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Multiple-peak and single-peak dental curing lights comparison on the wear resistance of bulk-fill composites

Beatriz Ometto SAHADI[a]
Richard Bengt PRICE[b]
Carolina Bosso ANDRÉ[a]
Maicon SEBOLD[a]
Gabriel Nima BERMEJO[a]
Regina Guenka PALMA-DIBB[c]
Juliana Jendiroba FARAONI[c]
Carlos José SOARES[d]
Marcelo GIANNINI[a]

[a]Universidade Estadual de Campinas – Unicamp, Piracicaba Dental School, Department of Restorative Dentistry, Piracicaba, SP, Brazil.

[b]Dalhousie University, Faculty of Dentistry, Department of Dental Clinical Sciences, Halifax, Canada.

[c]Universidade de São Paulo – USP, Ribeirão Preto School of Dentistry,Department of Restorative Dentistry, Ribeirão Preto, SP, Brazil.

[d]Universidade Federal de Uberlândia – UFU, School of Dentistry, Department of Operative Dentistry, Uberlândia, MG, Brazil.

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Corresponding Author:
Carolina Bosso André
E-mail: carolina.bosso@gmail.com

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Abstract: The effects of tooth brushing could affect the long-term esthetic outcome of composite restorations. This study evaluated the effect of two different emission spectrum light-curing units on the surface roughness, roughness profile, topography and microhardness of bulk-fill composites after *in vitro* toothbrushing. Valo (multiple-peak) and Demi Ultra (single-peak) curing lights were each used for 10s to polymerize three bulk-fill resin composites: Filtek Bulk Fill Posterior Restorative (FBF), Tetric EvoCeram Bulk Fill (TET) and Surefil SDR Flow (SDR). After 30,000 reciprocal strokes in a toothbrushing machine, the roughness profile, surface roughness, surface morphology, and microhardness were examined. Representative SEM images were also obtained. When light-cured with the Demi Ultra, SDR showed the most loss in volume compared to the other composites and higher volume loss compared to when was light-cured with Valo. The highest surface roughness and roughness profile values were found in SDR after toothbrushing, for both light-curing units tested. FBF always had the greatest microhardness values. Light-curing TET with Valo resulted in higher microhardness compared to when using the Demi Ultra. Confocal and SEM images show that toothbrushing resulted in smoother surfaces for FBF and TET. All composites exhibited surface volume loss after toothbrushing. The loss in volume of SDR depended on the light-curing unit used. Toothbrushing can alter the surface roughness and superficial aspect of some bulk-fill composites. The choice of light-curing unit did not affect the roughness profile, but, depending on the composite, it affected the microhardness.

Keywords: Composite Resins; Toothbrushing; Polymerization.

Introduction

The surface of resin-based restorative materials can be negatively affected by bacterial biodegradation or by salivary enzymes,[1,2,3] and occlusal and toothbrushing induced wear.[4,5] Previous studies have shown that toothbrushing can increase the surface roughness and alter the surface topography of resin composites,[6,7] which can increase the formation of biofilm on the tooth.[8] This may then increase the risk of recurrent caries and periodontal disease. Toothbrushing can also decrease the surface gloss of resin composites[9,10] and compounds the wear caused by occlusal loading.[4] Both of these factors can negatively affect the long-term esthetic outcome of the resin composite restorations.

Incremental filling and light curing techniques have been successfully used for many years and are recommended to improve internal and marginal adaptation of composites, to reduce the formation of enamel cracks around restorations, to reduce adhesive debonding and cusp deflection,[11,12] and to decrease shrinkage stress caused by the polymerization reaction.[11,13] The introduction of bulk-fill composites made it possible to increase the maximum thickness of each resin increment to 4 or 5 mm compared to the traditional layering technique that limited each increment to at most 2 mm thick.[1,2,3]

Bulk-fill composites use a combination of different filler particles, monomers and photoinitiators to achieve this increased depth of cure.[14,15] However, depending on the light-curing unit (LCU) and the photoinitiator used, the degree of conversion and surface microhardness values may be affected. Moreover, differences in filler particles and the resin composition may alter the wear resistance of the resin composite.[16,17]

Light-emitting diode (LED) LCUs can emit a single-peak (emitting blue light only) or multiple-peak (emitting a combination of both violet and blue light). These differences may affect the polymerization reaction, depending on the photoinitiators used within the resin composite.[18,19] Many studies have evaluated the mechanical properties, polymerization shrinkage stress and depth of cure of bulk-fill composites;[20,21,22,23,24] however, few studies have shown the effects of different LCUs on the microhardness, volume loss, surface roughness, and topography of bulk-fill composite resins after simulated toothbrushing.[25,26,27]

Since the interaction between the bulk-fill resin composites and LED LCUs may influence the clinical performance of composite restorations, this study analyzed the effects of two different LCUs (single and multiple-peak LED lights) on the surface roughness, morphology, microhardness, roughness profile and volume loss of three bulk-fill composites after 30,000 reciprocal strokes with a toothbrush. The null hypotheses were that surface roughness, topography, microhardness, roughness profile and volume loss would not be affected (1) by the choice of LCU (single-peak or multiple-peak), (2) by composite type (flowable bulk-fill or paste bulk-fill), and (3) by toothbrushing.

Materials and Methods

Specimen preparation, experimental groups and toothbrushing

Two LCUs were used in this study: a pen-style multiple-peak LED light (Valo Cordless, serial #C26561, Ultradent Products, Inc., South Jordan, UT, USA) and a gun-style single-peak LED light (Demi Ultra, serial #787016978, Kerr Corp., Orange, USA). The Valo delivered a spectral peak emission at 458 nm, with two additional peaks at 402 nm (violet) and 447 nm (blue). Demi Ultra delivered a single spectral peak emission at 461 nm. The emission spectra for both LCUs are shown in Figure 1. In 10 s the Valo and Demi Ultra delivered 16.8 J/cm^2 and 17.4 J/cm^2 to the samples respectively. These values were obtained using the anterior sensor on the MARC patient simulator (MARC-PS, BlueLight Analytics Inc., Halifax, Canada).

Three resin composites were compared: two paste consistency bulk-fill composites (Filtek Bulk Fill Posterior Restorative - FBF, and Tetric EvoCeram Bulk Fill - TET) and a flowable bulk-fill composite (Surefil SDR Flow - SDR). Their composition as provided by the manufacturers and their lot numbers are reported in Table 1.

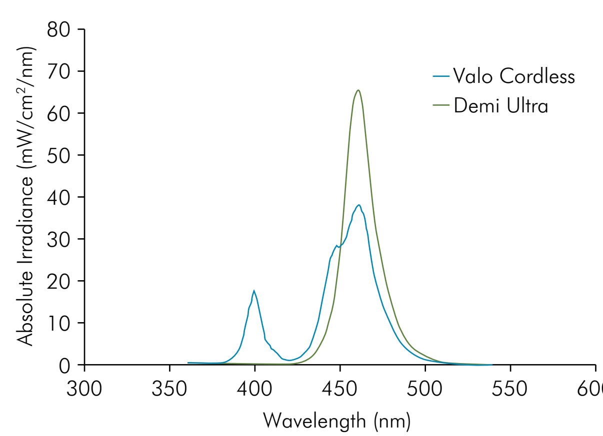

Figure 1. Emission spectra of Valo (blue line) and Demi Ultra (green line) LCUs.

Table 1. Composition and batch numbers.

Bulk-fill composites (manufacturer)	Composition	Lot number
Filtek bulk fill posterior restorative (3M Oral Care, St. Paul, USA)	Aromatic urethane dimethacrylate, 1,12-dodecane dimethycrylate, diurethane dimethacrylate, pentanedioic acid, 2,2-dimethyl-4-methylene-(reaction products with glycidyl methacrylate), ethyl 4-dimethyl aminobenzoate, benzotriazol, silane treated ceramic, silane treated silica, silane treated zirconia, ytterbium fluoride, water, titanium dioxide.	N685666
Surefil SDR flow (Dentsply Sirona, Konstanz, Germany)	Modified urethane dimethacrylate, tri ethylene glycol dimethacrylate, ethoxylated bisphenol A dimethacrylate, barium-alumino-fluoro-borosilicate glass, strontium-alumino-fluoro-borosilicate glass.	1503132
Tetric EvoCeram Bulk Fill (Ivoclar Vivadent, Schaan, Liechtenstein)	Bisphenol A glycidyl methacrylate, urethane dimethacrylate, barium glass, ytterbium trifluoride, oxides and prepolymers.	S40860

Resin disks (n = 10) that were 2 mm thick and 10 mm in diameter were made of each bulk-fill composite in silicon molds (Putty Soft, Express XT, 3M Oral care, St Paul, USA), for each light-cured tested (60 disks in a total). Sample size was calculated based on a pilot study for all methodologies investigated (desired power = 0.95 / α = 0.05). Although the results suggested a lower number of specimens, a sample size of 10 was used to ensure the reliability of the performed tests. The bulk-fill composites were placed into these molds, covered with a Mylar strip and light-cured for 10 seconds, with the light tip in contact with the Mylar strip, using one of the two LCUs. After light-curing, the disks were removed from the molds and the surface in contact with the Mylar strip (at the top of the mold) was slightly wet-polished with aluminum oxide (Al_2O_3) sandpaper (600-grit, 3M of Brazil, Sumaré, Brazil) for 10 seconds. The specimens were stored in deionized water for 24 hours at room temperature before toothbrushing. Adhesive tape (Scotch duct tape 471, 3M of Brazil, Sumaré, Brazil) was attached over half of the polished surface of the composite, so the covered area would be protected from brushing, and thus could act as the control area (unbrushed). The other half of the specimens (without adhesive tape) was submitted to 30,000 reciprocal strokes (150 cycles/min) of toothbrushing (Biopdi, São Carlos, Brazil), which corresponded to approximately two years of toothbrushing. [28,29,30]

A 200 g load was delivered by soft toothbrushes (Oral-B Indicator 35, Seropédica, RJ, Brazil), that were covered in a slurry of toothpaste (Oral-B Pro-Health, Procter & Gamble) solution (16 g of toothpaste with 100 mL of deionized water).

Analysis using confocal microscopy

After brushing, the adhesive tape was removed, and the specimens were washed, air-dried so that the surface roughness (Sa), roughness profile (Rv), and volume loss could be measured. Also, representative 3D images of the composite surfaces were obtained to compare the control (unbrushed) and brushed areas to visualize the surface roughness, volume loss, and wear profile. The Sa parameter describes the arithmetic height deviation from a mean plane three-dimensionally, and corresponds to the two-dimensional parameter Ra, which measures surface roughness by detecting the maximum peak to valley heights of a specific surface profile.[31]

The disks of composite were analyzed using confocal microscopy (LEXT 3D Measuring Laser Microscope OLS4000, Olympus Corp., Tokyo, Japan). A 5x objective lens (1x zoom) was used to obtain images (1024 x 1024 pixels, XYZ fast scan) with a 405 nm laser (Gaussian filter). Three-dimensional images, surface roughness, roughness profile and volume loss data were obtained using the OLS4000 software (Olympus Corp.). An image from the unbrushed side and another one from the brushed side was obtained from each sample to calculate the surface roughness. An image containing 0.5 mm of the unbrushed side margining the brushed side of each sample was obtained to calculate the roughness profile and the volume loss. The roughness profile (2D) was determined from the largest valley depth deviation from the mean line within a given length (10 readings at each image). To calculate the volume loss a reference plan from the top of unbrushed area was defined and the software calculated the volume loss located below this reference. Surface roughness data were expressed in µm and analyzed by three-way repeated measures ANOVA (between-subject factors: "LCUs" and "composite"; within-subject factor: "treatment") and post-hoc Tukey's test ($\alpha = 0.05$; IBM SPSS 21 Statistics Software, IBM Corp., Armonk, USA). Roughness profile (in μm) and volume loss (in μm^3) were analyzed by two-way ANOVA (factors: "composite" and "LCU") and post-hoc Tukey's test ($\alpha = 0.05$).

Top surface microhardness

Three microhardness indentations on the control side and other three on the brushed side of each composite surface were made with a Knoop microhardness tester (FM-ARS 900, Future-Tech Corp., Tokyo, Japan). A 100-gf load was applied for 15 s and the length of the Knoop indent was measured[32]. The average of the three measurements on each surface was calculated for each side of the specimens (brushed or unbrushed). Microhardness data were analyzed by three-way repeated measures ANOVA (between-subject factors: "LCUs" and "composite"; within-subject factor: "treatment") and post-hoc Tukey's test ($\alpha = 0.05$).

Surface Topography by Scanning Electron Microscopy (SEM) Observation

Composite disks were sputter-coated with gold in a vacuum evaporator (MED 010, Bal-Tec, Balzer, Liechtenstein) and observed using a scanning electron microscope (JSM-5600, JEOL Inc., Peabody, USA). Representative photomicrographs of brushed and unbrushed composite disks areas were taken at 2,000x magnification, and at 250x magnification at the border area between the unbrushed control and brushed sides.

Results

Surface roughness (Sa)

Table 2 reports the mean Sa of both unbrushed (control) and brushed areas of the resin composite disks that had been light-cured with the two LCUs. The "treatment" ($p = 0.008$) and "composite" ($p < 0.001$) factors and the interaction between "treatment" and "composite" ($p < 0.001$) significantly influenced the Sa results.

Toothbrushing had a significant effect on the Sa for all groups ($p < 0.05$), except for FBF that had been light-cured with Demi Ultra. Toothbrushing significantly increased the surface roughness of SDR. Of note, toothbrushing significantly decreased the Sa of FBF when it was light-cured with Valo. When TET was light-cured with Valo, it produced a lower Sa compared to FBF and SDR (on the brushed and unbrushed areas). The same result was found when TET was light-cured with Demi Ultra after the specimens were brushed. When SDR was light-cured with Demi Ultra, the unbrushed surfaces of the composite disks had a statistically higher Sa compared to the unbrushed surfaces of the other composites.

Roughness profile (Rv)

The mean Rv values of the bulk-fill composites light-cured with Valo and Demi Ultra curing lights are reported in Table 3. Two-way ANOVA showed the "composite" factor significantly influenced the Rv parameter ($p = 0.0001$), while type of "LCU" ($p = 0.1157$) and the factor interaction ($p = 0.3725$) did not. Tukey's test showed FBF and TET had a lower Rv than SDR.

Table 2. Mean (±SD) surface roughness (Sa in μm).

LCU	Composite	Control (unbrushed side)	Brushed side
Valo	Filtek bulk fill posterior	2.6 (0.3) a	2.3 (0.1) b*
	Surefil SDR flow	2.7 (0.1) a	3.6 (0.4) a*
	Tetric EvoCeram bulk fill	2.4 (0.2) b	2.0 (0.1) c*
Demi Ultra	Filtek bulk fill posterior	2.6 (0.2) b	2.4 (0.3) b
	Surefil SDR flow	2.8 (0.1) a	3.8 (0.4) a*
	Tetric EvoCeram bulk fill	2.4 (0.2) b	2.0 (0.1) c*

Means (SD) followed by different letters indicate a significant difference by three-way repeated measures ANOVA and post-hoc Tukey's test ($p < 0.05$). Lowercases compare resin composites for the same light and the same treatment (unbrushed or brushed). *Indicates difference from the control (unbrushed) side.

Table 3. Means (±SD) of the roughness profile (Rv in µm).

Composite	Valo	Demi Ultra
Filtek bulk fill posterior	4.0 (0.3) Ab	4.1 (0.4) Ab
Surefil SDR flow	5.9 (0.7) Aa	6.4 (0.9) Aa
Tetric EvoCeram bulk fill	3.7 (0.3) Ab	3.8 (0.3) Ab

Means followed by similar letters (uppercase letters compare the LCUs for the same composite and lowercase letters compare composites for the same LCU) indicate no significant difference by two-way ANOVA and post-hoc Tukey's test ($p > 0.05$).

Volume loss

Table 4 shows the volume loss of the bulk-fill composites after brushing. Two-way ANOVA indicated that "composites", "LCUs" and the interaction between these two factors affected volume loss ($p < 0.0001$). According to Tukey's test, TET showed significantly greater volume loss than FBF and SDR when polymerized with the Valo. When using the Demi Ultra curing light, SDR had the greatest volume loss and the lowest for FBF, while TET showed an intermediate value. The volume loss of SDR was also greater when it was light-cured with Demi Ultra compared to when the Valo was used (approximately 2x more). No difference was observed between Valo and Demi Ultra for the other composites.

Three-dimensional confocal and SEM images

Figure 2 shows the 3D confocal images of the composite surfaces, and Figures 3 to 5 are representative SEM images of the same brushed and unbrushed surfaces. The left side of the 3D confocal images represents the areas polished with 600-grit Al_2O_3 sandpaper, while the right side represents the polished and brushed areas. Thus, the volume loss created by toothbrushing can be observed. Scratches generated by the polishing procedure can be noticed at the left sides of the composite disks. The greatest volume loss occurred in the SDR/Demi Ultra (Figure 2E), TET/Valo, and TET/Demi Ultra groups (Figures 2C and 2F), although no difference in depth is observed comparing the unbrushed side with the brushed side for all groups in 3D images. Toothbrushing resulted in smoother surfaces for FBF (Figures. 2A and 2D) and TET (Figures 2C and 2F), while a rough surface with white spots can be observed on the brushed sides of SDR (Figures 2B and 2E). These white spots indicate exposed filler particles at the surface, which was confirmed by SEM images (Figures 4C and 4F). The same scratches were observed in the SEM images of the unbrushed sides of composites (Figures 3A, 3D, 4A, 4D, 5A and 5D), while apparently smoother surfaces are seen at the brushed sides of FBF and TET (Figures 3C, 3F, 5A and 5F).

Table 4. Mean (±SD) x 10^7 of volume loss (µm^3) of bulk fill composites after brushing.

Composite	Valo	Demi Ultra
Filtek bulk fill posterior	1.3 (0.4) Ab	1.5 (0.5) Ac
Surefil SDR flow	1.6 (0.4) Bb	3.4 (0.7) Aa
Tetric EvoCeram bulk fill	2.9 (0.4) Aa	2.7 (0.7) Ab

Means followed by similar letters (uppercase letters compare LCUs for the same composite and lowercase letters compare composites for the same LCU) indicate no significant difference by two-way ANOVA and post-hoc Tukey's test ($p > 0.05$).

Top surface microhardness

The Knoop microhardness results are reported in Table 5. The "treatment" ($p < 0.001$), "LCUs" ($p = 0.003$) and "composite" factors ($p < 0.001$), and the double interactions between "treatment" and "composite" ($p < 0.001$), and "LCUs" and "treatment" ($p < 0.001$) significantly influenced the surface microhardness results. There was no three-way interaction (among "LCUs", "composite" and "treatment", $p = 0.085$) or two-way interaction between "LCUs" and "treatment" ($p = 0.265$).

For both evaluations times (unbrushed and brushed), FBF produced the highest surface microhardness, followed by TET and SDR (FBF > TET > SDR) when light-cured with Valo. The same result was found for the unbrushed side when light-cured with Demi Ultra. The brushed side, light-cured with Demi Ultra, showed no difference between TET and SDR. Light activation of TET with Valo for 10 s resulted in higher surface microhardness than when it was cured with Demi Ultra for 10 s, while no difference was noted for SDR. FBF also resulted in higher surface microhardness when light-cured with Valo, but only on the unbrushed surfaces. Higher surface microhardness was obtained for SDR on the brushed sides compared to the control sides (unbrushed). FBF light-cured with Demi Ultra had an increased surface microhardness after brushing.

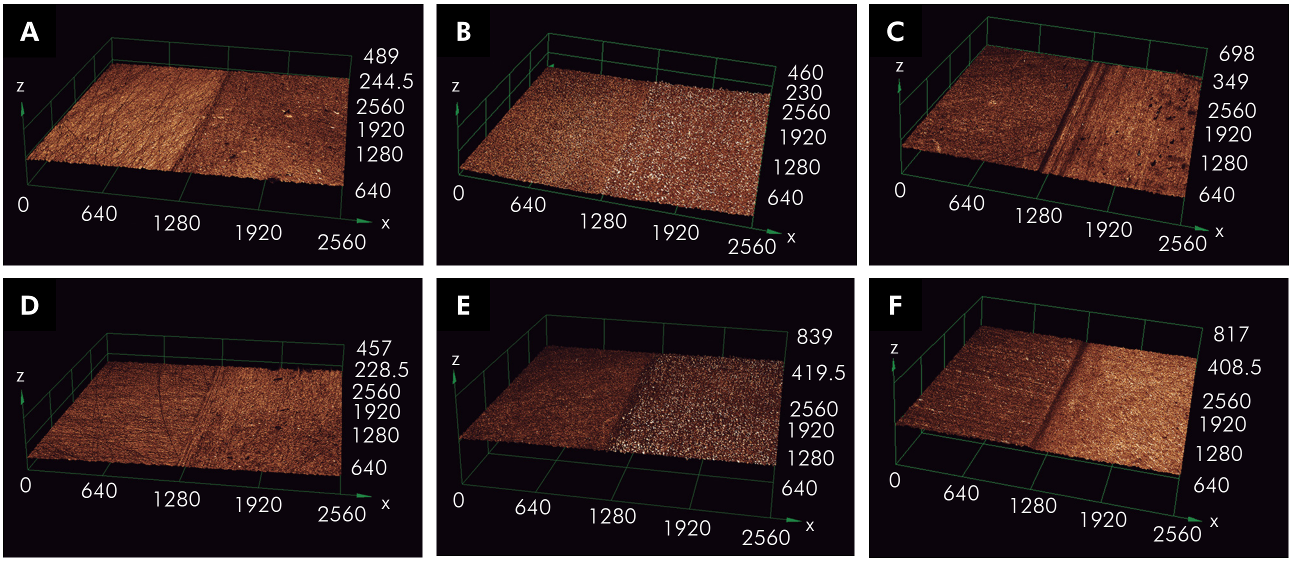

Figure 2. Three-dimensional confocal images showing the unbrushed/control (left side) and brushed (right side) areas of bulk-fill composites (A- FBF, B- SDR, and C- TET polymerized with the Valo, and D- FBF, E- SDR, and F- TET polymerized with the Demi Ultra).

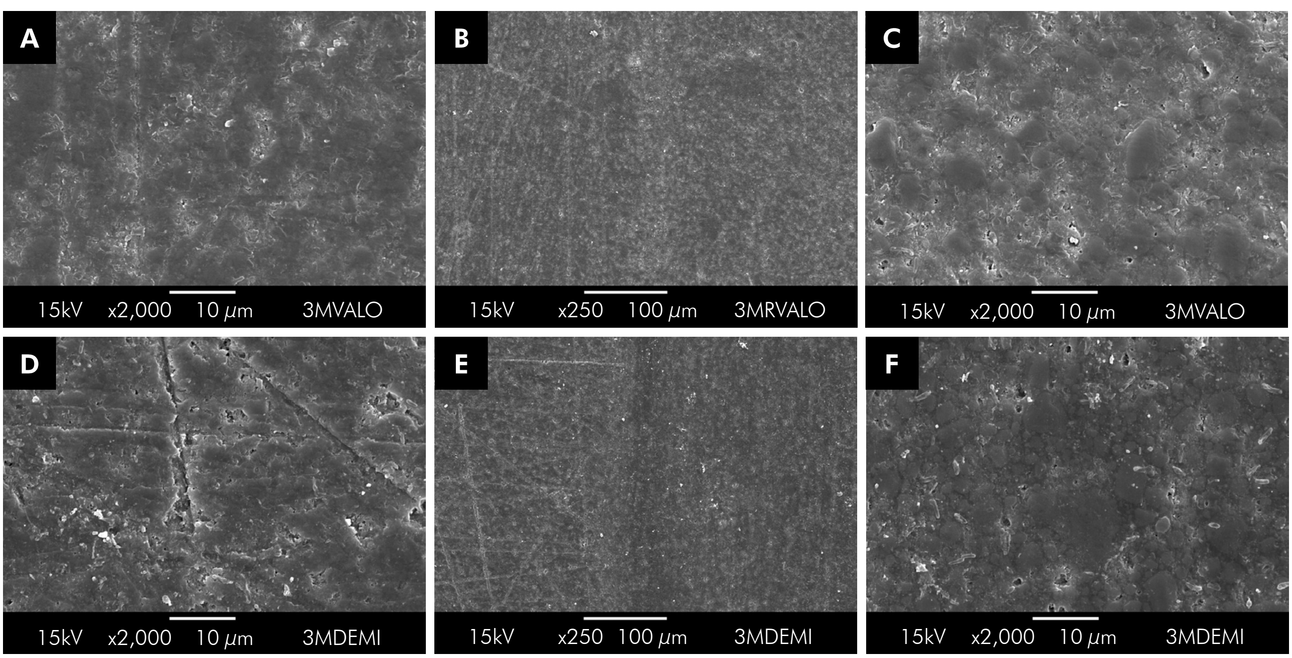

Figure 3. SEM images (250 x and 2000 x) showing the surfaces (unbrushed/control and brushed sides) of FBF. A- unbrushed area, B- border area between unbrushed control and brushed sides and C- brushed area polymerized with Valo. D- unbrushed area, E- border area between unbrushed control and brushed sides, and F- brushed area polymerized with Demi Ultra.

Discussion

The LCU, composite type and toothbrushing treatment all affected the results depending on which property was tested. Thus the three null hypotheses were rejected. This study used 30.000 brushing strokes, which simulated approximately two years of brushing, according to previous investigations.[28,29,30] Two of these studies estimated that 14,000 strokes corresponded to one year of toothbrushing,[28,30]

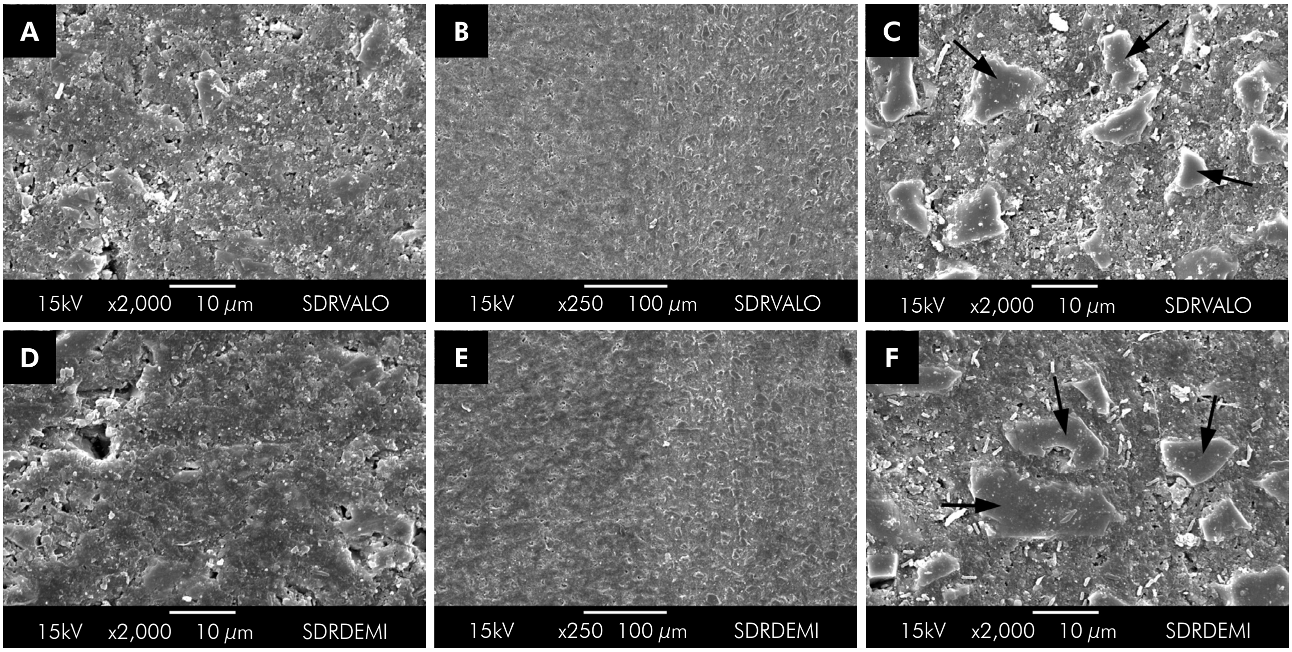

Figure 4. SEM images (250 x and 2000 x) showing the surfaces (unbrushed/control and brushed sides) of SDR. A- unbrushed area, B- border area between unbrushed control and brushed sides and C- brushed area polymerized with Valo. D- unbrushed area, E- border area between unbrushed control and brushed sides, and F- brushed area polymerized with Demi Ultra (arrows indicate the filler particles exposed on composite surface after brushing).

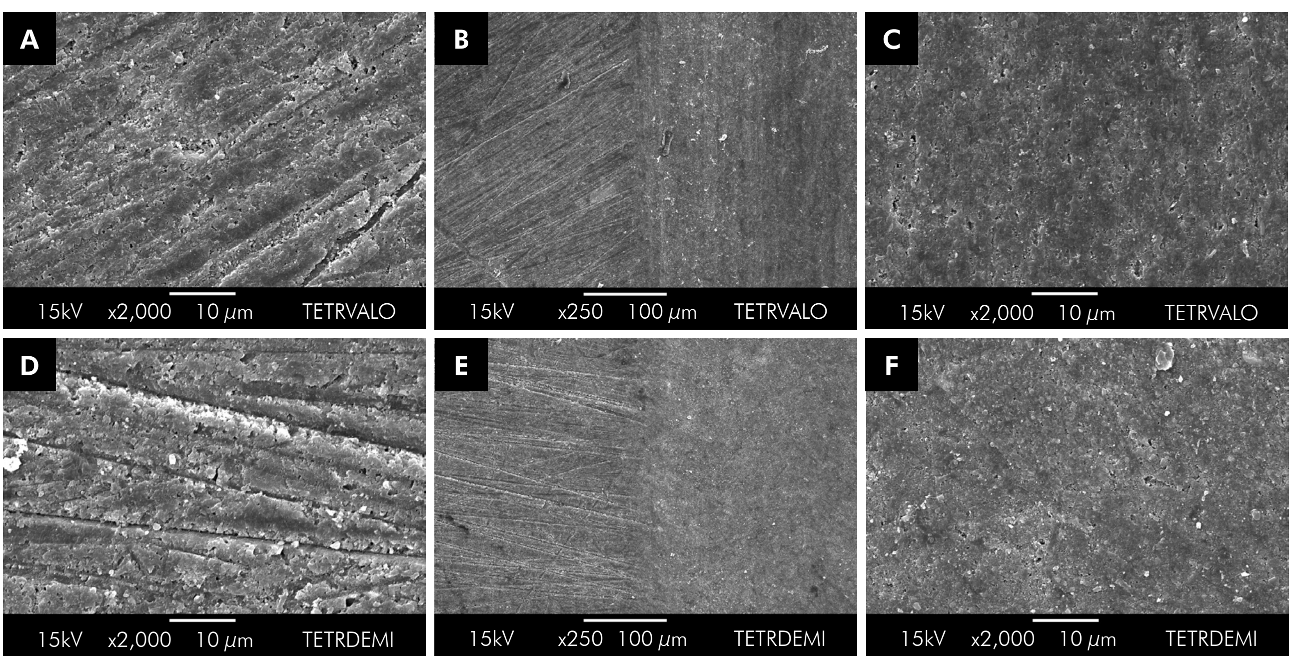

Figure 5. SEM images (250 x and 2000 x) showing the surfaces (unbrushed/control and brushed sides) of TET. A- unbrushed area, B- border area between unbrushed control and brushed sides and C- brushed area polymerized with Valo. D- unbrushed area, E- border area between unbrushed control and brushed sides, and F- brushed area polymerized with Demi Ultra.

while Aker et al.[29] reported 16,000 strokes in the toothbrushing machine were equal to brushing each tooth 22 strokes twice a day, which simulates brushing for one year.

Table 5. Mean (±SD) Knoop microhardness (KHN).

LCU	Composite	Control (unbrushed side)	Brushed side
Valo	Filtek bulk fill posterior	68.3 (5.4) Aa	67.8 (2.7) Aa
	Surefil SDR flow	36.7 (2.1) Ac	45.0 (4.7) Ac*
	Tetric EvoCeram bulk fill	56.5 (5.4) Ab	60.4 (7.1) Ab*
Demi Ultra	Filtek bulk fill posterior	62.6 (3.2) Ba	67.2 (8.1) Aa*
	Surefil SDR flow	37.2 (3.9) Ac	48.7 (6.3) Ab*
	Tetric EvoCeram bulk fill	48.6 (4.7) Bb	49.5 (5.4) Bb

Means (SD) followed by different letters indicate a significant difference by three-way repeated measures ANOVA and post-hoc Tukey's test ($p < 0.05$). Uppercase letters compare lights for the same resin composite. Lowercases compare resin composites for the same light and the same treatment (unbrushed or brushed). * Indicates difference from the control (unbrushed) side.

The disks of composite were wet-polished with 600-grit Al_2O_3 sandpaper to remove any potential resin-rich or air inhibited layer before they were brushed. This process simulated the finishing procedures commonly used to finish a posterior composite restoration. Some surface scratches induced by polishing were observed in the samples (Figures 2, 3A, 3D, 4A, 4D, 5A and 5D). Depending on the composite, the 30,000 cycles of toothbrushing used in this study removed a superficial layer of composite, eliminating some, but not all of these scratches. The brushed sides of FBF and TET bulk-fill composites had a lower surface roughness than the control (unbrushed) sides. However, toothbrushing increased the surface roughness of the SDR composite. After brushing, exposed filler particles in SDR became clearly visible. This composite, a flowable material, does not have a high wear resistance and, its manufacturer does not recommend placing this product in the occlusal surface of restorations. Instead it recommends that SDR be covered with a conventional, more resistant composite.

A study examining the filler content of some bulk-fill composites showed that SDR contains irregular particles of two distinct sizes: larger particles of approximately 20 µm, and smaller particles ranging from 0.5 to 1 µm.[33] In this study, confocal and SEM images confirmed the presence of these large filler particles in SDR. It is believed that this was the reason for the significant increase in surface roughness following toothbrushing and the small increase in Sa compared to the other composites at the unbrushed side (that had the surface pre-polished). Such a rough surface could potentially enhance biofilm formation, even in the presence of a salivary pellicle:[34] bacterial adhesion on rough surfaces is better protected against shear forces that can remove microorganisms.[31,35] Consequently, the increased bacterial retention on rough surfaces might result in increased cariogenic or periodontal issues, as well as esthetic flaws in the composite restoration.[6]

Another parameter provided by laser confocal microscopy was the roughness profile (Rv), which represents the largest valley depth deviation from a mean line along a sample length. Within the context of this study, the Rv parameter can be described as the maximum depth of toothbrushing-induced resin wear a patient would experience after a restoration had been exposed to the oral cavity and brushed for 2 years. Although differences were found among groups, the type of LCU did not affect the roughness profile of any of the tested bulk-fill composites. SDR showed a higher roughness profile than FBF and TET, because the large filler particles in SDR were exposed at the composite surface. This parameter may also be related to an increase in bacterial adhesion.[8] A study showed that the surface topography (roughness profile) might be considered more important in *S. mutans* biofilm formation than surface roughness, and deeper and larger depressions may provide more favorable region for bacterial colonization and biofilm formation due to the prevention of the dislodgement of bacterial colonies.[8]

The loss in volume was obtained by comparing the unbrushed and brushed sides of the same samples. All bulk-fill composites showed some volume loss; however, there were differences between composites and between LCUs. TET showed higher volume loss when polymerized with Valo, while no difference was observed between FBF and SDR. The higher wear obtained with TET may be related to the organic composition of this product compared to FBF, which has Bis-GMA, UDMA and pre-polymers; or the different percentage and size of filler particles;[36] or even to the quality of silanization of the organic matrix.[37]

FBF always showed the least volume loss, regardless of which LCU was used. This low surface wear seen on FBF might be due to high monomeric conversion, as the wear resistance may depend on the degree of conversion of the monomers;[38] or due to the fundamental difference in the composition of FBF that is the only resin composite that is composed partially of nanoparticles of zirconia that is considered extremely hard and wear resistant.[39] SDR showed higher volume loss when polymerized with Demi Ultra, suggesting it was less well cured using this light compared to the Valo. The SDR composite has more organic matrix and a lower concentration of filler particles than the two paste composites (FBF and TET).[33] These factors help to explain the greater volume loss and lower microhardness values in SDR. These findings support the manufacturer's recommendation that SDR should be covered with a conventional resin composite.

The lower volume loss found for FBF can be explained by its higher microhardness values, although the microhardness obtained with Valo before toothbrushing simulation was higher than that obtained with Demi Ultra (around 9%). TET showed intermediate values, while SDR had the lowest microhardness, except when light-cured with Demi Ultra and brushed. The type of LCU did not affect the microhardness of SDR; however, the light activation of TET with Valo yielded higher microhardness at the surface (around 16% for the unbrushed side and 22% for the brushed side). The manufacturer states that TET contains two types of photoinitiators (camphorquinone and Ivocerin) that are activated by blue and violet wavelengths, respectively. Valo is a multiple-peak light, while Demi Ultra emits blue light only. Therefore, light-activating TET with Demi Ultra might reduce the benefit of including Ivocerin as a photoinitiator.

Toothbrushing altered the microhardness of SDR, but there was no difference for FBF when it was light-cured with Valo, and for TET when light-cured with the Demi Ultra, comparing the unbrushed and brushed surfaces of the samples. The topography of SDR was changed by the exposure of filler particles, making it possible that indentation measurements were located over the barium-alumino-fluoro-borosilicate or strontium-alumino-fluoro-borosilicate glass fillers instead of the organic matrix, which may have led to higher microhardness values for the SDR samples.

The present study highlights important information about the effects of toothbrushing on bulk-fill composites surfaces and how light-activation with a multiple-peak or a single-peak LCU can interferes with some of the surface properties of these materials. The results can help practitioners choose which bulk-fill material to use, as well as the best LCU to polymerize these materials. In summary, light-curing SDR with Valo promoted lower volume loss compared to Demi Ultra; and light-curing FBF (unbrushed side) or TET promoted a higher microhardness compared to Demi Ultra, although no alternative photoinitiator is described in SDR or FBF composition. Thus, these findings suggest the use of a multiple-peak light-curing unit for the composites tested. Moreover, this LED light-curing unit delivers light in different wavelengths (458, 447 and 402 nm – two blue lights and violet light), which is able to light-activate all types of composites, regardless the type of photoinitiator contained in their compositions. Also, Valo is a pen-style LED light that facilitates its accessibility into different regions of oral environment when compared to gun-style LED light-curing units.[40]

Conclusion

Within the limitations of this study the following conclusion can be made:

1. The 30,000 toothbrushing cycles promoted some volume loss for all the bulk-fill composites tested.
2. For SDR, the amount of wear depended on the type of LCU used and benefits from a multiple-peak light.
3. Toothbrushing significantly increased the surface roughness and microhardness of SDR and this material should always be covered.

4. FBF always showed the least volume loss, regardless of which LCU was used.
5. The type of LCU did not affect the roughness profile of any of the bulk-fill composites after brushing, but the surface microhardness of TET was improved when a multiple-peak light (Valo) was used.

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