., Tirapelli, C., Cruz, P. C., & Andrade, I. M. (2009). In vitro and clinical evaluation of specific dentifrices for complete denture hygiene. *Gerodontology, 26*(1), 26–33. https://doi.org/10.1111/j.1741-2358.2008.00235.x

Papadiochou, S., & Polyzois, G. (2017). Hygiene practices in removable prosthodontics: A systematic review. *International Journal of Dental Hygiene*, *16*(2), 179-201. https://doi.org/10.1111/idh.12323

Paranhos, H. F. O., SILVA-LOVATO, C. H., Souza, R. F., Cruz, P. C., Freitas, K. M., & Peracini, A. (2007). Effects of mechanical and chemical methods on denture biofilm accumulation. *Journal of Oral Rehabilitation*, *34*(8), 606-612. https://doi.org/10.1111/j.1365-2842.2007.01753.x

Peracini, A., Andrade, M., Oliveira, V. C., Macedo, A. P., Silva-Lovato, C. H., Watanabe, E., & HF, O. P. (2017). Antimicrobial action and long-term effect of overnight denture cleansers. *American Journal of Dentistry*, *30*(2), 101-108. PMID: 29178772

Peracini, A., Andrade, I. M. D., Paranhos, H. D. F. O., Silva, C. H. L. D., & Souza, R. F. D. (2010). Behaviors and hygiene habits of complete denture wearers. *Brazilian Dental Journal*, *21*(3), 247-252. https://doi.org/10.1590/s0103-64402010000300013

Santos, A. C. M., Oliveira, V. C., Macedo, A. P., Bastos, J. K., Ogasawara, M. S., Watanabe, E., Chaguri, I. M., Silva-Lovato, C. H., & Paranhos, H. F. O. (2021). Effectiveness of Oil-Based Denture Dentifrices-Organoleptic Characteristics, Physicochemical Properties and Antimicrobial Action. *Antibiotics (Basel, Switzerland), 10*(7), 813. https://doi.org/10.3390/antibiotics10070813

Silva, C. H. L. D., & Paranhos, H. D. F. O. (2006). Efficacy of biofilm disclosing agent and of three brushes in the control of complete denture cleansing. *Journal of Applied Oral Science*, *14*(6), 454-459. https://doi.org/10.1590/s1678-77572006000600012

Silverstone, L. M., & Featherstone, M. J. (1988). Examination of the end rounding pattern of toothbrush bristles using scanning electron microscopy: a comparison of eight toothbrush types. *Gerodontics*, *4*(2), 45-62. PMID: 3209027

Sorgini, D. B., Silva-Lovato, C. H. D., Muglia, V. A., Souza, R. F. D., Arruda, C. N. F., & Paranhos, H. D. F. O. (2015). Adverse effects on PMMA caused by mechanical and combined methods of denture cleansing. *Brazilian Dental Journal*, *26*(3), 292-296. https://doi.org/10.1590/0103-6440201300028

Sorgini, D. B., Silva-Lovato, C. H. D., Souza, R. F. D., Davi, L. R., & Paranhos, H. D. F. O. (2012). Abrasiveness of conventional and specific denture-cleansing dentifrices. *Brazilian Dental Journal*, *23*(2), 154-159. https://doi.org/10.1590/s0103-64402012000200011

Tan, E., & Daly, C. (2002). Comparison of new and 3-month-old toothbrushes in plaque removal. *Journal of Clinical Periodontology*, *29*(7), 645-650. https://doi.org/10.1034/j.1600-051x.2002.290709.x

Wictorin, L. (1972). Effect of Toothbrushing on Acrylic Resin Veneering Material: II Abrasive Effect of Selected Dentifrices and Toothbrushes. *Acta Odontologica Scandinavica*, *30*(3), 383-395. https://doi.org/10.3109/00016357209004605