In Vitro Toothbrush-Dentifrice Abrasion of Two Restorative Composites

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ABSTRACT

Background: Surface wear can be a problem with directly placed composites.

Purpose: This study evaluated the in vitro wear and surface roughness of two composites at different cycle intervals after being subjected to toothbrush-dentifrice abrasion.

Materials and Methods: Twenty specimens of a microhybrid, Filtek Z250 (3M ESPE, St. Paul, MN, USA), and a nanofill composite, Filtek Supreme (3M ESPE), were prepared according to the manufacturer's directions. Each specimen was subjected to toothbrush-dentifrice abrasion (250 g vertical load) using a deionized water-dentifrice slurry (Close-Up, Lever Ponds Ltd., La Lucia, ZA) and toothbrush heads (Oral-B 40, Oral-B Laboratories, Delmont, CA, USA). A brushing sequence of 10,000, 20,000, 50,000, and 100,000 strokes was performed for all samples at a rate of 1.5 Hz. At baseline and each cycle interval, a surface profilometer was used to determine average surface roughness, Ra. At the same intervals, vertical loss of material was measured with a precision micrometer. Data were analyzed using repeated-measures analysis of variance at p value .05. Analyses with atomic force microscopy (AFM) and scanning electron microscopy (SEM) were also performed.

Results: After 20,000, 50,000, and 100,000 cycles, Filtek Supreme showed less significant wear than Z250. Filtek Supreme demonstrated higher surface roughness than Z250 after 50,000 and 100,000 cycles. However, AFM and SEM images indicated a more uniform surface topography for Filtek Supreme than for Z250. Abrasion wear and surface roughness increased with each cycle interval for both materials.

Conclusions: Although the initial performance of both materials was similar, a greater number of brushing cycles revealed differences between the wear resistance and generated surface roughness of the materials.

CLINICAL SIGNIFICANCE

The wear resistance and roughness results of Filtek Supreme suggest that it is suitable for clinical use, mainly in areas that are more subject to abrasive wear, such as Class V restorations.

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Introduced nearly 40 years ago, composite resins have been improved to the point that their applications are truly impressive. In addition to handling and color-matching ability, manufacturers seek to increase strength, wear resistance, and polishability in an effort to create a universal restorative.[1] New products continue to be developed as different combinations of filler content and monomer type are introduced. When optimizing these changes, properties related to surface texture are among the many that must be considered.[2]

An increase in surface roughness of materials used in the oral environment has many consequences. A rougher surface texture can lead to decreased gloss and discoloration or staining of the material surface, both of which affect the esthetic quality of restorations.[3] Furthermore, it may also lead to the accumulation of dental plaque, leading to secondary caries and periodontitis.[4,5] It is therefore ideal to obtain composite restorations with smooth surfaces that do not deteriorate over the course of time.[6]

It is important to determine the performance of restoratives as a consequence of toothbrush abrasion because this abrasion is the main cause of material loss that restorations encounter in nonstress locations.[7] Abrasion is an undesirable phenomenon, not only leading to an increase in surface roughness, but also resulting in the gradual removal of substance.[8] Furthermore, toothbrush abrasion causing changes in surface conditions of different materials is one of the experimental conditions that can be used to predict clinical behavior.[3]

Wear is one of the least understood properties of restorative materials because it involves different processes such as abrasion, adhesion, fatigue, and erosion, which may not be independent—they may interact with each other.[8,9] Several investigations have been conducted using wear-testing machines or instruments that simulate toothbrushing.[2,6,8–17] Many of the recent studies have evaluated prosthetic materials or conventional or hybrid glass ionomers,[8,12–17] but the need to evaluate newly developed composites is also important owing to their frequency of use and range of applications. Microhybrid composites are the most commonly used material for direct restorations.[1] Although, new composites integrating nanofiller technology are being introduced into clinical practice to achieve better polishability and wear resistance, their properties are still unknown.

In this study, the in vitro abrasion wear and change in surface roughness of two composites were evaluated at different cycle intervals after being subjected to toothbrush-dentifrice abrasion.

MATERIAL AND METHODS

Two direct restorative materials, one microhybrid composite (Filtek Z250) and one nanofill composite (Filtek Supreme), were tested; Table 1 outlines details of some of the materials used. Restorative materials, both shade A2, were handled according to manufacturer's instructions. Ten disk-shaped specimens per material ($N = 20$) were tested (Figure 1). Aluminum disks 18 mm in diameter and 1 mm thick were used as the base of the specimens. Prior to the application of the composite, an alloy primer (Alloy Primer, Kuraray Co. Ltd., Osaka, Japan) and bonding agent (Gluma Comfort Bond, Heraeus Kulzer Inc., South Bend, IN, USA) were applied to each aluminum disk to ensure adhesion between the metal substrate and the composite. The disks were placed into a silicone mold, 2 mm in height, which was then slightly overfilled with composite. A glass slab was pressed over the surface to ensure a smooth, flat surface and to expel excess material. The specimens were light cured for 20 seconds at four different locations on the surface (Demetron VCL 401, Kerr, Danbury, CT, USA). The curing light unit was tested for light output using a curing radiometer (Model 100, Demetron Research Corp., Kerr), which showed an intensity of 600 mW/cm^2 before the samples were light cured. After curing, the specimens were aged in deionized water at 37°C for 1 week. Polishing was performed

TABLE 1. MATERIALS USED IN THE STUDY.*

Material	Manufacturer	Filler Type	Polymer	Particle Range (μm)	Mean Particle Size (μm)	% Filler (by vol)	Batch No.
Filtek Z250 (enamel A2)	3M ESPE, St. Paul, MN, USA	Zirconia/ silica	UDMA, BIS-EMA, BIS-GMA, TEGDMA	0.01–3.5	0.60	60%	20020615
Filtek Supreme (body shade A2)	3M ESPE	Zirconia/ silica	UDMA, BIS-EMA, BIS-GMA, TEGDMA	Clusters: 0.6–1.4	NA	59.5%	20030222
Close-Up†	Lever Ponds Ltd., La Lucia, ZA						

BIS-EMA = bisphenol A ethoxylated dimethacrylate; BIS-GMA = bisphenol A glycol dimethacrylate; TEGDMA = triethylene glycol dimethacrylate; UDMA = urethane dimethacrylate.
*Information obtained from the manufacturers.
†Composition: sodium monofluorophosphate (active ingredient), sorbitol, water, hydrated silica, sodium lauryl sulfate, SD alcohol 38-B, flavor, cellulose gum, sodium saccharin, red 33, red 40. Relative dentin abrasivity = 80.

using a sequence of 320, 400, 600, and 1,200 grit SiC abrasive to produce a uniform starting composite thickness (1.0 ± 0.05 mm) and surface finish on each specimen.

Each sample was air dried and initial thicknesses were measured with a precision micrometer (L.S. Starrett Co., Athol, MA, USA) mounted to a stainless steel post on a heavy steel platform. A surface profilometer (Surfanalyzer System 5000, Federal Products Co., Providence, RI, USA) was used to obtain measurements for the average roughness, characterized by the height parameter, Ra (μm). This parameter was determined from the following relationship:

$$Ra = \sum_{n=1}^{N} \frac{|z_n - z|}{N}$$

where z represents the data set of height coordinates and N represents the total number of z coordinates for each scan (6,400). Six scans (4 mm long) were made on each specimen, including three in the direction parallel to toothbrush travel and three in the perpendicular direction. The average surface roughness for each specimen was taken as the average of the six Ra values. The specimens were kept hydrated when they were not being measured.

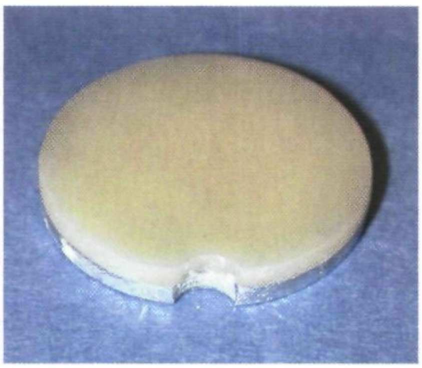

Figure 1. Toothbrush abrasion test specimen.

The specimens were then placed in a toothbrush abrasion machine (Figure 2), simulating a vertical back-and-forth movement. The simulator was equipped with 10 independent stations in which to place the specimens. Toothbrush heads (Oral-B Indicator 40 Soft, Oral-B Laboratories, Delmont, CA, USA) with straight, soft bristles were placed in special attachments aligned parallel to the base. New toothbrush heads were used for each material. Each specimen was subjected to cyclic brushing at a stroke rate of 1.5 strokes per second and a vertical load of 250 g in an abrasive slurry at room temperature (25°C). The slurry consisted of a deionized water and dentifrice (Close-Up Classic Red Gel; see Table 1) solution in a ratio of 1:1 by weight. This dentifrice was chosen because it possesses an intermediate relative dentin abrasivity and because it is a commonly used product. Surface roughness and vertical wear of the toothbrush-abraded specimens were measured at five intervals (baseline and 10,000, 20,000, 50,000, and 100,000 cycles). The wear for each specimen was reported as the difference from its initial thickness. After each cycle

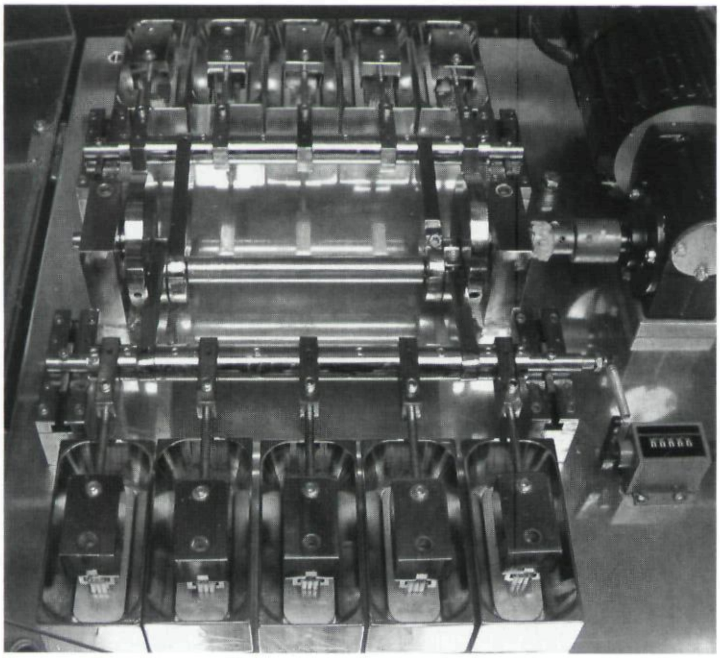

Figure 2. Toothbrush abrasion testing machine. The device operates with a back-and-forth movement at 1.5 Hz (250 g vertical load).

interval, the machine was cleaned and the slurry was replaced.

All groups of specimens were analyzed for means and SDs. The two materials were compared at each cycle interval using analysis of variance (ANOVA). All cycle intervals for each material were analyzed using repeated-measures ANOVA followed by *t*-tests for the pairwise comparison of cycle intervals ($p \leq .05$). Data were analyzed using SPSS 9.0 software (SPSS Inc., Chicago, IL, USA).

Scanning electron microscopy (SEM) was used to observe the surface microstructure of samples before toothbrush abrasion and after 100,000 cycles. Four specimens were mounted on aluminum stubs with carbon tape and were sputter coated with pure gold for 90 seconds. Specimens were observed at an accelerating voltage of 15 kV at a 90° angle and a working distance of 28 mm.

Atomic force microscopy (AFM) was also performed before toothbrush abrasion (baseline) and after 100,000 cycles to qualitatively and quantitatively assess the surface morphology. A multimode atomic force microscope (Auto Probe CP, Veeco Instruments Inc., Woodbury, NY, USA) was used to obtain topographic images of the composite surfaces. Contact mode imaging was used, in which a silicon nitride AFM tip was oscillated at its resonant frequency. After scans (50 × 50 μm) were performed on all specimens, the average roughness (Ra), root-mean-square roughness (Rms), and maximum peak-to-valley distance (Rp-v) of both groups were determined. Statistical analysis was performed for the AFM data comparing the groups at baseline and after 100,000 cycles.

RESULTS

Repeated-measures ANOVA with one between-subject factor (material) and one within-subject factor (cycle interval) was performed for each outcome variable (roughness and wear) at *p* value .05. Because the material × cycle interaction was statistically significant, further testing was performed to explore the differences between materials at each cycle interval and the differences between cycle intervals separately for each material. One-way ANOVA was used to compare the two materials at each cycle interval. Within each material, a repeated-measures ANOVA was used as a global test of the cycle effect on Z250 and Filtek Supreme. When the global test was significant, comparisons between cycle intervals for each material were performed using paired *t*-tests. Wear results after toothbrush abrasion for 10,000 to 100,000 cycles are reported in Table 2. Significant differences in wear between the two composites at each interval, as well as significant differences between each cycle interval for both materials, are also

TABLE 2. TOOTHBRUSH ABRASION WEAR (μm ± SD).

Material	At 10,000 Cycles*	At 20,000 Cycles*	At 50,000 Cycles*	At 100,000 Cycles*
Filtek Z250	$24.3 \pm 1.8^{A,a}$	$49.0 \pm 1.9^{A,b}$	$57.0 \pm 2.2^{A,c}$	$107.9 \pm 2.4^{A,d}$
Filtek Supreme	$21.5 \pm 1.2^{A,a}$	$29.0 \pm 1.8^{B,b}$	$35.6 \pm 1.8^{B,c}$	$50.0 \pm 3.3^{B,c}$

*Superscript uppercase letters in each column indicate statistically significant differences ($p \le .05$). Superscript lowercase letters in rows indicate statistically significant differences ($p \le .05$).

reflected in Table 2. For both composites, abrasion wear increased with the increasing number of cycles. The average cumulative wear between 10,000 and 100,000 cycles for Z250 ranged from 24.3 to 107.9 μm, whereas that of Filtek Supreme ranged from 21.5 to 50.0 μm. Statistically significant differences between the materials were observed after 20,000, 50,000, and 100,000 cycles, with Filtek Supreme having less toothbrush abrasion wear. Z250 showed a statistically significant increase in wear for each successive cycle interval. Filtek Supreme showed an increase in wear for all cycle intervals; however, between 50,000 and 100,000 cycles, there was no significant difference.

Mean average roughness values are reported in Table 3. Significant differences between the two composites for each given interval as well as significant differences between each successive cycle interval for both materials are presented. Between 10,000 and 100,000 cycles, the Ra values for each material ranged from 0.200 to 0.410 μm and from 0.200 to 0.536 μm for Z250 and Filtek Supreme, respectively. Significant differences between materials were observed at 50,000 and 100,000 cycles, in which Filtek Supreme had higher roughness values. In addition, there was a statistically significant increase in roughness between baseline and cycle intervals for each material.

Roughness data determined by AFM are reported in Table 4. The mean roughness value (μm) of Filtek Supreme measured by AFM was significantly lower than that of Z250 after 100,000 cycles of toothbrush abrasion for all the parameters (Ra, Rms, and Rp-v). At baseline the only significant difference between materials was observed for Rp-v values.

Representative SEM and AFM images of composite surfaces after the polishing procedure (baseline) and after 100,000 cycles of toothbrush abrasion are shown in Figures 3 to 10. The topography analysis showed similar surface characteristics for both materials before toothbrush-dentifrice abrasion, with a minimal appearance of filler particles. After toothbrush abrasion, more filler particles of each material were exposed. The surface of Filtek Supreme was homogeneous with visibly rounded filler particles (see Figure 9), whereas that of Z250 was more varied with larger protruding filler particles (see Figure 10).

DISCUSSION

In this study wear and surface roughness were investigated, with

TABLE 3. AVERAGE ROUGHNESS MEASURED BY MECHANICAL PROFILOMETRY (μm ± SD).

Material	At Baseline*	At 10,000 Cycles*	At 20,000 Cycles*	At 50,000 Cycles*	At 100,000 Cycles*
Filtek Z250	$0.200 \pm 0.000^{A,a}$	$0.250 \pm 0.036^{A,b}$	$0.300 \pm 0.039^{A,c}$	$0.368 \pm 0.029^{A,d}$	$0.410 \pm 0.050^{A,e}$
Filtek Supreme	$0.200 \pm 0.000^{A,a}$	$0.245 \pm 0.026^{A,b}$	$0.317 \pm 0.018^{A,c}$	$0.435 \pm 0.052^{B,d}$	$0.536 \pm 0.089^{B,e}$

*Superscript uppercase letters in each column indicate statistically significant differences ($p \le .05$). Superscript lowercase letters in rows indicate statistically significant differences ($p \le .05$).

TABLE 4. ROUGHNESS VALUES DETERMINED BY ATOMIC FORCE MICROSCOPY (μm).						
	Baseline Values (μm)*			Values after 100,000 Cycles (μm)*		
Material	Ra	Rms	Rp-v	Ra	Rms	Rp-v
Filtek Z250	0.051 ± 0.041^{A}	0.069 ± 0.045^{A}	0.784 ± 0.123^{A}	0.118 ± 0.017^{A}	0.152 ± 0.024^{A}	1.443 ± 0.18^{A}
Filtek Supreme	0.017 ± 0.006^{A}	0.024 ± 0.011^{A}	0.103 ± 0.085^{B}	0.037 ± 0.009^{B}	0.044 ± 0.006^{B}	0.594 ± 0.11^{B}

Ra = average roughness; Rms = root-mean-square roughness; Rp-v = maximum peak-to-valley distance.
*Mean values in each column designated with the same superscript uppercase letters indicate groups that are not statistically significant ($p \leq .05$).

the results showing that these properties were different for each composite. Both resin matrix and filler particle type or content are thought to affect surface conditions after toothbrushing owing to the selective abrasion of the resin matrix and the dislodgment of filler particles after long-term exposure.[14,18,19] Although toothbrush abrasion testing is influenced by factors such as the type of testing device, loading, number of strokes, toothbrush type, and dentifrice type,[2,20] these parameters were standardized for each group to better evaluate the effect of toothbrush abrasion on the characteristics of the tested restorative materials. Some of the properties affecting wear resistance of composites include size and distribution

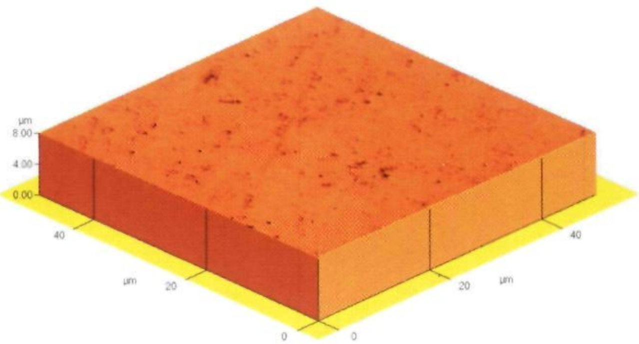

Figure 3. Atomic force microscopy image of a polished Filtek Supreme specimen (before toothbrush abrasion).

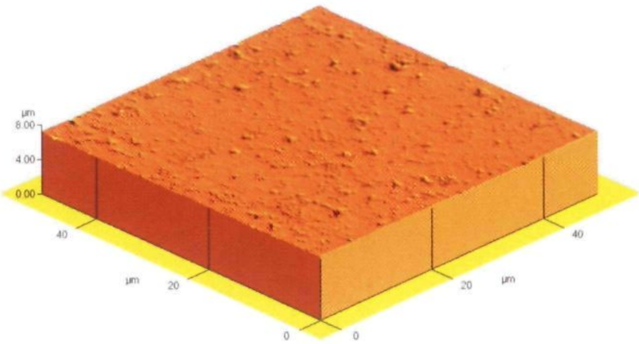

Figure 4. Atomic force microscopy image of a polished Filtek Z250 specimen (before toothbrush abrasion).

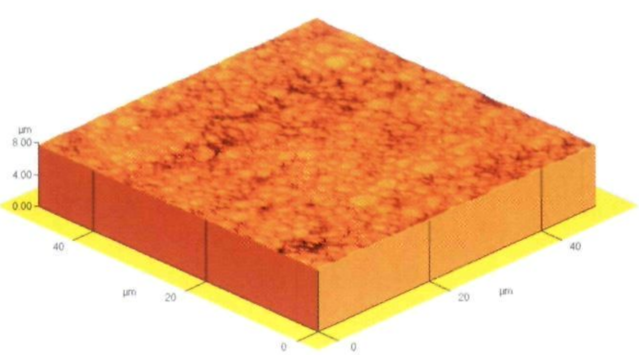

Figure 5. Atomic force microscopy image of a toothbrush-abraded Filtek Supreme specimen (100,000 cycles).

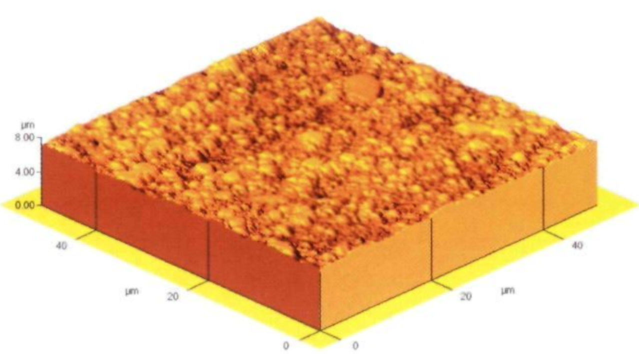

Figure 6. Atomic force microscopy image of a toothbrush-abraded Filtek Z250 specimen (100,000 cycles).

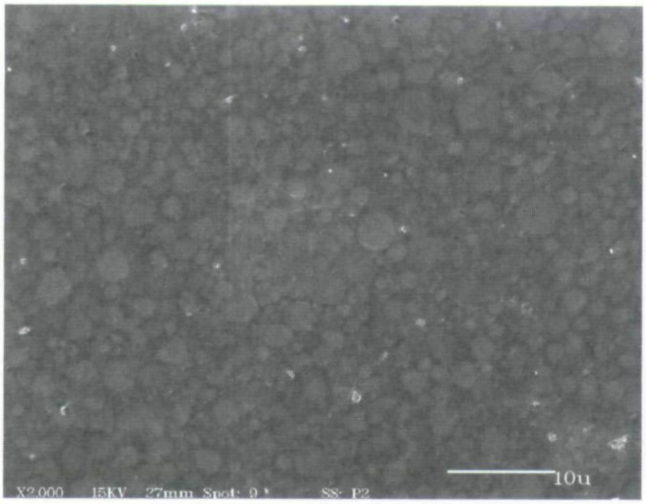

Figure 7. Scanning electron microscopy image (×2,000 original magnification) of a polished Filtek Supreme specimen (before toothbrush abrasion).

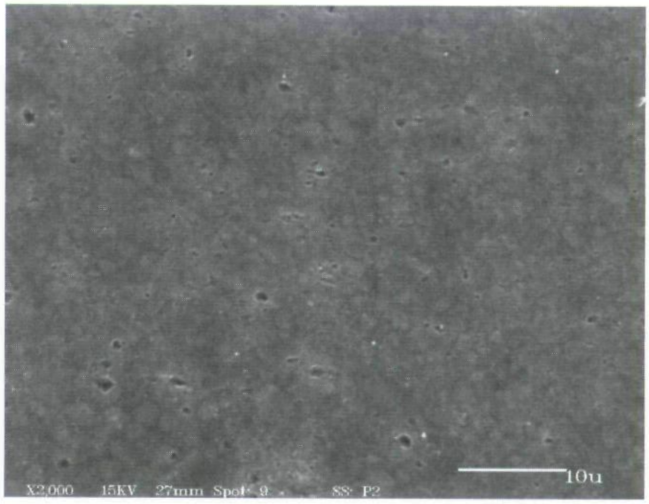

Figure 8. Scanning electron microscopy image (×2,000 original magnification) of a polished Filtek Z250 specimen (before toothbrush abrasion).

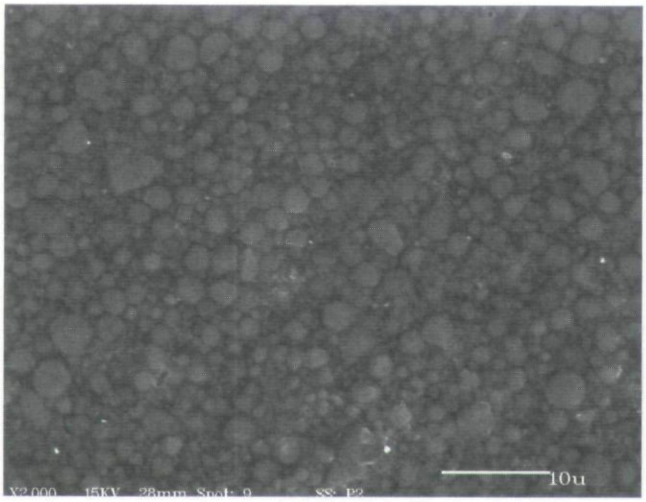

Figure 9. Scanning electron microscopy image (×2,000 original magnification) of a toothbrush-abraded Filtek Supreme specimen (100,000 cycles).

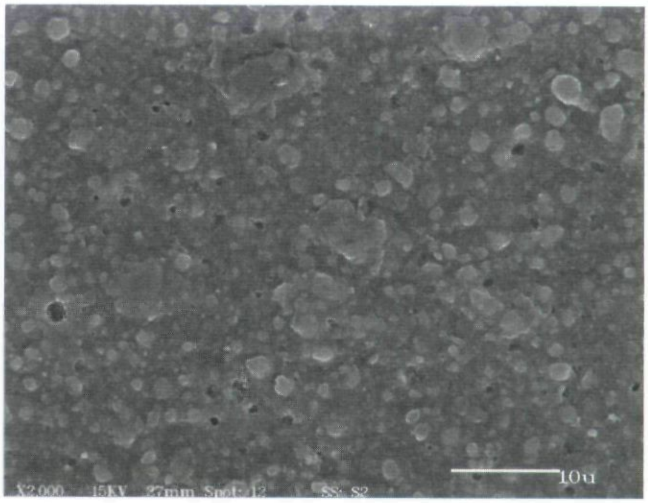

Figure 10. Scanning electron microscopy image (×2,000 original magnification) of a toothbrush-abraded Filtek Z250 specimen (100,000 cycles).

of filler particles, percentage of surface area occupied by the filler particles, filler-matrix interactions, and degree of polymerization.[9,13,17] Furthermore, the initial and developed surface roughness characterizing the outer surface of composites is also an important parameter in determining abrasive wear rate and polishability.[10,12]

A series of 10,000, 20,000, 50,000, and 100,000 cycles was chosen for this study with the assumption that 10,000 strokes simulate approximately 1 year of toothbrush wear, which is in agreement with other studies.[2,8,17] Although some studies have reported the short-term effects (1–2 yr) of toothbrush abrasion, little is known about the long-term behavior of different composite materials.[2,6,8,10,11,13,15,17,21] This study, however, not only evaluates the short- and long-term effects but also assesses the behavior of the materials at different cycle intervals.

Surface roughness significantly increased with each cycle interval for both materials. The profilometry results indicated that Filtek Supreme had higher surface roughness values than did Z250 at 50,000 and 100,000 cycles. However, the appearance of the AFM images after 100,000 cycles showed that Z250 had more irregularities with sharper peaks and valleys than were seen in Filtek Supreme (see Figures 5 and 6). In addition, the Ra, Rms, and Rp-v values obtained from AFM were lower for Filtek Supreme. The AFM images and data indicate a different trend than was observed from the surface profilometry results.

When comparing rough surfaces, it is not clear which surface features should be used to indicate that one surface is rougher than another, especially when measurements are conducted at different levels of dimensional resolution. The size of convolutions, spatial frequency, and distribution of features should be considered. However, the shape of the features, whether sharp or rounded, is more important. SEM and AFM techniques can be used to measure surface features and can develop accurate images of the surface topography and texture even to the atomic scale, differing from the measurement scale of a standard mechanical surface profilometer (Figure 11). Features that can be clearly resolved with AFM, such as an individual filler particle in a dental composite, are not always seen in a mechanical profilometer trace. Additionally, features such as troughs created in a dental composite surface by a row of bristles in a toothbrush abrasion process may be too large to be characterized with AFM. This may explain the different results obtained from the AFM and the surface profilometry analyses. This may also indicate the need to consider multiple analytical techniques (AFM, surface profilometry, etc) that can obtain information over a broad dimensional range when attempting to fully characterize surface morphology.

The SEM images for each material showed different surface characteristics. The surface of Filtek Supreme after abrasion was uniform with spherical filler particles exposed. However, the surface of the Z250 was less homogeneous than that of Filtek Supreme owing to its wide range of filler particle sizes. After 100,000 cycles, the exposed particles of the Z250 were much more uneven. Therefore, differences between the developed surface morphologies of the two materials can be explained, in part, by their microstructure. With the same resin composition, the two materials differ primarily by their filler particle size and distribution (3M ESPE Technical Product Profile). Although Filtek Supreme is marked as a nanofill, the SEM images suggest that this material contains larger particles. It is possible that the larger particles observed in the AFM scans are agglomerates of nanofiller particles or nanoclusters. Thus, the distinction between microhybrid and nanofill composites should be more distinctly defined.

There was no significant difference in the cumulative wear between the

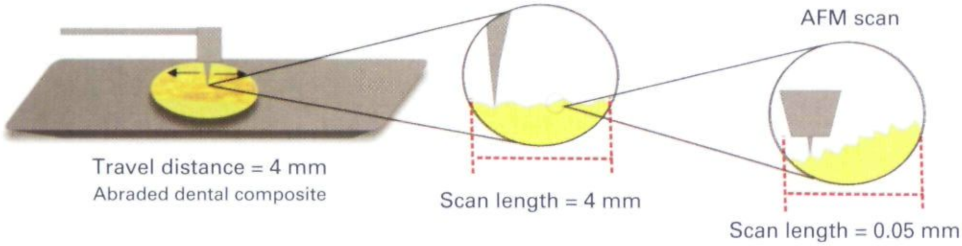

Figure 11. Schematic representation illustrating the different dimensional resolution range measurable using a mechanical profilometer and atomic force microscopy. Each instrument resolves features on a distinctly different dimensional level.

two materials at 10,000 cycles. After 20,000, 50,000, and 100,000 cycles, Filtek Supreme demonstrated significantly less wear than did Z250. The average rate of material loss was lower for Filtek Supreme than for Z250. Thus, although no initial differences were evident, after approximately 2 years, the wear rate of Z250 was large enough to produce a significantly greater amount of cumulative wear than was evident for Filtek Supreme. Furthermore, for Z250 the amount of cumulative wear significantly increased with a greater number of cycles for all intervals. However, this was not the case for Filtek Supreme, which did not show a statistically significant increase in wear between 50,000 and 100,000 cycles. This could indicate that Filtek Supreme shows more long-term wear resistance to toothbrush abrasion than does Z250. SEM also showed more voids in Z250 after 100,000 cycles where the particles were stripped from the matrix, which supports the increased wear measured in Z250. Because abrasion caused by toothbrushing results in an initial loss of resin matrix and subsequent exposure of filler particles,[18,19] the removal of filler particles increases the amount of wear. The wear and surface roughness results are supported by Tanoue and colleagues,[15] who determined that composite wear resistance was not positively associated with lowered surface roughness.

In this study it was determined that both materials performed similarly after initial cycle intervals. This may indicate that both materials demonstrate the same response to toothbrush abrasion for approximately 2 years, but that after long-term abrasion, Filtek Supreme may be less vulnerable to this type of wear. However, determination of wear resistance of restorative materials is a complex process that requires clinical trials to support expectations of performance based on in vitro studies since abrasion mechanisms are influenced by the interaction of mechanical, chemical, and biologic processes.

Some clinical studies have reported good clinical performance of other resin-based composites having in vitro wear rates of the same magnitude demonstrated in this study.[1,22] Therefore, the rates of toothbrush abrasion wear for Filtek Supreme and Z250 may not be of short-term clinical concern. In addition, although there was an increase in the average roughness values, the surfaces of the composites still appeared to remain relatively smooth visually. Nevertheless, the surfaces of composite restorations should be evaluated after long-term placement as a regular component of their maintenance.

CONCLUSIONS

Findings indicated that the values of roughness and wear were material dependent. Although better roughness values were observed for Z250 than for Filtek Supreme after 50,000 and 100,000 cycles using profilometry, the AFM analysis showed a smoother surface for Filtek Supreme. The overall results also suggest that Filtek Supreme should be expected to have better resistance to wear abrasion than Z250. However, other properties should be tested to demonstrate that Filtek Supreme can be used for both anterior and posterior restorations as a universal restorative material.

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COMMENTARY

IN VITRO TOOTHBRUSH-DENTIFRICE ABRASION OF TWO RESTORATIVE COMPOSITES

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This article focuses on a timely issue concerning resin composites—surface wear characteristics. What is interesting about this research design is that it does not evaluate factors related to occlusal surface loss, which is associated with posterior composites and is a common area of study. It instead focuses on factors related to abrasive forces on facial or axial surfaces, which impact the appearance or the esthetics of resin composites. The clinical relevance of the study evolves around the impact of oral hygiene maintenance, a process patients do several times a day, on the tooth-composite complex. A commercially available toothpaste formulation was evaluated for its effect on the surface characteristics of two different formulations of hybrid direct restorative resin composites. This particular subject, toothpaste formulations and their contribution to surface degradation, may shed some light on a recurrent phenomenon that all restorative dentists

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notice when they place either direct anterior resin composites or laboratory fabricated crowns/bridges having resin composite veneers: what happens to that initial high shine/luster on the surfaces of these restorations after they have been in the mouth for a period of time? A recent clinical trial evaluating fiber-reinforced composite bridges noted that the majority of bridges had lost their luster or high shine from the resin veneer surfaces soon after placement in the mouth.[1]

The reason for surface degradation of resin composites can be related to a complex set of interactions and factors, including the resin/filler composition, degree of conversion, initial finishing/polishing techniques, various bacterial metabolic byproducts in plaque, and the patient's diet. The additional impact on surface wear characteristics from the plethora of toothpaste formulations on the market and an increasing number of toothbrush designs are important areas that need to be examined. Toothbrush design/toothpaste composition may turn out to be the major factors in resin composite surface degradation in patients, especially in those who are meticulous with their oral hygiene habits. This type of degradation would not only result in the loss of surface luster and smoothness but would increase the tendency for stain food particle/plaque accumulation.

The authors' experimental design used an accepted conventional approach that employed a mechanical toothbrush abrasion testing apparatus. The effect on the surface of the resin composite from the toothpaste/toothbrush was measured by profilometry and AFM and SEM images. The data showed a significant effect on surface roughness between baseline and the test periods for both resin composite formulations. The two resin composite formulations could not hold their initial surface characteristics from the onset of toothpaste contact. The data did indicate that differences in resin composite formulation influenced the rate of surface degradation in this challenge. One can surmise that there would be similar differences in surface degradation with the many resin composite formulations available today and that a ranking could be established of the available resin composites from best to worst in their ability to hold their initial surface profile. Knowing which resin composites show the most resistance to toothbrush/toothpaste maintenance would be valuable for clinicians who are concerned with the durability and sustainability of surface characteristics of resin composites placed in facial applications.

Unfortunately, two areas were overlooked in this experimental design. The effect of just the toothbrush bristle design was not isolated from the toothpaste, and no measure of surface gloss or luster was performed. Surface gloss or luster is a more clinically relevant measure of surface change, one that is recognizable by both the patient and the dentist. However, one could try and translate the increase in surface roughness to a loss in surface gloss or luster.

With the increasing use of resin composites as the direct restorative material of choice and the use of resin composites as overlying veneers for crowns and bridges that use either fiber-reinforced composite or metal substructures, an understanding of the causes of surface degradation and then methods to reduce or minimize it should be a concern for dental material manufacturers and clinicians and provide a fertile area of investigation. The impact of various toothbrush head designs, the emergence of the battery-driven the rotary/pulsating and sonic toothbrushes, and the multitude of toothpaste formulations all need to be assessed for their impact on resin composite surface integrity. More information in this area would drive improvements in material formulations and help determine patient instructions for oral hygiene measures that address both gingival health and a minimal impact on the surface of resin composite restorations.

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