Effect of Tooth Brushing on the Surface of Enamel and Direct and Indirect CAD/CAM Restorative Materials

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Purpose: To determine the effects of tooth brushing on the surface roughness (Sa) and morphology, maximum relative depth (Rv), gloss (gloss units [GU]), and microhardness of four esthetic restorative materials and enamel. Materials and Methods: A light-curing composite resin (Filtek Supreme Ultra [FSU]), two hybrid resin/ceramic CAD/CAM materials (Lava Ultimate [LAV] and VITA Enamic [VEN]), and a CAD/CAM feldspathic ceramic (VITABLOCS Mark II) were evaluated. Bovine enamel (ENA) was used as a control group. All surfaces were polished in accordance with the manufacturer’s instructions. Samples were analyzed before and after brushing (30,000 cycles) regarding Sa and Rv using a 3D laser-measuring microscope. GU was evaluated every 10,000 tooth brushing cycles. Microhardness was measured before and after tooth brushing. The surfaces were observed using scanning electron and laser measuring microscopies to determine the wear patterns. Data were analyzed using paired t test, one-way or two-way repeated-measures analysis of variance, and Tukey test (α = .05), depending on the method performed. Results: The Sa increased significantly after brushing for all materials, except for VMA, which showed the opposite effect. ENA and VEN showed higher Rv than VMA. After 30,000 tooth brushing cycles, VMA showed the highest GU, while FSU showed the lowest. Also, few surface topography changes were observed for VMA. Microhardness did not change significantly after 30,000 brushing cycles, except for LAV. Conclusion: Brushing caused surface alterations in all tested materials except for feldspathic ceramic. The changes were more evident in resin-based materials. Int J Prosthodont 2021;34:473–481. doi: 10.11607/jip.6594

Esthetic discomfort of patients is normally related to color, shape, and position alterations of the maxillary anterior teeth.¹ One of the restorative approaches for this area is the placement of a full crown; however, this requires excessive preparation of sound teeth that may compromise their structural, pulpal, and periodontal health.¹,² Recently, technologic advances in dental materials and restorative techniques have allowed natural esthetic results to be obtained with minimal intervention.¹ Among those techniques, laminate veneer restorations are considered an esthetic...
and conservative treatment that may be acquired in two different ways: direct or indirect. Direct laminate veneers are based on the application of composite resin directly to the prepared tooth surface. They are easily contoured and polished, and, as a further advantage, the veneer may be easily repaired when necessary. However, these restorations have limited longevity because composite resins are susceptible to discoloration, wear, and marginal fractures. On the other hand, indirect laminate veneers might exhibit superior esthetic appeal and longevity, but require at least two clinical appointments, as they are produced in the laboratory from composite or ceramic materials. Their reparable is also not easy compared to direct treatment.

CAD/CAM systems have undergone extraordinary evolution, enabling the production of dental restorations such as veneers, inlays, onlays, and crowns from prefabricated blocks. Typically, two steps are required to fabricate a veneer in the laboratory: milling and sintering. More sophisticated blocks may have a one-step process that can be performed by the dentist and not require sintering. Also, they are easy to polish and may be repaired intraorally. One of these one-step systems is the VITABLOCS Mark II (VITA Zahnfabrik; VMA), a CAD/CAM feldspathic ceramic block that has been used for more than 20 years and is indicated for inlays, onlays, and veneers.

Composite resin blocks for CAD/CAM have been developed using high-pressure/high-temperature polymerization for block fabrication, which results in a well-polymerized, less porous material with improved mechanical properties. In addition, composite CAD/CAM blocks offer better machinability with less milling time, increasing the bur lifetime. There are two classes of composite resin blocks for CAD/CAM, which differ depending on their microstructure. The first is a composite resin block containing ceramic nanoparticles bound in a resin matrix (Lava Ultimate [LAV], 3M ESPE). The second is a polymer-infiltrated ceramic network obtained by the infiltration of a feldspathic ceramic with a monomer mixture (VITA ENAMIC [VEN], VITA Zahnfabrik).

While ceramic materials may exhibit lower intraoral wear, composite materials suffer degradation following interaction with the oral environment. Therefore, there are major concerns regarding the performance of one-step CAD/CAM blocks (feldspathic and hybrid resin/ceramic material) in terms of their long-term in vivo performance, as the restorations are subjected to a variety of factors, such as food and daily cleaning, that may alter the quality of the surface. Tooth brushing may have a significant role in affecting the surface roughness (Sa) and gloss retention of restorative materials and dental hard tissues. Little information is available regarding the influence of tooth brushing on the surface of one-step CAD/CAM blocks. Therefore, the purpose of this study was to determine the effects of tooth brushing on the Sa and morphology, gloss retention, and microhardness of four esthetic restorative materials and enamel. The null hypothesis was that tooth brushing would not alter the surface of enamel, direct composite, or CAD/CAM materials.

**MATERIALS AND METHODS**

**Specimen Preparation**

A visible light–activated composite resin (Filtek Supreme Ultra [FSU], 3M ESPE), two hybrid resin/ceramic CAD/CAM blocks (LAV and VEN), and a feldspathic ceramic CAD/CAM block (VMA) were used in the present study. Bovine enamel (ENA) was used as a control. The compositions, lot numbers, and manufacturers of the tested materials are listed in Table 1.

Resin disks (n = 10) of FSU (10 x 12 x 2 mm) were prepared using silicone molds (Express ST Putty Soft, 3M ESPE). The composite was placed into the molds, covered with a Mylar strip, and pressed with a glass slide. The composite was light-cured (VALO, Ultradent) in contact with the Mylar strip for 20 seconds. Subsequently, the blocks were polished with 1,200- and 2,400-grit silicon carbide (SiC) sandpaper (3M ESPE) on a polishing machine (Aropol-2V, Arotec). For the final polishing, a polishing paste (Universal Polishing Paste, Ivoclar Vivadent) was used.

Ten specimens were obtained from each CAD/CAM block (LAV, VEN, and VMA). All the specimens were sectioned in 2-mm thickness using a low-speed diamond saw (IsoMet, Buehler). Afterward, the specimens were wet-polished with 1,200- and 2,400-grit SiC sandpaper on a polishing machine. LAV and ENA were additionally polished with the polishing paste.

For the ENA blocks, 10 crowns of extracted bovine incisors, without fractures or cracks, were stored in distilled water at 4°C for less than 3 months. The crowns were embedded in acrylic resin (VIP Flash) and polished following the protocol proposed by Fernández et al.

The facial surfaces were ground on wet 400-grit SiC sandpaper to achieve a flat enamel surface and then wet-polished with 600- and 1,200-grit SiC sandpaper on a polishing machine. Final polishing was performed with a 1-mm diamond solution (MetaDi Supreme, Buehler). A single operator performed all the polishing procedures.

**Tooth Brushing**

Tooth brushing was performed following the protocol proposed by Sahadi et al. Briefly, specimens were stored in water for 24 hours before tooth brushing. An adhesive tape (Scotch duct tape, 3M) was fixed over half of the polished surface to protect this area from brushing.
and to serve as a control area (unbrushed). The other half of the specimen surface (without adhesive tape) was submitted to 30,000 tooth brushing cycles (150 cycles/minute), with a vertical force of 2 N on the toothbrushes (Colgate Essencial Clean Soft, Colgate-Palmolive) at 2 Hz, using a tooth brushing machine (Maquina de Escivaçã, Biopdi). Toothbrushes were not replaced during the cycles. A toothpaste solution was prepared by mixing 25 g of toothpaste (Colgate Total 12 Pro Gum Health, Colgate-Palmolive) and 50 mL of deionized water using a magnetic mixer for 10 minutes. The solution was placed into the reservoir of the tooth brushing device and was periodically changed every 10,000 cycles (Fig 1).

Profilometry
After brushing, the adhesive tape was removed and the specimens were washed, air dried, and analyzed regarding Sa and surface profile (maximum relative depth [Rv]).

A 3D noncontact laser-scanning microscope (LEXT OLS4000 3D Laser Measuring Microscope, Olympus) was used to obtain the measurements and the 3D images, Sa, and Rv of the samples. For Rv calculation, five measurements that started on the control area and extended into the brushed region were made, and the mean value was calculated. The data were analyzed with OLS4000 software (Olympus).

Gloss Retention
Gloss measurements were performed with a glossmeter (ZGM 1120 Glossmeter, Zehnten Testing Instruments) with an incident angle of 60 degrees. The glossmeter was calibrated on a black glass provided by the manufacturer. The surface gloss (gloss units [GU]) of the specimens was measured before brushing and after 10,000, 20,000, and 30,000 cycles. Three readings were taken at the center of each specimen, each time turning the specimen by 90 degrees. The obtained values were averaged to obtain a mean for each specimen.

Microhardness
Microhardness was determined by using a Knoop microhardness tester (FM-ARS 9000, Future-Tech) at a 50-gf load applied for 5 seconds. Three Knoop hardness indentations, with 100-µm distance between them, were made on both the control and brushed areas of each specimen. The mean hardness on each surface was calculated for each side of the specimens.

Scanning Electron Microscopy Observation
Representative specimens of each material (closest to the average) were selected and sputter-coated with gold in a vacuum evaporator (MED 010, Leica Microsystems). Scanning electron microscopy (SEM; Leo 345 VP, Leica Microsystems) was used to observe and capture images of the surfaces. Photomicrographs of representative

<table>
<thead>
<tr>
<th>Material (abbreviation)</th>
<th>Manufacturer (lot no.)</th>
<th>Shade (size)</th>
<th>Composition</th>
<th>Filler (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional composite resin</td>
<td>3M ESPE (652583688062)</td>
<td>A28</td>
<td>Monomers: Bis-GMA, UDMA, Bis-EMA, TEGDMA, PEGDMA</td>
<td>73</td>
</tr>
<tr>
<td>Composite resin block</td>
<td>3M ESPE (N813127)</td>
<td>A2HT (14L)</td>
<td>Monomers: Bis-GMA, UDMA, Bis-EMA, TEGDMA</td>
<td>80</td>
</tr>
<tr>
<td>Hybrid ceramic block</td>
<td>VITA (37830)</td>
<td>2M2HT (EM14)</td>
<td>Monomers: UDMA, TEGDMA</td>
<td>86</td>
</tr>
<tr>
<td>Feldspar ceramic block</td>
<td>VITA (52210)</td>
<td>1M2C (I14)</td>
<td>Feldsparic crystalline particles in glassy matrix</td>
<td>–</td>
</tr>
</tbody>
</table>

Bis-GMA = bisphenol A diglycidyl methacrylate; UDMA = urethane dimethacrylate; Bis-EMA = ethoxylated bisphenol A glycol dimethacrylate; TEGDMA = trimethylolpropane trimethacrylate; PEGDMA = poly(ethylene glycol)-dimethacrylate.
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areas were taken of the control (unbrushed) and brushed sides at ×1,500 magnification.

Statistical Analysis

Statistical analysis was performed with SPSS version 21 (IBM) software. Gloss data (GU) and Sa (in µm) were analyzed using one-way repeated-measures analysis of variance (ANOVA) followed by post hoc Tukey test. Rv (in mm) was analyzed using one-way ANOVA and post hoc Tukey test. Microhardness data were analyzed using paired t test. The level of significance was α = .05 for all analyses.

RESULTS

The mean and SD values of Sa for both unbrushed and brushed areas of all materials are summarized in Table 2. ANOVA showed that the Sa results were influenced by tooth brushing. The interaction between these two factors was statistically significant (P < .0001). Tukey post hoc test demonstrated that the brushing increased the Sa for all groups (P < .05), except for VMA, in which the tooth brushing significantly decreased the Sa.

The Rv of all materials is presented in Table 3. ANOVA demonstrated that there was a significant difference among materials (P < .0001), and Tukey test showed that ENA and VEN showed higher Rv values than VMA.

The mean and SD values for GU are presented in Table 4. ANOVA showed that the GU results were significantly influenced by tooth brushing, and the interaction between brushing and material was also significant (P < .0001), indicating that the effect of brushing on GU was different for each material. Tukey post hoc test revealed that, except for VMA, all tested materials showed a significant decrease in GU after 10,000 cycles. For LAV, FSU, and VEN, GU was stabilized after 10,000 cycles. In contrast, ENA suffered a continuous loss of surface gloss throughout the test.

Surface microhardness data are presented in Table 5. Paired t test showed that microhardness did not change significantly after tooth brushing for ENA or for any of

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Surface Roughness (µm) Before and After Brushing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Unbrushed</td>
</tr>
<tr>
<td>ENA</td>
<td>0.27 ± 0.10A,a</td>
</tr>
<tr>
<td>FSU</td>
<td>0.34 ± 0.16A,a</td>
</tr>
<tr>
<td>LAV</td>
<td>0.41 ± 0.23A,b</td>
</tr>
<tr>
<td>VEN</td>
<td>0.68 ± 0.26A,b</td>
</tr>
<tr>
<td>VMA</td>
<td>0.62 ± 0.19A,b</td>
</tr>
</tbody>
</table>

Data are reported as mean ± SD. Different uppercase superscript letters indicate significant differences between unbrushed and brushed sides within the same material, and different lowercase superscript letters indicate significant differences between materials (P < .05, one-way repeated-measures ANOVA and post hoc Tukey test).

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Maximum Relative Depth (Rv) for Restorative Materials and Enamel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Rv, mean ± SD</td>
</tr>
<tr>
<td>ENA</td>
<td>1.54 ± 0.45A</td>
</tr>
<tr>
<td>FSU</td>
<td>1.31 ± 0.18A,B</td>
</tr>
<tr>
<td>LAV</td>
<td>1.21 ± 0.14A.B</td>
</tr>
<tr>
<td>VEN</td>
<td>1.60 ± 0.39A</td>
</tr>
<tr>
<td>VMA</td>
<td>1.01 ± 0.29A</td>
</tr>
</tbody>
</table>

Different superscript letters indicate significant differences between materials (P < .05, one-way ANOVA and post hoc Tukey test).

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Values (GU) of Tested Restorative Materials and Enamel at Each Measurement Following Tooth Brushing Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Initial (unbrushed)</td>
</tr>
<tr>
<td>ENA</td>
<td>110.6 ± 2.6A,a</td>
</tr>
<tr>
<td>FSU</td>
<td>81.6 ± 4.3A,c</td>
</tr>
<tr>
<td>LAV</td>
<td>95.1 ± 2.9A,b</td>
</tr>
<tr>
<td>VEN</td>
<td>75.4 ± 10.3A,C</td>
</tr>
<tr>
<td>VMA</td>
<td>82.9 ± 9.0A,c</td>
</tr>
</tbody>
</table>

Data are reported as mean ± SD. Different uppercase superscript letters indicate significant differences between brushing cycles within the same material, and lowercase superscript letters between materials within the same number of cycles (P < .05; one-way repeated measures ANOVA and post hoc Tukey test).

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Knoop Microhardness (KHN) Before and After Brushing for Restorative Materials and Enamel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Unbrushed</td>
</tr>
<tr>
<td>ENA</td>
<td>272.2 ± 8.5A</td>
</tr>
<tr>
<td>FSU</td>
<td>76.2 ± 5.2A</td>
</tr>
<tr>
<td>LAV</td>
<td>94.6 ± 3.9A</td>
</tr>
<tr>
<td>VEN</td>
<td>247.2 ± 17.1A</td>
</tr>
<tr>
<td>VMA</td>
<td>554.1 ± 17.7A</td>
</tr>
</tbody>
</table>

Data are reported as mean ± SD. Different superscript letters indicate a significant difference between unbrushed and brushed sides (P < .05, paired t test).
the indirect restorative materials ($P > .05$), except for LAV, in which the microhardness significantly decreased after brushing ($P = .002$). VMA showed the highest microhardness value, and FSU the lowest.

The 3D confocal images of ENA and each restorative material tested before and after 30,000 brushing cycles are shown in Fig 2. Before tooth brushing, all materials showed a smooth surface; however, some scratches can be observed on the left (control) sides, which were caused by the polishing. Figure 2a shows a representative image of ENA in which the abrasion and volume loss are clearly visible on the brushed surface, revealing a presence of fissures, which became more evident after brushing. Tooth brushing increased $S_a$ and superficial defects for FSU and LAV (Figs 2b and 2c). For VEN, a decrease in the surface quality evident by the appearance of spherical fillers can be observed (Fig 2d). For VMA, the surface changes were not significant after tooth brushing on the control side (Fig 2e).

Figure 3 shows the SEM images of each restorative material before and after 30,000 tooth brushing cycles. All materials presented a smooth surface before...
brushing. ENA samples showed surfaces with scratches caused by polishing (Fig 3a); after tooth brushing, the surfaces were severely affected by the brushing, and the abrasion could be clearly observed (Fig 3b). The FSU and LAV samples showed similar compositions, with different spherical filler sizes dispersed on the surfaces and minor scratches from polishing (Figs 3c and 3e). After tooth brushing, the resin matrix wear and the filler exposure could be observed (Figs 3d and 3f). VEN samples showed a ceramic network interconnected with a polymer-based network (Fig 3g). Although resin matrix loss was observed, no changes were observed in the ceramic structure (Fig 3h). The VMA samples showed a surface with few scratches caused by SiC polishing (Fig 3i), and after tooth brushing, surfaces without scratches were observed (Fig 3j).

**Fig 3** Representative SEM images showing the unbrushed (left) and brushed (right) sides of each material and enamel surfaces. (a, b) ENA. (c, d) FSU. (e, f) LAV. (g, h, facing page) VEN. (i, j, facing page) VMA. ×1,500 magnification.
DISCUSSION

In the present study, the results demonstrated that the surface roughness, gloss, and microhardness were significantly influenced by the material composition. In general, resin-based materials suffer more surface alterations. The null hypothesis of the present study was rejected because tooth brushing altered the surfaces of enamel, direct composite, and hybrid resin-ceramic CAD/CAM materials, as detected by profilometry, hardness, and other methods. On the other hand, feldspathic CAD/CAM material (VMA) showed gloss retention, no changes in microhardness, and the lowest Sa and Rv values after brushing. The topography analysis after tooth brushing also showed minor surface alterations for VMA.

For one-step CAD/CAM blocks (feldspathic and hybrid resin-ceramic materials), glaze and stain firing are not required, and the only necessary step after the milling process is polishing before cementation. In addition to the CAD/CAM materials, a direct composite resin was also tested, while the bovine enamel served as control. Due to the variety of tested materials, each one received a specific polishing procedure in order to meet the manufacturer’s requirements. To obtain a flat and polished surface, the pink rubber polisher was replaced by 1,200-grit SiC paper, and the gray polishing abrasive by 2,400-grit SiC paper. A single operator performed all the polishing procedures due to previous reports of polishing results being affected by the pressure applied during the process. Clinically, there are several factors that may alter the surfaces of restorative materials and dental tissues. Tooth brushing is one such factor and may cause side effects in superficial roughness and gloss. In order to simulate the clinical situation, the tooth brushing protocol used in this study was performed following the ISO/TS 14569-119 technical specification, with a brushing force of 2 N. A soft-bristle toothbrush was used, as is commonly recommended by dentists. Additionally, the selected toothpaste has a relative dentin abrasivity (RDA) level of 44, which is considered to be a low abrasion value. RDA is a method of measuring the abrasive effect of toothpaste on the dentin surface. A toothbrush and dentifrice were used in 30,000 brushing cycles, which may correspond to a clinical simulation of 4 to 6 years with twice-daily brushing. Some studies have shown that toothpaste with high RDA may increase gloss loss, with a greater increase in the Sa and the wear of composite resin.

Different methods were used in this study to evaluate the effects of tooth brushing on the material’s surface: confocal profilometry, gloss, microhardness, and SEM. 3D images, Sa, and Rv data were obtained by
a 3D noncontact laser measuring microscope, which has certain advantages when compared to mechanical profilometry. A profilometer contains an optical sensor with a resolution of around 20 to 50 µm, ensuring that the obtained Sa values are more accurate, especially when very smooth surfaces are analyzed. In addition, noncontact profilometry excludes any possible superficial damage that could cause alterations in the results obtained by the mechanical sensor.17 Moreover, the optical sensor allows the analysis of a wide representative area of each specimen. The scanned area in the present study was 2.5 x 2.5 mm.

Composite wear resistance depends on several factors, such as filler content, quality of the interfacial bond between the fillers and matrix, the extent of the curing of the resin matrix, and manufacturing process.24–27 Wear resistance is a crucial factor in maintaining stable occlusal contacts over time and guarantees the longevity of a restoration.27 Many parameters have been used to evaluate wear resistance, but the parameters Sa and Rv were adopted for the present study. Sa is based on the depth of the scratches on a material's surface.7,28,29 All materials tested suffered an increase in their Sa after 30,000 tooth brushing cycles, except for VMA, which showed a decrease in Sa values. VMA is a feldspathic glass-ceramic with greater hardness, and the abrasive silica particles in the toothpaste, along with the toothbrush, might have acted as a long-term polishing procedure (Fig 2e)9 that affected only the higher peak irregularities, producing a smooth surface as observed in the SEM image (Fig 3j).

FSU and LAV present similar monomeric compositions and particle shapes (Figs 3c to 3f), but different filler content (FSU: 56 vol%; LAV: 65 vol%)9 and manufacturing processes.24–26 Differences between these materials did not influence Sa results, and these materials both presented visible wear after tooth brushing according to noncontact profilometry (Figs 2b and 2c). VEN samples also showed a significant increase in Sa and slight wear detected by SEM and noncontact laser microscopy. VEN is a hybrid material that combines feldspathic particles and methacrylate polymers. The increase of Sa may be related to polymeric organic matrix degradation and removal by tooth brushing (Figs 3g and 3h).29

Unexpectedly, tooth brushing resulted in increased Sa values in ENA with mineral loss and topography changes that were noted by microscopy investigations (Figs 2a, 3a, and 3b). In an oral environment, saliva has a protective effect on the enamel and may contribute to its remineralization, minimizing the effects of tooth brushing.30–32

Although Sa is usually used to express surface profile/roughness, it does not fully describe the surface of the material, and other parameters should be used.33 Some studies consider that the surface morphology provides information related to biofilm formation, since the presence of deeper and larger depressions creates protective walls for bacterial colonization and biofilm formation.16,28 Rv expresses the maximum value of valley depth in a surface of the sample. In this study, VMA presented lower Rv after tooth brushing than VEN and ENA, but did not differ from FSU and LAV, which contained spherical filler particles and presented intermediate Sa results.

Surface gloss is a parameter that is more perceptible by clinicians and patients.7 Surface gloss represents the amount of specular (mirror-like) reflection from a surface and is used to evaluate the visual appearance of an object.6 Significant differences in the mean GU were obtained before and after brushing. The gloss of all materials showed a significant decrease after 10,000 cycles, except for VMA, which maintained the gloss up to 30,000 cycles. However, no material was below the range recommended by the ADA specifications (40 to 60 GU).9,34 Several studies have demonstrated that composites show a greater gloss loss than ceramics due to the resin matrix being more easily abraded.6,7,10,20 In addition, as the filler particles are much harder, the matrix is easily worn during tooth brushing.7 Excluding VMA, all other restorative materials tested have an organic matrix, which may explain why VMA maintained the gloss after tooth brushing. Also, LAV presented more gloss retention than FSU, and this may be a consequence of the high-pressure and temperature manufacturing process used.

The Knoop microhardness method is useful to evaluate the characteristics of composites related to wear resistance.7 The surface hardness varied among restorative materials due to the difference compositions of each material tested (Table 5). The microhardness results after brushing showed a significant decrease only for LAV, indicating that this material is closer to a composite resin than to a ceramic.8 Conversely, FSU maintained its microhardness value. Studies have shown that LAV suffered surface deterioration after storage in water.6 In contrast, VMA showed the highest microhardness, similar to previous reports.7,10 According to Koizumi et al,7 hardness is influenced not only by the inorganic filler content, but also by the filler size, shape, and polymeric matrix. Therefore, it is reasonable to assume that tooth brushing can easily scratch materials with lower hardness, resulting in higher Sa values and loss of gloss retention after 30,000 tooth brushing cycles.

Thus, alterations on the surface of the material will affect the gloss because the alterations can scatter light instead of reflecting it.6 On the other hand, hardness is a factor that makes the polishing procedure difficult, reducing the possibility of obtaining a smooth surface. However, it also improves the wear resistance of the material, increasing its gloss retention.35

This study provided information about roughness, gloss, and microhardness of four esthetic restorative
materials and enamel after tooth brushing. Only the CAD/CAM feldspathic ceramic block was not negatively affected by brushing cycles, while the other resin-based materials showed a significant increase in roughness and decrease in gloss after tooth brushing. Thus, clinicians should consider the best results from the gloss retention, microhardness, surface roughness, and profile and morphology analyses when choosing a restorative material for aesthetic reasons or for occlusal areas. Although long-term clinical studies are necessary to better understand the clinical performance of these materials, the present results suggest that glass-ceramics present adequate esthetic outcomes after 30,000 tooth brushing cycles, which is an in vitro simulation of 3 years of brushing, while the indirect hybrid composite CAD/CAM materials should behave similarly to direct composites.

CONCLUSIONS

Tooth brushing promotes surface alterations in composite resin, hybrid resin/ceramic CAD/CAM blocks, and bovine enamel. Surface roughness, gloss, and microhardness were significantly influenced by the material composition, and resin-based materials are more prone to surface alterations.

ACKNOWLEDGMENTS

CAPES grant number: 1777/2014. The authors report no conflicts of interest.

REFERENCES