Resin composite polishing--filling the gaps

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Abstract

The search for the ideal polishing agent for resin composite materials is still ongoing. A new polishing brush with abrasive bristles for polishing resin-based restorations was tested to determine if it polishes restorations, including those with concave surfaces, macrostructured occlusal surfaces, and textured surfaces, without destroying their delicate texture or microstructure.

Reference


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Resin composite polishing—Filling the gaps

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Objective: The search for the ideal polishing agent for resin composite materials is still ongoing. A new polishing brush with abrasive bristles for polishing resin-based restorations was tested to determine if it polishes restorations, including those with concave surfaces, macrostructured occlusal surfaces, and textured surfaces, without destroying their delicate texture or microstructure. Method and materials: The polishing effectiveness and the ultimate destructive potential of these brushes were assessed quantitatively and subjectively in vitro. In addition, the durability of the brushes after repeated use and autoclaving was also evaluated. Results: The brushes were nondestructive to resin-based restoratives, enamel, dentin, and the restoration interface. They produced a shiny surface on resin-based restorative materials without destroying the surface texture. The abrasive brushes were autoclavable and demonstrated satisfactory durability, despite multiple heat sterilization cycles. Conclusion: These brushes can be considered to be key products to polish concave surfaces, anatomically shaped occlusal surfaces, and textured surfaces without damaging the surface characteristics. (Quintessence Int 1999;30:490–495)

Key words: abrasive bristle, finishing, Occlusbrush, polishing, resin composite

CLINICAL RELEVANCE: Brushes with abrasive bristles complement the range of products available to polish resin-based restorations. The brushes are both structure friendly and efficient.

Resin composite, compomer, and resin-modified glass-ionomer restorations must be finished and polished after polymerization for the following 4 reasons1-3: First, matrix bands cannot be placed as precisely as required to avoid subsequent adjustments to restorations. Second, the development of adhesive knife edges because of beveling for restoration retention and esthetic blending with the surrounding tooth structure are necessary to conform to the principles of adhesive dentistry.4 Third, resin-based restorative surfaces cured against a matrix band are the smoothest but have a higher resin content and thus have a different color and a different wear resistance than does the bulk of the material.5 Fourth, because polymerization is inhibited by oxygen, newly cured, free surfaces are sticky and soft and encourage the accumulation of plaque. Consequently, a slight excess of restorative material is a prerequisite to building up feather edges and to preventing cavities from being underfilled after removal of the physicochemically and esthetically inferior surface layer.

The trimming procedure for resin-based restorations comprises 4 steps:

1. Coarse finishing or reduction of excess: For the reduction of large amounts of excess restorative material, instruments with high grinding effectiveness are preferred. These coarse, abrasive burs have some destructive potential. Their use should thus be confined to the outer excess material.
2. Contouring: The aim of contouring is to achieve the final form of the restoration as prescribed by functional and esthetic criteria.
3. Fine finishing: This comprises the final, precise adjustment of the restoration margins and the improvement of surface smoothness.
4. Polishing: A smooth and glossy, but nonetheless textured, surface is the final objective of any polishing procedure.

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TABLE 1 Clinical concept for efficient, nondestructive finishing and polishing of enamel, dentin, resin-based restoratives, and restoration interfaces

<table>
<thead>
<tr>
<th>Steps</th>
<th>Convex surfaces; smooth surfaces</th>
<th>Concave and occlusal surfaces; sulcular region; precision trimming</th>
<th>Proximal surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross finishing:</td>
<td>Flexible disks, coarse</td>
<td>Finishing diamond, 40 μm</td>
<td>Diamond file, 90 μm</td>
</tr>
<tr>
<td>exceed reduction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contouring</td>
<td>Flexible disks, coarse and medium</td>
<td>Finishing diamond, 40 μm</td>
<td>Diamond file, 40 μm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Diamond strips, 40 μm</td>
</tr>
<tr>
<td>Finishing</td>
<td>Flexible disks, medium and fine</td>
<td>Finishing diamonds, 16 μm and 8 μm</td>
<td>Diamond file, 15 μm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Diamond strips, 15 μm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Strips, coarse and medium</td>
</tr>
<tr>
<td>Polishing</td>
<td>Flexible disks, fine and extra</td>
<td>Finishing diamond, 8 μm</td>
<td>Diamond file, 8 μm</td>
</tr>
<tr>
<td></td>
<td>fine extra</td>
<td></td>
<td>Strips, fine and extra</td>
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<tr>
<td></td>
<td></td>
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<td>EXTRA FINE BRUSH</td>
</tr>
</tbody>
</table>

With regard to tooth surface form and location, 3 different sites can be distinguished: (1) convex and smooth surfaces; (2) concave surfaces, occlusal surfaces, and the sulcular region; and (3) proximal surfaces.

There is an abundance of literature on finishing and polishing. The majority of these studies are confined to assessing the induced surface roughness with profilometers and scanning electron microscopes (SEMs). The findings indicate that flexible aluminum oxide disks produce smoother surfaces than diamond finishing burs, tungsten carbide burs, mounted stones, and rubber points when used with polishing pastes.

Concerning restoration longevity and long-term esthetics, the destructiveness of trimming instruments, ie, the potential to damage the restorative material, enamel, dentin, and various interfaces between restoration and tooth, require evaluation. The occurrence of marginal tooth and restoration fractures correlates directly with the energy transfer from the trimming instrument to the substrate during the finishing procedure. Flexible disks are the most tooth and restoration friendly. Among rotary instruments, diamond finishing burs are superior to tungsten carbide burs, mounted stones, or rubber points because they are used without any pressure as a result of their superior grinding efficiency. Following the same principle, flexible diamond-coated files were developed for trimming proximal surfaces in a reciprocating motion. Based on this research, a clinical procedure was developed to gently finish and polish restorative materials, tooth surfaces, and the various interfaces, particularly of resin-based restorations (Table 1).

Flexible disks are used to trim convex and smooth surfaces. Based on extensive research, fine diamonds (average particle sizes 8 to 40 μm) are ideal to contour and finish concave and occlusal surfaces, to finish feather edges, to trim the sulcular region, and for localized precision trimming. Oscillating flexible files have a unique ability to access and finish interproximal and subgingival areas. Their reciprocating action, however, results in higher surface roughness than do rotary or planar motions. Consequently, with diamond-coated flexible files and strips, smaller average diamond particle sizes should be selected for contouring and finishing than would be selected with flexible disks and diamond finishing burs.

Final polishing is mainly carried out using disks, strips, diamond or alumina polishing paste, or rubber polishers. These polishing procedures are not ideal. Rubber polishers are too bulky to access all the recesses in naturally shaped occlusal surfaces. Furthermore, they are destructive to the margins. Polishing pastes are difficult to apply, and they selectively abrade the composite matrix. Thus, the inorganic fillers may be exposed or even dislodged, increasing the surface roughness in resin-based restorative materials. Disks are nondestructive, but their effect on anatomically contoured occlusal surfaces is limited because they cannot access the narrow fissures on the surface for geometric reasons. Textured surfaces almost completely lose their characteristics when polished with flexible disks or with rubber points and polishing pastes. Consequently, new approaches have been sought to allow efficient polishing of anatomic occlusal surfaces without damaging the restoration interfaces and without changing the surface texture.

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The aim of this study was to evaluate the polishing of occlusal and textured surfaces of resin-based restorative materials using brushes with newly developed abrasive bristles (Occlbrush, Hawe-Neos). Special attention was paid to the polishing effect, the destructive potential, and the durability of the abrasive bristles.

METHOD AND MATERIALS

Description of the abrasive polishing brushes

The appearance of the brushes is similar to that of currently available prophylaxis brushes. The brushes are available in the form of cups, minicups, or minipoints (Fig 1). To prevent confusion with prophylaxis brushes, the metallic parts are gold plated. The bristles are made of a special, rather rigid polycarbonate fiber, which is impregnated with silicon carbide particles.

Assessment of the destructive potential (test 1)

Six extracted, caries-free human molars were selected; they had been stored in 0.1% thymol after extraction until used. The roots were scaled and pumiced, and the teeth were mounted centrally on metal SEM specimen stubs with cold-curing acrylic resin (Paladur, Heraeus-Kulzer).

Standard, box-shaped occlusal cavities without taper were prepared in the molars. Initial preparation was carried out with 80-μm diamond burs (Universal Prep Set, Intensiv), and margins were finished with 25-μm diamonds (Universal Prep Set) used under a stereomicroscope at ×12 magnification. Care was taken to have straight and fracture-free cavity margins after finishing. Without etching of the enamel, the cavities were filled with a fine hybrid resin composite (Tetric, Vivadent) in a 2-step horizontal layering technique. Each increment was irradiated separately for 60 seconds with a halogen light (Translux EC, Heraeus-Kulzer) with irradiance of 560 mW/cm², as assessed by a Demetron Curing Radiometer.

After light curing, the restorations were finished with 25-μm diamond burs, used without pressure but with abundant water spray. Subsequently, an impression (President light body, Coltène) was taken to prepare resin-based replicas for the SEM evaluation. The restoration surfaces were then polished with the abrasive brushes (Occlbrush), used with a maximal contact pressure of 2.5 N, as monitored by a digital balance (PM11-K, Mettler) underneath the test teeth. The brushes were used first with and then without water cooling, for a total of 8 minutes. At this point, a second impression was taken.

Both silicon impressions were cast using epoxy resin after 24 hours’ storage (Stycast 1266, Emerson & Cuming). The replicas were gold sputtered (SCD 030, Balzers), and the tooth-restoration interfaces were quantified in an SEM (Amray 1810T, Amray) at ×200 magnification using a computer-assisted program. The qualities of marginal enamel fractures and marginal restoration fractures before and after polishing were statistically tested with the paired t test (StatView 4.0, Abacus Concepts), and the percentage of the total marginal length showing defects was determined.

Quantification of surface roughness (test 2)

Five composite samples (Tetric) were prepared in 8 × 2-mm molds. After finishing with 25-μm diamonds, the surfaces were polished for 1 minute without moisture at a pressure of 2.5 N using the test brushes. The average surface roughness (Ra) was then quantified with a computerized profilometer (Form Talysurf 50, Rank Taylor Hobson). The average readings of 10 measurements per composite specimen were compared to the findings after polishing with flexible disks (Sof-Lex Discs, 3M Dental) used under the same conditions. Results were statistically tested with the unpaired t test (StatView 4.0). The enamel surfaces of 2 unprepared human molars served as natural controls.

In addition, replicas of the polished surfaces were made and analyzed in the SEM to assess surface disintegration of the composite resulting from the finishing and polishing procedures.
**Subjective assessment of surface luster (test 3)**

Twelve box-shaped Class I restorations (Tetric) in extracted teeth were contoured with 25-μm finishing diamonds and randomly divided into 2 equal groups. Specimens in group 1 were polished for 1 and 2 minutes each with the abrasive brushes, and those in group 2 for the same period with extra-fine flexible disks (Sof-Lex). The surface luster produced by the 2 polishing procedures after 1 minute and after 2 minutes was subjectively compared, in analogy to a clinical assessment, by 2 experienced dentists and 2 laboratory technicians.

**Subjective assessment of surface texture preservation (test 4)**

Twenty-four resin composite disks (Charisma, Kulzer), 2 mm high and 10 mm in diameter, were ground wet with 1,200-grit silicon carbide paper in accordance with standard metallographic procedures. The surfaces were then roughened with a coarse diamond preparation bur (No. 255, 5.0, coarse, Intensiv), used dry at low speed. The 24 specimens were randomly divided into 4 equal groups. They were then polished to subjectively equal luster with 1 of the following 4 polishing procedures: (1) flexible disks (Sof-Lex), (2) rubber polishers (composite polishers, Hawe-Neos), (3) abrasive brushes (Occlubrush), or (4) abrasive brushes preceded by a fine-grit flexible disk (Sof-Lex). The maintenance of the original surface texture was evaluated by direct visual comparison by 2 experienced dentists and 2 laboratory technicians.

**Investigation of Instrument durability and autoclavability (test 5)**

To assess durability, 20 abrasive brushes were divided into 2 equal groups. After repeated test runs, the brushes in group A (n = 10) were visually examined after each cycle. A test run comprised dry polishing of a tooth’s natural occlusal surface for 60 seconds at 2.5 N and 5,000 rpm in a contra-angle handpiece. Brushes in group B (n = 10) were ultrasonically cleaned between each test run and placed alternately in disinfecting solutions, such as Micro 10 (Unident), Lysetol FF (S + M), Cidex F 7 (Johnson & Johnson), Gigasept FF (S & M), Hibitane 20a (IC1), and Deconex (Wild), or autoclaved at 140°C. Bristle wear was quantified with a digital slide caliper, measuring the lengths of the bristles before and after 25 test runs.

**TABLE 2** Quantitative, computer-assisted, scanning electron microscopic evaluation of marginal defects* after finishing and polishing (mean ± standard deviation; n = 8)

<table>
<thead>
<tr>
<th>Marginal quality†</th>
<th>Finishing diamond (25 μm)</th>
<th>Abrasive bristle brush</th>
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</thead>
<tbody>
<tr>
<td>Marginal enamel fractures (%)</td>
<td>5 ± 4</td>
<td>5 ± 3</td>
</tr>
<tr>
<td>Marginal restoration fractures (%)</td>
<td>13 ± 4</td>
<td>13 ± 5</td>
</tr>
</tbody>
</table>

*Marginal defects in box-shaped, nonbonded, Class I resin composite restorations after finishing with 25-μm diamonds and after polishing of the same restorations with abrasive-bristle brushes.
†Marginal quality was determined as a percentage of the total marginal length showing defects.

**RESULTS**

**Assessment of the destructive potential (test 1)**

The percentages of marginal enamel fractures and marginal restoration fractures after the restorations were polished with the abrasive brushes were not significantly different from the marginal qualities after the restorations were finished with 25-μm diamond burs (Table 2); in fact their marginal quality remained unchanged.

**Quantification of surface roughness (test 2)**

The Ra scores are shown in Fig 2. The abrasive brushes did not level out the irregularities on the composite surface as well as did the finest flexible disks. The surface roughness of natural enamel was higher than that of composite surfaces finished with 25-μm diamond burs.

**Subjective assessment of surface luster (test 3)**

The surface luster produced by the abrasive brushes after a 1-minute treatment was subjectively greater on both the restorative material and the enamel surfaces than that produced by extra-fine flexible disks. In both procedures, a 2-minute surface treatment scarcely improved the surface gloss over the 1-minute results.

**Subjective assessment of surface texture preservation (test 4)**

Texture maintenance and gloss were to be achieved by using the abrasive brushes and fine flexible disks. Flexible disks and rubber polishers leveled out the sur-
surface texture during the polishing procedure; the abrasive brushes maintained the surface texture, but could not produce an adequate surface gloss when not preceded by fine flexible disks (Fig 3).

**Investigation of instrument durability and autoclavability (test 5)**

Bristles in group A were first dislodged from the brushes after 16 cycles. The brushes, however, could still be used after 25 cycles, at which point the experiment was terminated. In contrast, the bristles in group B were dislodged after 7 cycles and signs of wear first became apparent after 11 cycles. After 20 cycles, the brushes could no longer be used because of splaying. Linear wear of the brushes, caused by abrasion, was 320 µm after 25 cycles, corresponding to a 13-µm loss of bristle length per cycle.

**DISCUSSION**

The purpose of the present study was to assess the destructive potential of the abrasive brushes under extreme conditions (test 1). Consequently, butt-joint cavosurface line angles were prepared, and the composite restorations were placed without adhesion to the enamel. This restorative procedure resulted in deliberate marginal gaps and unsupported enamel and composite margins, both of which were fracture prone. In addition, an 8-minute polishing period was chosen to simulate extreme conditions concerning polishing time and thus energy transfer to the restoration margins. In spite of this, few marginal fractures were induced by the abrasive brushes. Consequently, the abrasive brushes were nondestructive to both restoration and enamel margins.

The roughness measurements (test 2) demonstrated that a nonmached, natural enamel surface has a distinct surface texture, although its shiny appearance gave the impression that the natural surface was uniformly plane. For a composite restoration to be rendered imperceptible to the naked eye, its surface should resemble the surrounding enamel surface as closely as possible. Thus, polished composite restorations should demonstrate both an enamel-like surface gloss and an enamel-like surface texture. The current findings showed that even the exclusive use of extra-fine disks flattened the surface relief. On the other hand, the surface roughness scores and the assessed surface luster after polishing proved that the abrasive brushes could produce a high surface gloss on the resin-based restoratives without completely flattening the surface texture deliberately created with a coarse preparation diamond bur (tests 3 and 4). This is in agreement with the basic requirements of esthetic dentistry.

Repeated use of nondisposable polishing instruments lowers costs and is environment friendly. However, polishing instruments can only be safely reused if they are hygienic and can be autoclaved. In test 5, the abrasive brushes were repeatedly sterilized, and the results indicated no negative effects even after 10 to 15 sterilization cycles. Any wear on the bristles was clinically irrelevant.
The abrasive polishing brushes were primarily designed to polish occlusal surfaces of resin-based restorations. However, 3 years of clinical use of the abrasive brushes has shown that they can be used for other purposes as well. The brushes can be used to polish amalgams, ceramics, and compomers as well as during a dental prophylaxis.

CONCLUSION

The abrasive brushes complement the spectrum of instruments clinically available to finish resin-based restorations. They can be used to polish all kinds of surfaces without leveling them out. These brushes are nondestructive to tooth surfaces, to restorative materials, and to restoration-tooth interfaces. Furthermore, the abrasive bristle brushes exhibit good durability following repeated sterilization cycles.

REFERENCES