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Comparison of Two-Step Versus Four-Step Composite Finishing/ Polishing Disc Systems: Evaluation of a New Two-Step Composite Polishing Disc System

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Clinical Relevance

The two-step composite disc finishing/polishing system, Enhance Flex NST, can provide a nearly equivalent surface finish as two four-step systems on a variety of composites, in approximately half the time. All systems produce clinically acceptable gloss and surface roughness.

SUMMARY

Objective: The purpose of this study was to evaluate surface finish and gloss of a two-step composite finishing/polishing (F/P) disc system compared with two multistep systems on five composites. Methods: Seventy-five disc-shaped composite specimens (D=10.0 mm, 2 mm thick, n=15 per composite) were made of microfill (Durafill-D), nanofill (Filtek Supreme-FS), nanohybrid (Premise-PR), and microhybrids (Filtek Z250-FZ, Esthet-EX). One side of each specimen was initially finished with a carbide bur. Five specimens of each resin composite were randomly assigned to receive full F/P by each of the disc systems: two-step (Enhance Flex NST-EF) and four-step (Sof-Lex-SL, Super-Snap-SS). Surface gloss was measured with a glossmeter and surface roughness was measured with a profilometer. Results were ana-

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lyzed by two-way analysis of variance (ANOVA)/Tukey's ($\alpha<0.05$). Results: No difference in gloss was noted among the three F/P systems when used with D and EX; no difference between SL and EF when used with any composite, except for FS; and no difference between SL and SS when used with any composite. SL and EF showed similar surface roughness when used on all composites, except for EX. EF and SS showed similar surface roughness on PR. SL and SS showed similar surface roughness values on every composite, except for FZ. Conclusions: EF was capable of providing similar gloss and surface roughness to SL on four composites evaluated but was not able to produce as glossy or as smooth a surface as SS for three of the five composites.

INTRODUCTION

The smooth surface of a restoration provides both optimum esthetics and low plaque accumulation.[1] A rougher surface texture can lead to decreased gloss and increased discoloration of the material surface, both of which affect the esthetic quality of a restoration.[2] Surface roughness refers to the finer irregularities of the surface texture that usually result from the production process acting in combination with the specific composition of the material.[3] Bollen and coworkers performed a literature review on comparing surface roughness of oral hard materials, including direct resin composite, vs threshold surface roughness of 0.2 μm for bacterial plaque retention. They stated that values above the threshold would favor the development of both caries and periodontal inflammation.[4] Another study reported that a change in surface roughness on the order of 0.3 μm can be detected by a patient with the tip of the tongue.[5] Gloss is defined as "angular selectivity of reflectance, involving surface-reflected light, responsible for the degree to which reflected highlights or images of objects may be seen as superimposed on a surface."[6] Like surface roughness, gloss depends on characteristics of the material and on particular process variables. Different particle sizes of composites promote different surface roughness and gloss; in addition, differing polishing systems yield different results on material surfaces.[7]

Several finishing and polishing (F/P) systems are available for dental professionals. They are normally classified into six major categories, including burs (diamond or carbide); rubber-based cups, points, discs, and wheels; coated abrasive discs and strips; pastes; silicon carbide brushes; and liquid polish. Among all polishing systems available on the market, the effectiveness of discs on the surface of composites has been evaluated most extensively.[7-25] A great majority of discs are impregnated with aluminum oxide; however, silicon carbide, garnet, emery, and quartz can also be present. F/P discs are utilized in a sequence ranging from the coarsest grits of 55-100 μm to the finest grits of 7–8 μm.[26] Standard four-step systems generally comprise two finishing discs (coarse and medium) and two polishing discs (fine and superfine). Steps are usually followed in sequential order, and skipping any step may cause imperfections on the surface of the composite. Each sequential disc with a finer grit removes imperfections caused by the former disc, with the ultimate goal of creating a smooth and shiny surface.

To achieve this goal in fewer steps, a new two-step finishing/polishing system was introduced on the market. According to the manufacturer, these discs present a novel nanosphere technology (NST), which refers to sphere-shaped particles that are aggregates of nanoparticles and diamond particles. These nanoparticle aggregates are broken into smaller particles during finishing and polishing, promoting a smooth, shiny composite surface. Compared with regular polishing abrasive particles, these NST particles have no sharp edges and thus significantly reduce scratches on the restorations. To date, no known studies have compared the performance on the surface of resin composites of this two-step system vs multistep discs.

The purpose of this study was to evaluate the surface finish and gloss of a two-step composite finishing/polishing disc system on five dental composites and compare it with two other multistep disc systems. The null hypotheses were that no difference in surface roughness or gloss would be found among the polished resin composites or among the different polishing systems when used on the same composites.

METHODS AND MATERIALS

Five commercial resin composites (Table 1) and three F/P disc systems (Table 2) were evaluated in this study. The five resin composites were chosen because of differences in their particle sizes, and the three disc systems were selected because they possess different composition and numbers of polishing steps. Seventy-five disc-shaped specimens (D=10.0 mm, 2 mm thick, n=15 per composite and n=5 per disc) were made by packing uncured composite (A2 enamel shade) into a metal ring mold. Mylar strips were placed over each surface of the uncured composite to

Table 1: *Resin Composites Tested*

Resin Composite	Type	Inorganic Filler Level	Average Particle Size	Manufacturer	Lot #
Filtek Supreme Plus-FS	Nanofill	78.5 wt%	20 or 70 nm	3M ESPE Dental Products, St Paul, MN, USA	20051216
Durafill VS-D	Microfill	52 wt%	40 nm	Heraeus Kulzer Gruner, Hanau, Germany	010200
Premise-PR	Nanohybrid	84 wt%	0.02–50 μm	Kerr Orange, CA, USA	2719074
Filtek Z250- FZ	Minifill Hybrid	82 wt%	0.6-0.8 μm	3M ESPE Dental Products, St Paul, MN, USA	20051226
Esthet-X-EX	Minifill Hybrid	77 wt%	0.85-0.9 μm	Dentsply Caulk, Milford, DE, USA	050829

prohibit oxygen inhibition. A 500 g load was placed on the mold for 20 seconds to extrude the excess material. Specimens were then light-polymerized for 40 seconds using the Demi light-curing unit (Kerr, Danbury, CT, USA) with an 11 mm diameter light tip. The energy of the polymerization light was monitored with a dental radiometer (Model 100, Kerr Demetron, Danbury, CT, USA) after initial measure-

Table 2: *Polishing Systems Tested*

Polishing System	Approximate Average Particle Size*	Manufacturer	Lot #
Enhance Flex NST- EF (aluminum oxide and diamond-silica)	40-100 μm (aluminum oxide), 40-60 μm (1 μm diamond particles imbedded in a matrix of nano-scale silica)	Dentsply Caulk, Milford, DE, USA	090323
Enhance Flex NST- EF (diamond-silica)	40-60 μm (1 μm diamond particles imbedded in a matrix of nano-scale silica)	Dentsply Caulk, Milford, DE, USA	090225
Sof-Lex-SL Red (aluminum oxide)	60 μm (electrostatically coated)	3M ESPE Dental Products, St Paul, MN, USA	2385P
Sof-Lex-SL Medium orange (aluminum oxide)	30 μm (electrostatically coated)	3M ESPE Dental Products, St Paul, MN, USA	2385P
Sof-Lex-SL Light orange (aluminum oxide)	30 μm (slurry coated)	3M ESPE Dental Products, St Paul, MN, USA	2385P
Sof-Lex-SL Yellow (aluminum oxide)	3 μm	3M ESPE Dental Products, St Paul, MN, USA	2385P
Super-Snap-SS Black (silicon carbide)	60 μm	Shofu Dental Corporation, San Marcos, CA, USA	1109721
Super-Snap-SS Violet (silicon carbide)	30 μm	Shofu Dental Corporation, San Marcos, CA, USA	1109721
Super-Snap-SS Green (aluminum oxide)	20 μm	Shofu Dental Corporation, San Marcos, CA, USA	1109721
Super-Snap-SS Red (aluminum oxide)	7 μm	Shofu Dental Corporation, San Marcos, CA, USA	1109721

ment with a laboratory grade laser power meter (Power Max 5200, Molectron, Portland, OR, USA) and averaged ~600 mW/cm^2.

Immediately after the light-curing cycle, the specimens were taken from the mold and were initially finished with a 16-fluted carbide finishing bur (H135.31.014 #ET9, Brasseler, Savannah, GA, USA) with light pressure, removing the initial shiny surface caused by curing against the Mylar strip and thus simulating a clinical finishing procedure. This procedure was done in a uniform manner using a device with a sliding stage that is moved into a stabilized rotating bur. Specimens were positioned on a 1 mm thick metal ring and were attached to the base with double-sided adhesive tape in such a way that the specimen was placed 1 mm above the base of the ring, facilitating the finishing procedure. One trained operator performed the finishing. Five specimens of each resin composite were randomly assigned to undergo the final F/P step by one of the three polishing systems. All F/P was performed by a single trained operator using the same slow-speed handpiece (W&H, Burmoos, Austria) throughout. Each disc was used only once, the polishing motion was circular and constant, and the discs were used dry. This procedure was accomplished as follows:

<u>Enhance Flex NST-EF discs</u> – Total time = 52 seconds

- Step 1 (medium grit): low rpm (average 10,000 rpm), 20 seconds, rinse and dry with water/air syringe for a total of 6 seconds.
- Step 2 (fine grit): high rpm (average 20,000–30,000 rpm), 20 seconds, rinse and dry with water/air syringe for a total of 6 seconds.

<u>Sof-Lex-SL discs (Extra Thin), Super-Snap-SS discs</u> – Total time = 104 seconds

- Step 1 (coarse grit): low rpm (average 10,000 rpm), 20 seconds, rinse and dry with water/air syringe for a total of 6 seconds.
- Step 2 (medium grit): low rpm (average 10,000 rpm), 20 seconds, rinse and dry with water/air syringe for a total of 6 seconds.
- Step 3 (fine grit): high rpm (average 20,000–30,000 rpm), 20 seconds, rinse and dry with water/air syringe for a total of 6 seconds.
- Step 4 (superfine grit): high rpm (average 20,000–30,000 rpm), 20 seconds, rinse and dry with water/air syringe for a total of 6 seconds.

After polishing, the specimens were evaluated for gloss and surface roughness. Average surface roughness (Ra, μm) was measured with a surface profilometer (TR 200 Surface Roughness Tester, TIME Group, Pittsburgh, PA, USA) using a tracing length of 2 mm and a cutoff value of 0.25 mm to maximize filtration of surface waviness. Four tracings were made on each specimen in a wheel spoke arrangement, and the average Ra was calculated. Gloss was measured using a small-area glossmeter (Novo-Curve, Rhopoint Instrumentation, East Sussex, UK) with a square measurement area of 2×2 mm and 60 degrees geometry. Gloss measurements are expressed in gloss units (GU). A jig was designed to place the specimen over the aperture in the same place each time, and four measurements were made by rotating the specimen 90 degrees around its center. The average of the four measurements was determined.

Statistical Analysis

Statistical analyses were done using computer software (Sigmastat 3.11, Systat Software Inc, San Jose, CA, USA). Two-way analysis of variance (ANOVA) was performed for the gloss and surface roughness data (composite and F/P system served as two independent variables) followed by Tukey's multiple comparison tests ($\alpha<0.05$).

RESULTS

Gloss results are given in gloss units (GU) in Table 3. Surface roughness results are given in Ra (μm) in Table 4.

No difference in gloss was noted among the three F/P systems when used with D and EX. No difference between EF and SL was observed when used with any composite, except for FS. EF showed lower surface gloss than SS when used with FS, PR, and FZ. No difference between SL and SS was reported when used with any composite.

All composites evaluated showed equivalent surface gloss when polished with SL or SS. EF, D, PR, and EX showed equivalent surface gloss and the highest surface gloss. FS showed the lowest surface gloss, and PR and EX were not significantly different from FZ. EF and SL showed similar surface roughness values when used on all composites, except for EX, which showed a lower surface roughness when F/P with SL. EF and SS showed similar surface roughness values when used on PR. SS showed lower surface roughness values than EF on FS, FZ, and EX. SL and SS showed similar surface roughness values when used on every composite, except for FZ.

Table 3: *Average Gloss Values (GU) and Standard Deviation (±SD) for the Five Resin Composites and Three Finishing/Polishing Discs Tested*[a]

Resin/Polishing Systems	Enhance Flex NST	Sof-Lex	Super-Snap
Filtek Supreme	44.57[b/C] (±1.04)	63.6[a/A] (±1.43)	64.22[a/A] (±1.80)
Durafill	65[a/A] (±2.50)	58.02[a/A] (±2.40)	58.62[a/A] (±2.86)
Premise	57.57[b/AB] (±0.75)	60.96[a,b/A] (±1.24)	65.60[a/A] (±1.00)
Z250	51.38[b/B] (±2.17)	57.6[a,b/A] (±0.84)	62.60[a/A] (±1.61)
Esthet-X	58.76[a/AB] (±0.94)	61.82[a/A] (±1.20)	62.47[a/A] (±1.22)

[a] *Values with the same superscript are not significantly different. Lowercase superscripts refer to the rows (polishing system within composite). Uppercase superscripts refer to the columns (composite within polishing system).*

Table 4: *Average Surface Roughness (Ra, m) and Standard Deviation (±SD) for the Five Resin Composites and Three Finishing/Polishing Discs Tested*[a]

Resin/Polishing Systems	Enhance Flex NST	Sof-Lex	Super-Snap
Filtek Supreme	0.22[b/A,B] (±0.04)	0.15[ab/A] (±0.03)	0.12[a/A] (±0.03)
Durafill	0.14[a/A] (±0.06)	0.17[ab/A] (±0.03)	0.24[b/B] (±0.05)
Premise	0.21[a/A,B] (±0.01)	0.15[a/A] (±0.02)	0.18[a/A,B] (±0.1)
Z250	0.23[b/B] (±0.02)	0.19[b/A] (±0.08)	0.10[a/A] (±0.02)
Esthet-X	0.24[b/B] (±0.04)	0.12[a/A] (±0.04)	0.13[a/A] (±0.02)

[a] *Values with the same superscript are not significantly different. Lowercase superscripts refer to the rows (polishing system within composite). Uppercase superscripts refer to the columns (composite within polishing system).*

All composites showed similar surface roughness when polished with SL. All composites showed similar surface roughness when polished with EF, except for D, which was significantly lower than FZ and EX. All composites showed similar surface roughness when polished with SS, except for D, which was significantly rougher than FS, FZ, and EX.

DISCUSSION

Coated abrasive discs are made by bonding abrasive particles onto a thin polymer or plastic backing; they are useful on flat or convex surfaces. They work well on anterior restorations, such as those involving incisal edges and embrasures, and to a limited extent on posterior composites, especially on interproximal and some buccal and lingual areas.[26] Several studies have evaluated the surface roughness[7-25] and gloss[7,25] of composites polished with SL discs, and one study evaluated SS discs.[14] Several investigators concluded that flexible aluminum oxide discs are the best instruments for attaining low roughness on composite surfaces.[10-13,16,18,21] To the best of the authors' knowledge, no studies have compared the two four-step systems or the three systems that were evaluated in this study.

The null hypotheses that no difference in surface roughness or gloss would be found among the polished resin composites or among the different polishing systems when used on the same composites were partially accepted but were F/P system and composite dependent.

The two-step F/P disc system is different from the four-step systems evaluated. It presents a novel technology that incorporates diamond-silica and a mixture of large and small particles. Both finishing and polishing discs contained particles that have an average size of 40 to 60 μm. The spheres comprise 1 μm diamond particles imbedded in a matrix of nano-scale silica. The finishing disc also contains aluminum oxide grits, which range from 40 to 100 μm. The stated main advantage of this system is that it can reproduce similar surface smoothness and gloss as four-step systems on resin composites in half the time. While it took 52 seconds to finish and polish the composite specimen with the two-step system, it took 104 seconds with the four-step systems. However, the NST system was not always able to produce as high a gloss or as low a surface roughness as the other systems. Perhaps with longer usage, smoother and glossier surfaces could have been produced on these particular composites.

The two four-step systems evaluated behaved very similarly when the gloss and surface roughness of each composite were evaluated, except for the surface roughness of FZ, in which SS produced a smoother surface. Despite the fact that the two finishing discs for the two systems have different compositions (ie, SS has a silicon carbide abrasive and SL has aluminum oxide), the abrasive particles in the two systems are similar in size and composition. Thus it is not surprising that these systems showed similar results.

The four-step F/P system (SL) and the two-step F/P system (EF) produced similar gloss on the surface of all composites except for FS, and similar surface roughness for all composites except for EX. Although EF was capable of providing a surface roughness comparable with that of SL discs when used on FS, it could not produce the same glossy effect as this four-step system. It seems that particles present in the EF F/P discs were able to remove scratches produced during the initial finishing procedure; however, the single polishing disc was not able to produce as shiny a surface as the two polishing discs in the SL system. The opposite was true for EX, in that EF was capable of producing a surface gloss similar to that of SL, but it did not produce as smooth a surface as was produced by this four-step system. It seems that the EF finishing disc produced some scratches on the composite that could not be removed or reduced sufficiently by the polishing disc.

The four-step F/P system (SS) and the two-step F/P system (EF) produced similar gloss on the surface of D and EX and similar surface roughness on PR. SS was able to provide better or similar gloss and surface roughness on four of the five composites evaluated. It seems that the coarsest silicon-based SS does not produce as many initial scratches as the EF finishing disc; therefore the silicon-based SS produces smoother composite surfaces. Moreover, because the scratches were not as deep and were more easily removed, this four-step system was able to produce a glossier surface on the composites when compared with the two-step system.

All composites evaluated showed equivalent surface gloss when polished with SL or SS. The two-step system produced similar surface gloss on the microfill composite (D), the nanohybrid composite (PR), and the minifill hybrid composite (EX). The shiniest surface was achieved on D and the least shiny on the nanofill composite (FS). Traditionally, it is believed that the ability to polish composites varies depending on particle size,[27] and microfilled resin composites should be more easily polished than hybrid types because of their smaller overall filler size. The finding that the nanofill composite showed reduced gloss compared with the microfill composite was unexpected because both the nanofill and microfill composites evaluated in this study contained only particles smaller than 100 nm. Apparently, NST technology is not as effective at producing a highly glossy surface on FS; this may be related to the presence of nanoclusters in this composite.

The two-step system produced similar surface roughness on all composites, except on the microfill (D). The smoothest surface was on D, and the least smooth surface was on EX. Although the two-step system did not produce as glossy a surface on the nanofill composite as on the microfill, it was able to produce a similarly smooth surface on both composites.

Although different polishing systems produced different surface roughness values on the composites, values achieved by all systems for all of the composites were below 0.25 μm, suggesting little if any difference among them clinically. According to Chung and coworkers, restorations appear to be optically smooth when their surfaces present a roughness of less than 1 μm.[28] A reflective surface below 1 μm is below the resolution of the wavelength of visible light.[29] In this study, the surfaces of all materials tested were well below 1 μm. No studies were found that identify a clinically relevant level of gloss. According to the American Dental Association (ADA) professional product review, 40–60 GU was identified as a typical desired gloss based on observations from an expert panelist.[30] Gloss values achieved by all F/P systems on all composites evaluated were greater than 40 GU.

CONCLUSION

Within the limitations of this study, it can be concluded that the only two-step composite disc finishing/polishing system (EF) was capable of providing similar gloss and surface roughness results to those attained with the four-step system (SL) on four of the five composites evaluated. However, the two-step system was not able to produce as glossy or as smooth a surface as the SS discs for three of the five composites. All systems produced clinically acceptable gloss and surface roughness.

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