This study utilized spectrophotometry to evaluate in vitro superficial dye deposition on resin-modified glass ionomer, following different surface finishing and polishing treatments. Materials that were photocured adjacent to the mylar strip produced the surfaces with the lowest mean after superficial staining. A restorative technique without excesses resulted in a smoother surface and prolonged the life of the restoration. The resin-modified glass ionomers tested offer adequate clinical performance.

Received: August 5, 2002
Accepted: September 23, 2002

The glass ionomer cement developed by Wilson and Kent in 1972 was the first restorative material to demonstrate anticariogenic activity (due to its continuous fluoride release) as well as the first such material capable of adhering to the dental structure chemically.\(^{10,12}\)

This cement's physical properties also included less desirable characteristics, such as low abrasion resistance, reduced translucence, friability, poor esthetics (due to the cement's opacity), and sensitivity to the technique. This sensitivity occurs because of the manipulation and setting reaction of the conventional glass ionomer cements, which are affected greatly by the presence or absence of water.

When superficial protection procedures are not respected, the material undergoes a process called soaking or dehydration.\(^{13,14}\) Glass ionomer/composite resin hybrid materials were developed to improve the existing qualities of the conventional glass ionomer cements and facilitate their clinical use.\(^{15,16}\)

The altered composition of these materials resulted in improved setting time and initial mechanical resistance while reducing their susceptibility to both dehydration and humidity absorption.\(^{17}\) Clinical considerations should be established for the correct use of such materials regarding cavity preparation, manipulation, surface protection, and finishing and polishing.\(^{2,18}\)

Finishing and polishing have become fundamental to the restorative process, providing improved marginal adaptation and adequate surface smoothness.\(^{17}\) As a result, the accumulation of bacterial plaque has been observed; this gathering reduces the risk of secondary caries while also maintaining gingival health (especially in cervical lesions).\(^{16,18}\) Finishing and polishing have become even more important for esthetic restorations because they reduce both the superficial deposition of dyes contained in food and the extent to which the original color is altered.\(^{16,19}\) The need to replace these restorations is reduced; as a result, the dental structure enjoys greater longevity.\(^{20,21}\)

This study sought to evaluate the superficial dye deposition of resin-modified glass ionomers following superficial finishing and polishing treatments.

Materials and methods

Two resin-modified glass ionomers, Fuji II LC (GC America Inc., Alsip, IL; 800/323-7063) and Photac-Fil (3M ESPE, St. Paul, MN; 888/364-3577), were selected for this study, as were two abrasive systems, Soflex (3M EPSE) and Enhance tips (Dentsply Caulk, Milford, DE; 800/532-2855), and a control group (a mylar strip).

Six acrylic matrices (11.5 cm x 5.5 cm), with four cylindrical perforations (4.0 mm internal diameter) were used to manufacture samples.

The Photac-Fil's capsule was activated by its own Aplicap system device and taken to a high-speed mixer (Capmix, 3M ESPE). The cement was agglutinated for 15 seconds, following the manufacturer's instructions.

The Fuji II LC ionomer was agglutinated following the manufacturer's recommendations (3.0 g of powder/1.0 g of liquid) for 25 seconds. The materials were inserted into the perforation of the acrylic matrix with a Centrix syringe and

0.5 mm diameter LCCV tips (Centrix, Shelton, CT; 800/235-5862).

The Photac-Fil was inserted into the matrix using the Aplicap system syringe provided by the manufacturer. After insertion, a polyester strip and a microscopy glass slab were positioned on the material and the acrylic matrix and pressed with a load of 500 g. All of the specimens were cured individually for 40 seconds with a halogen light photocuring device (Visilux II, 3M ESPE) and each specimen was stored individually in test tubes that were identified and sealed.

The specimens were finished and superficially polished for 30 seconds; distilled water cooling was utilized to avoid dehydration. The specimens of each group (control, Enhance, and Soflex) were affixed to a glass plaque with double-faced adhesive tape. Each specimen was covered with two coats of colorless nail polish and left to dry for 10 minutes.

Staining evaluation

Serra's method was used to quantify the staining.\(^{18}\) The specimens were immersed in a 2.0% blue methylene aqueous solution for three minutes, washed in distilled water for 15 seconds, and dried using absorbent paper; at that point, the specimens were ground individually with a stainless steel mortar and pestle and transferred to their respective test tubes along with 3.0 mL of absolute ethyl alcohol.\(^{18}\)

The tubes were sealed with PVC film, agitated individually, and left for 24 hours to ensure maximum solubility. After 24 hours, the specimens were centrifuged at 2,000 rpm for three minutes using an LC 15AN (Tomy Tech, Fremont, CA; 800/545-8669). The supernatant/ floating solution was analyzed through a DU-70 spectrophotometer (Beckman-Coulter, Fullerton, CA; 800/742-2345).

The calibration curve was achieved before the quantification of the samples by using standard blue methylene solutions (10 mg/mL, 8.0 mg/mL, 6.0 mg/mL, 4.0 mg/mL, and 2.0 mg/mL, referred to as
Table 1. Tukey test staining means for hybrid factor (p < 0.05).

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>Mean (µg/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photac-Fil</td>
<td>1.1109</td>
</tr>
<tr>
<td>Fuji II LC</td>
<td>0.1824</td>
</tr>
</tbody>
</table>

Table 2. Tukey test staining means for the finishing material factor (p < 0.05).

<table>
<thead>
<tr>
<th>Finishing material</th>
<th>Mean (µg/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhance</td>
<td>0.8615</td>
</tr>
<tr>
<td>Sof-lex</td>
<td>0.5787</td>
</tr>
<tr>
<td>Control</td>
<td>0.4998</td>
</tr>
</tbody>
</table>

P10, P8, P6, P4, and P2, respectively) and a specimen (referred to as P0) placed in 3.0 mL of pure alcohol; this blank solution was utilized before the specimens were examined. Throughout the experiment, the specimens were read using the standard solutions of calibration curve and the maximum absorbency peak found on the 650 nm wavelength.

Results
The results of staining were submitted to two-way ANOVA and Tukey tests. There were statistically significant differences among the three finishing materials and between the two restorative materials. For the restorative materials, Fuji II LC showed lower staining means, statistically different from Photac-Fil (p < 0.05) (see Table 1). When the finishing materials were compared, the control group showed the lower staining means while Enhance showed the higher staining means (see Table 2). Both mean figures were statistically different from those of the other finishing materials (p < 0.05).

Discussion
Glass ionomer/resin composite hybrid materials were developed to overcome some of the less desirable properties of conventional glass ionomer cements.24 The resin-modified glass ionomers consist of polyacrylic acid or modified polyacrylic acid; resins components, which could be a photocured hydroxyethyl methacrylate (HEMA) monomer or a photocured lateral chain linked to a polyacrylic acid; a glass that can be ionized; and water.24 The hybrid materials’ setting reaction is based on a photocatalytic polymerization reaction and an acid-base reaction. The acid-base reaction results from the dissolution of glass, which results in the formation of calcium polycarbonate and aluminum polycarbonate. The material manifests as a complete structure after the final setting; glass particles are united by an aluminum and calcium polycarbonate hydrogel.8 The reaction of these materials creates both a salt hydrogel matrix and a poly-HEMA matrix.25,26 The organic matrix formed by the polymer protects the acid-base reaction, diminishing dehydration, swelling, and the effects of early contamination created by water while allowing the dentist to finish and polish a restoration immediately after placement.45

For this study, Sof-lex discs and Enhance tips were the selected materials for finishing and polishing. Sof-lex discs were selected because they can be used successfully with glass ionomer cements, composites, and hybrid materials, producing smoother surfaces with fewer superficial porosities. The Enhance tips were chosen because their three different shapes (cups, cones, and discs) may be used on different dental surfaces.

All materials were finished and polished for 30 seconds, the materials were cooled to prevent excessive dehydration, and a quantitative spectrophotometry analysis—determined to be efficient for measuring the quantity of dye impregnated on polished surfaces—was used to evaluate the treated surfaces.27

Curing the resin-modified glass ionomer next to the mylar strip resulted in smaller superficial dye deposits on the surfaces. Tate and Powers reported similar findings in 1996 when they determined that curing the Fuji II LC next to a smooth surface produced surfaces with less superficial roughness.10

The Fuji II LC displayed greater pigmentation on surfaces treated with Enhance tips, while the Sof-lex discs and the control group both produced smoother surfaces, suggesting that matrix particles were dislocated during finishing and polishing.8 The Enhance tips may show greater granulation than the Sof-lex discs; however, the Enhance tips should be used for finishing and polishing surfaces that do not allow dentists to utilize Sof-lex discs. The Photac-Fil hybrid displayed no statistical difference between the Soflex discs and the Enhance tips, suggesting that polishing also depends on the composition of the restorative material.

Among the materials used to finish and polish the Fuji II LC fillings, the Sof-lex discs demonstrated less staining and a greater surface smoothness, capable of promoting a smoother and more uniform surface.37 The Sof-lex discs also demonstrated a smaller number of irregular particles and a smaller chance that those particles could become dislocated.87

In other studies involving conventional glass ionomer cements and composites, smoother surfaces were obtained when the cement gelled and the composite was cured next to the mylar strip.9,26,27 In the present study, the Fuji II LC resin-modified glass ionomer demonstrated greater pigmentation than any other hybrid material used; possibly due to the composition of the hybrid materials and/or the size, quantity, and distribution of the glass particles; smaller particles do not always produce a smoother surface. The surface's smoothness after finishing and polishing is influenced by the composition and nature of the different hybrid materials.

The results suggest that an appropriate restorative technique reduces the labor time, creates a smoother surface, prolongs the useful life of the filling, and produces better clinical performance from these materials.

Conclusion
Among the finishing and polishing materials used in this study, the Sof-lex discs showed the least superficial dye deposition; among the hybrid materials, the Fuji II LC resin-modified glass ionomer demonstrated the lowest superficial staining mean. The mylar strip presented significantly lower superficial dye deposition than either the Sof-lex discs or the Enhance tips.

Disclaimer
The authors have no relationship with the manufacturers or products listed in this article.

Author information
Dr. Liporoni is a professor, Department of Operative and Restorative Dentistry, School of Dentistry UNIVAP, Campinas.
São Paulo, Brazil, where Dr. Paradella is a graduate student. Drs. Paulillo and Cury are professors, Department of Restorative Dentistry, School of Dentistry UNICAMP, Piracicaba, São Paulo, Brazil, where Dr. Dias is a professor, Department of Mathematics and Statistics.

References


Reprints of this article are available in quantities of 1,000 or more. E-mail your request to Jo-Elynn Posselt at AGDJournal@agd.org.