Effect of toothbrushes and denture brushes on heat-polymerized acrylic resins

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It is important to choose an appropriate brush for denture cleaning to prevent damage to the surface properties of prosthetic devices. The purpose of this study was to evaluate the abrasiveness of toothbrushes and denture brushes on boiled and microwave-processed acrylic resins. Specimens of 4 resin brands were prepared (n = 30). Five brands of brushes (n = 6) were used in a toothbrushing machine, first for 17,800 strokes and then for an additional 35,600 strokes (total of 53,400), at a load of 200 g. An analytical balance and a profilometer were used to assess the weight and surface roughness, respectively, before and after 17,800 and 53,400 strokes. Analysis of variance and Tukey tests were used for data analysis (α = 0.05). Weight loss increased with time, while surface roughness remained the same. There were no statistically significant differences among toothbrushes and denture brushes in the resulting weight loss (17,800 strokes, 1.83 mg; 53,400 strokes, 3.78 mg) or surface roughness (17,800 or 53,400 strokes, 0.14 µm). The weight loss values after 53,400 brush strokes indicated that Clássico (2.28 mg) and VIPI Wave (2.75 mg) presented significantly greater abrasion resistance than Lucitone 550 (3.36 mg) and Onda-Cryl (2.85 mg) (P < 0.05).

The type of brush and the polymerization method did not influence resin wear after brushing.

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Optimal denture cleaning is essential to the prevention of disease among edentulous patients, since some oral and systemic infections may originate from colonized inner surfaces of complete dentures. Denture surfaces commonly accumulate biofilm, and studies have shown a link between biofilm accumulation and denture stomatitis. Many denture wearers use a toothbrush, dentifrice, and water to mechanically remove debris, but this economical and simple technique, although effective, can result in wear of the denture base and relining materials. The use of nonabrasive pastes and brushes has been recommended for denture cleaning to prevent damage to the surface properties of prosthetic devices. The hypothesis tested was that different resins and toothbrushes or denture brushes influence weight loss and surface roughness after brushing.

Materials and methods

Study design

Four different brands of acrylic resins were selected to be used in the present study, rendering 4 groups (n = 30) of specimens. Each resin group was subdivided into 5 subgroups (n = 6), and a different toothbrush brand was assigned to each subgroup. The selected brushes included Oral-B Indicator Soft (Procter & Gamble); Johnson REACH Professional Soft (Johnson & Johnson); Johnson REACH Professional Medium (Johnson & Johnson); Prótese BITUFO (Hypermarcas S/A); and Medic Denture (Condor SA).

The geometries of bristle tips of the different brushes were observed, at 20× magnification, with a profilometer (Nikon, Nippon Kogaku KK). The bristle tips were classified according to the categories described by Silverstone & Featherstone, as modified by Jung et al.

Specimen preparation

For this experiment, 120 rectangular specimens (90 × 30 × 4 mm) were made using boiled (Clássico, Clássico Artigos Odontológicos, Ltda; Lucitone 550, VIPI Wave), boiled and microwave processed (Clássico Artigos Odontológicos, Ltda; Lucitone 550, VIPI Wave), and microwave processed (Clássico Artigos Odontológicos, Ltda; Lucitone 550, VIPI Wave).
Complete Dentures  Effect of toothbrushes and denture brushes on heat-polymerized acrylic resins

DENTSPLY International) and microwave-processed acrylic resins. All specimens were manufactured using a polymethyl methacrylate matrix. The matrix was flasked in type III and IV dental stone (Herodent Soli-Rock, Vigodent SA Indústria e Comércio) within appropriate flask designs (metallic for conventional polymerization and plastic for microwave polymerization). After the gypsum was completely set, the matrix was removed, the acrylic resin was packed, and the flasks were placed in a polymerizing unit. The resins were processed following their manufacturer’s instructions. For microwave-cured acrylic resins, the plastic flasks were placed in a microwave oven (Brastemp Clean, Whirlpool Latin America).

All flasks were bench cooled for 2 hours, subsequently removed, and ground with progressively smoother aluminum oxide papers (320, 400, and 600 grit) in a horizontal polisher (APL-4, Arotec SA). A brush wheel (TMP-200, Equilam Indústria e Comércio) with pumice slurry and a felt cone with chalk powder (Branco-Rio, OAB-ME) were used for mechanical polishing. All of the specimens were exposed to the same procedures, and each mechanical polishing step was performed for 1 minute on each surface.

The polished specimens were stored in distilled water at 37°C for 7 days, rinsed in running water, and then placed in an ultrasonic bath with distilled water and 1% of detergent for 1 minute. The specimens were dried with absorbent paper until all visible moisture disappeared. After 1 minute, the initial weight (mass \( m_1 \)) in milligrams was obtained with the aid of an analytical electronic scale with a sensitivity of 0.1 mg (Mettler-Toledo LLC). Roughness measurements were taken with a profilometer (Surfset SJ-201P, Mitutoyo America Corporation), calibrated at a specimen length of 0.8 mm, indentation of 4.0 mm, speed of 0.5 mm/s, and resolution of 0.01 μm. The initial surface roughness (Ra1) in microns was measured on specimens at 3 predetermined areas to establish a mean measurement for each specimen.

**Brushing assays**

The specimens were submitted to brushing assays in accordance with the recommendations of the International Organization for Standardization.14

The toothbrushing procedure involved a mechanical cross-brushing machine (Pepsodent, Precision Shop, University of São Paulo) in which 6 specimens could be brushed simultaneously at a load of 200 g. The brushing was performed with distilled water only, at 23°C (SD, 3°C). All specimens were subjected to 17,800 strokes, measured (weight and surface roughness), and then subjected to an additional 35,600 strokes. The total of 53,400 strokes correspond to 3 years of manual brushing.18,37 Brushes were replaced with new ones at each interval of 17,800 strokes.

**Weight loss and surface roughness calculations**

The gravimetric method was employed to calculate weight loss as \( \Delta m = m_1 - m_2 \), and \( \Delta m_3 = m_1 - m_3 \), where \( m_1 \) is the initial mass, \( m_2 \) is the mass after 17,800 brush strokes, and \( m_3 \) is the mass after 53,400 brush strokes. Surface roughness analysis was conducted by comparing the initial Ra values (Ra1) and the values obtained after 17,800 (Ra2) and 53,400 (Ra3) brush strokes.

**Statistical analysis**

Normality of the data was tested with a chi-square test. The weight loss and surface roughness variables showed normal and homogenous distribution. Therefore, 3-way analysis of variance (ANOVA) was used for comparisons among variation factors (number of brush strokes, tooth and denture brushes, and acrylic resins). When differences were identified, the Tukey test was applied as a post hoc test (α = 0.05). Weight loss and surface roughness data were reported as mean and standard deviation of the mean.

**Results**

Comparisons among groups showed a statistically significant difference (\( P < 0.05 \)) between weight loss after 17,800 (mean for all groups, 1.83 mg; SD, 0.60 mg) and 53,400 strokes (mean for all groups, 3.78 mg; SD, 0.90 mg), demonstrating an important increase in wear on the acrylic resins with brushing time (Table 1). In addition, resistance to abrasion also differed significantly among acrylic resin brands, although there were no differences among the brushes tested. Lucitone 550 was less abrasion resistant than all other resins. Clássico was the most resistant, followed by VIPI Wave and Onda-Cryl (Table 2).

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**Table 1. Analysis of variance table for weight loss.**

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>228.5394</td>
<td>1</td>
<td>228.5394</td>
<td>232.00</td>
<td>( P &lt; 0.05 )</td>
</tr>
<tr>
<td>B</td>
<td>10.8326</td>
<td>4</td>
<td>2.7082</td>
<td>2.75</td>
<td>NS</td>
</tr>
<tr>
<td>R</td>
<td>34.9979</td>
<td>3</td>
<td>11.6660</td>
<td>11.84</td>
<td>( P &lt; 0.05 )</td>
</tr>
<tr>
<td>T × B × R</td>
<td>7.8843</td>
<td>12</td>
<td>0.6570</td>
<td>0.67</td>
<td>NS</td>
</tr>
<tr>
<td>Residuals</td>
<td>197.0164</td>
<td>200</td>
<td>0.9851</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total variation</td>
<td>575.0148</td>
<td>239</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: B, brushes; df, degrees of freedom; NS, not significant; R, acrylic resins; MS, mean square; SS, sum of squares; T, number of strokes.

**Table 2. Weight loss (mg) of acrylic resins after 53,400 brush strokes.**

<table>
<thead>
<tr>
<th>Acrylic resin</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lucitone 550</td>
<td>3.36a</td>
<td>1.28</td>
</tr>
<tr>
<td>Clássico</td>
<td>2.28b</td>
<td>0.68</td>
</tr>
<tr>
<td>VIPI Wave</td>
<td>2.75bc</td>
<td>0.66</td>
</tr>
<tr>
<td>Onda-Cryl</td>
<td>2.85bc</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Means with different superscript letters are significantly different (\( P < 0.05 \)).
Surface roughness of the specimens differed significantly ($P < 0.05$) among resins (Table 3). These significant differences were related to the initial surface roughness of each resin before brushing (Table 4). The initial roughness values (0.14 µm) were not significantly changed after the abrasion assays (17,800 or 53,400 brush strokes), regardless of the toothbrush or denture brush used.

**Discussion**

The present study tested weight loss and surface roughness, which are adequate parameters to determine abrasion caused by brushing.\(^{18,24,26,32}\) The variation factors were the number of brush strokes (17,800 or 53,400), 4 brands of acrylic resins (boiled and microwave cured), and 5 brands of brushes, including toothbrushes and denture brushes. To evaluate the abrasiveness caused by brush bristles on various brands of acrylic resins, distilled water was chosen instead of a dentifrice to avoid interference of its abrasive agents and possible chemical influence on the substrate and to prevent variations in its retention by the different bristles.\(^{15,24}\) Studies that assess the abrasiveness caused by brushes alone are rare, especially comparisons of toothbrushes against brushes designed specifically for dentures.

Most studies that test abrasion caused by brushing employ dentifrices, with the intent of evaluating only the substrates and not the brushes.\(^{32,35}\) There is significant variation in the results of those studies due to the use of various types of dentifrices, with distinctive abrasive particles in different concentrations, making comparisons to the present data a challenge. The present work aimed to isolate the action of brushes by analyzing different types of bristles and the influence of these factors on the wear resistance of various brands of acrylic resin. The purpose was to test the hypothesis that specific denture brushes were more abrasive than toothbrushes considered soft. The bristle tips of all the toothbrushes and denture brushes in the present study were considered unacceptable, according to the classification proposed by Silverstone & Featherstone and modified by Jung et al.\(^{42,43}\) Most in vitro studies found in the literature use 20,000-100,000 brushing cycles, which simulate from 1-5 years of manual brushing.\(^{15,37}\) The present study chose to simulate the abrasion generated during the first 12 (17,800 cycles) and 36 months (53,400 cycles) of denture brushing. Since dentures should be replaced every 5-7 years, simulations held in the present study were equivalent to half the period that a patient should use the same denture.

The weight loss of specimens increased from an average of 1.83 (SD, 0.6) mg, or 0.02%, after 17,800 brush strokes to 3.78 (SD, 0.9) mg, or 0.03%, after 53,400 strokes. This increment was statistically significant ($P < 0.05$), indicating that brushing associated with distilled water can produce some level of abrasion. However, this weight loss is minimal when compared to the weight loss observed in the presence of dentifrices. Richmond et al demonstrated a weight loss of 300-500 mg on denture base polymers after 20,000 brushing cycles in the presence of toothpaste.\(^{26}\) However, they reported no weight loss following 50,000 brushing cycles without toothpaste. Other studies have also shown that brushing in association with water produces minimum wear on different substrates.\(^{15,17,35}\) To the authors’ knowledge, no previous studies have compared the abrasiveness of different types of brushes in the absence of dentifrices.

In the results of this study the different toothbrushes and denture brushes tested did not differ in their abrasiveness. This lack of difference was observed in weight loss and surface roughness, reinforcing the evidence that toothbrushes and denture brushes alone do not threaten the integrity of acrylic resins, regardless of the level of bristle hardness. Brushing with water alone did not alter surface roughness of the specimens, maintaining the values below 0.2 µm, previously reported as the critical value of surface roughness for bacterial adhesion.\(^{30}\) Therefore, importance should be given to the substances used with toothbrushes and denture brushes and to their ability to provide appropriate denture cleaning, given that many surveys have shown the influence of cleaning materials, mainly dentifrices, on the roughness of different dental materials. Dyer et al found a roughness range of 3.15-4.26 µm on acrylics submitted to 20,000 brushing cycles with toothpaste.\(^{15}\) Richmond et al observed roughness of 1.36-9.43 µm on acrylic resins after 100,000 brushing cycles.\(^{25}\) Oliveira et al found roughness of 0.88 µm on acrylic resins after 30,000 brushing cycles.\(^{36}\)}
Conclusion
Within the limitations of the present study, the following could be concluded:
1. Soft and medium toothbrushes and denture brushes showed equivalent abrasiveness on boiled or micro-wave-cured acrylic resins.

2. Acrylic resins expressed wear resistance in the following order: Clássico (conventional) resin demonstrated the highest wear resistance (i.e., least weight loss), followed by VIPI Wave (microwave), Onda-Cryl (microwave), and Lucitone 550 (conventional).

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