Evaluation of surface roughness and color stability of direct resin composites after different polishing protocols
Carlos Eduardo dos Santos Bertoldo, Diogo Azevedo Miranda, Eduardo José Souza-Junior, Flávio Henrique Baggio Aguiar, Débora Alves Nunes Leite Lima, José Roberto Lovadino

Abstract
Background: Polished and smooth composite resin restorations present a better esthetic appearance and greater longevity. Aims: To compare the effect of different polishing protocols on surface roughness and color stability of two direct composites. Materials and Methods: Sixty specimens (6mm in diameter and 2mm in thickness) were divided into six experimental groups (n=10), composite resins (Z250 and 4 Seasons) and polishing systems (Sof-Lex and Jiffy). Baseline readings from surface roughness and CIE L*a*b* color was obtained after polishing procedures. Final roughness readings were made after this step. The specimens were immersed in 2ml of coffee solution under the follow regime: 15 minutes/7 days. After this, new color measurements were realized, getting the color variation (\(\Delta E\)). Results: The results were analyzed by two-way ANOVA and Tukey test (\(\alpha = 5\%\)). For both values, the polishing systems differed between the group control (unpolished), and each other. The specimens polished with Jiffy showed lower roughness values and color variation. Z250 presents highest roughness values in comparison with 4 Seasons. Conclusion: The 4 Seasons composite polished with Jiffy System exhibits lower rates of surface roughness and staining susceptibility.

Key Words: Roughness; color; resin composites

Introduction
The search for esthetic materials has led to advances in the study of dental materials, especially composite resins. The main advantages of resins are related to the material’s esthetic properties, decrease of marginal leakage, increased resistance of the tooth remnant, and less need for removal of healthy tooth structure. (1-3) In addition, the reduced polymerization shrinkage and improved wear resistance of resins allow their use not only in anterior but also in posterior teeth. (2, 4) The esthetics and longevity of restorations strongly depend on the quality of the surface finishing and polishing. The presence of irregularities can influence appearance, plaque retention, surface discoloration, gingival inflammation. (5-7) In addition, the surface roughness of composites can reduce some mechanical properties such as hardness (6) and increase the wear of restorations. (8, 9) Thus, polished and smooth composite resin restorations present a better esthetic appearance and greater longevity. (2, 8, 9)

Another important aspect is the need for removing the superficial resin layer that does not polymerize when in contact with oxygen. (10) Studies have shown that a smoother surface is obtained when the resin is cured against a strip of appropriate matrix. (9) Removal of this surface by the usually required finishing procedures will produce a harder, more resistant and esthetically acceptable surface. (2, 9) Several studies have been conducted to determine the effects of staining solutions on the surface characteristics of esthetic restorative materials. (8-10) The consumption of coffee and soft drinks, for example, has a high prevalence in the contemporary society, especially in industrialized countries. It has been demonstrated that surface discolorations in composite resins are related to hygiene, eating habits and smoking. The maintenance of the esthetics of a restoration is therefore related to the patients’ habits and lifestyle. (11)

Various polishing protocols have been tested in vitro to evaluate their effects on the surface roughness of restorative materials. These results have been useful to establish protocols for in vivo application. (12) Several composite resins have been the subject of surface roughness studies, but few investigations are available comparing the surface roughness of microhybrid resins, as well as the use of a new silicon polishing system (Jiffy) recently launched on the market. (2) This study was conducted to evaluate surface roughness of two composites (microhybrid and nanohybrid) after the use of different polishing systems, as well as to evaluate the effectiveness of these systems in the color stability of the material after staining with a coffee solution.

Materials and Methods
Two resin composites were selected: 4 Seasons (A3 - Ivoclar Vivadent, Schaan, Liechtenstein) and Z250 (A3 - 3M ESPE, St. Paul, MN, USA). The composition of the resin composites is described in Table 1. Two polishing system were chosen: SofLex (3M/ESPE, St. Paul, MN, USA) and Jiffy (Ultradent Products Inc. South
The composites presented were of each artificial saliva (pH 7.0) which, in turn, pressure and low speed for 20 s each. The specimens were washed with an air/water spray to remove debris, air dried and then polished with another disk of lower grit for the same period of time.

The specimens were washed with an air/water spray to remove debries, air dried and then polished with another disk of lower grit for the same period of time. The specimens were washed with an air/water spray to remove debries, air dried and then polished with another disk of lower grit for the same period of time.

Table 1. Restorative materials and polishing systems tested. Information supplied by the manufacturer.

<table>
<thead>
<tr>
<th>Resin</th>
<th>Manufacturer</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z250</td>
<td>3M ESPE, St. Paul, MN, USA</td>
<td>Bis – GMA, UDMA, Bis – EMA, Zirconium, Silica 60% (0.01 a 3.5μm)</td>
</tr>
<tr>
<td>4 Seasons</td>
<td>Ivoclar Vivadent (Schaan, Liechtenstein)</td>
<td>Bis-GMA, TEGDMA, UDMA 76 wt% of barium glass load, trifluor terbium, Ba-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Al Fluor Silicate glass and dispersed silica with load particles sized 0.04 – 3.0 μm, and load average size of 0.6μm.</td>
</tr>
<tr>
<td>Jiffy</td>
<td>Ultradent Products Inc.</td>
<td>Abrasive, silicon-impregnated rubber.</td>
</tr>
<tr>
<td></td>
<td>South Jordan UT, USA</td>
<td>Latex free material.</td>
</tr>
</tbody>
</table>

In the controls groups of each resin, the specimens were not submitted to any polishing procedure after curing under a polyester matrix. The specimens polished with aluminum oxide-impregnated disks (Sof-Lex®, 3M/ESPE) (dark blue, medium blue and light blue back, measuring 19.05 mm in diameter) at intermittent pressure and low speed for 20 s each. The specimens were washed with an air/water spray to remove debris, air dried and then polished with another disk of lower grit for the same period of time. The specimens were washed with an air/water spray to remove debris, air dried and then polished with another disk of lower grit for the same period of time.

Average surface roughness (Ra, in μm) of the specimens was determined with a previously calibrated mechanical roughness tester (Surftest 301, Mitutoyo America Corporation, Suzano, SP, Brazil) over a distance of 0.25 mm. Six measurements were made in the center of each specimen in two directions (three in the vertical and 3 in the horizontal direction).

A baseline photoreflectance reading (L1) was taken for each sample after polishing procedures utilizing a spectrophotometer CM-700d (Konica Minolta Sensing Americas, Ramsey, New Jersey, USA) coupled to a cabin light (MM-1eUV/D65). Data obtained was submitted to interpretation on a software OnColor QC Lite and the results were tabulated as CIE L*a*b* System. The obtained results for roughness and color variation were tabulated, and the homogeneity was verified by Shapiro-Wilk tests. After observation of these parameters, a two-way Analysis of Variance was performed for roughness. To color variation a two-way Analysis of Variance of repeated-measures was performed. When the difference was statistically significant (p<0.05), the Tukey test was used for comparison between means. The statistical analysis was carried out by SAS 9.2 (SAS Institute, Cary, NC, USA).

Results

The analysis of variance showed the interaction between the variables “composite resins” and “polishing systems” (p=0.017). Means from roughness and standard deviations as well as results of Tukey test are presented in Table 2. There was a significant roughness increasing for all resins after any type of polishing. However the resins polished with SofLex System presented higher roughness values. The composites presented statistical difference between themselves only when were polished with SofLex.

Table 2: Means Roughness - Ra pattern (standard deviation). Mean values followed by distinct letters (uppercase in horizontal rows and lowercase in vertical columns) show statistical differences among the groups according to the Tukey test (p<0.05).
The analysis of variance showed the interaction between the variables “composite resins” and “polishing systems” (p<0.001). Means from color variation and standard deviations as well as results of two-way ANOVA with repetition are presented in Table 3. There was a significant color alteration for 4 Seasons composite only when the polishing with SofLex was performed. To Z250 composite, all types of polishing presented higher ΔE values in comparison with control. The composites doesn’t presented statistical difference between themselves only for control.

<table>
<thead>
<tr>
<th>Resin</th>
<th>Polishing System</th>
<th>Control</th>
<th>Jiffy</th>
<th>SofLex</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Seasons</td>
<td>2.76 (0.91)Aa</td>
<td>3.35</td>
<td>4.72</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.02)Aa</td>
<td>(1.12)Ba</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z250</td>
<td>2.5 (0.87)Aa</td>
<td>4.63</td>
<td>5.47</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.23)Bb</td>
<td>(1.34)Cb</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: ΔE Means (standard deviation). Mean values followed by distinct letters (uppercase in horizontal rows and lowercase in vertical columns) show statistical differences among the groups according to the Tukey test (p<0.05)

Discussion

Studies have shown that tooth color differences showing ΔE > 1 can be visually detectable, judging ΔE > 3.3 the critical value for clinical acceptability of a restoration.(11) Moreover, any color difference (ΔE=0) indicates a material with full color stability or not stained by pigments.(13)

The use of nanotechnology induces the resin composite manufacturers to develop this type of composites, such as 4 Seasons, both for anterior and posterior tooth restoration. The resin composites with nano-size particles in its composition are new materials that improve their surface polishing due to their reduced size filler particles. This fact allows the combination of good mechanical properties and polishing.(14, 15) However, according to some studies, it was observed in this study that groups not subjected to any polishing procedure had lower values of surface roughness and staining.(2, 16)

The chemical composition of resin composites may interfere in the polishing quality. Z250 presented higher roughness compared to 4 Seasons. This composite contains Bis-EMA, and reduced amount of TEGDMA, and these characteristics promote better resistance of the polymer network in addition to the filler particle size, that is higher than the glass fillers presented in the 4 Seasons composite composition and consequently higher microhardness. Thus, the Z250 resin composite becomes less susceptible to polishing procedures in comparison with nanofilled resins.(17)

The effectiveness of surface finishing and polishing procedures is of fundamental importance for any restoration.(18) These procedures are commonly required after placement of direct composite resin restorations since they minimize the retention of plaque and stains and other problems resulting from the exposure of rough surfaces to the oral environment.(19) Smoother composite surfaces are obtained when the material was cured against a polyester matrix.(20) Even if care is taken in the placement of the matrix removal of the excess material and recontouring of restorations are frequently necessary. However, as observed in this study, these procedures significantly increase surface roughness.(19) Thus, a large number of polishing techniques is available for composites.(21)

The polishing methods tested had different effects on the surface of the composites. The lowest Ra was observed after polishing with the Jiffy system for both composites. The present results showed a significant change on composites’ surfaces according to the polishing system used. This findings are in agreement with those reported in previous studies.(22, 23)

A similar study reported that the polishing approach for Z250 composite resin with micro-polisher disks (PoGo), a similar method to Jiffy System used in our article, (0.51 ±0.15) resulted in lower surface roughness than the use of aluminum oxide (Sof-Lex) (1.12 ± 0.27) and rubber polishing disks (Identoflex) (1.53 ± 1.70). In addition, no significant difference in surface roughness was found between unfinished materials (polyester matrix surface).(24) This study agrees with our findings.

Color change can be assessed both visually and by specific instruments.(23) The methodology used in this study is in accordance with previous studies that used spectrophotometry and the CIE L*a*b* coordinates system.(18) The CIE L*a*b* system was chosen to evaluate color variation (ΔE) because it is well suited for small color changes determination and have advantages such as repeatability, sensitivity and objectivity. Coffee was chosen as a staining solution in this study because it has shown a high capacity of staining anterior composite resins and natural teeth.(11)

A positive correlation was observed between surface roughnesses and staining. The specimens showed greater color variation according to the largest surface roughness obtained, so the groups polished with Jiffy system showed lower roughness values and color variation in comparison with Sof-Lex groups. Lower staining for control groups was also observed,
which was cured under polyester matrix and had lower roughness values.

**Conclusion**

Under the conditions of this in vitro study, it may be concluded that: (1) when any polishing procedure was realized, the resin composites presented greater surface smoothness and lower staining, (2) the silicon polishing system presented lower roughness values and coffee staining.

**Authors Affiliations:** 1. Dr.Carlos Eduardo dos Santos Bertoldo, 2. Dr.Diogo Azevedo Miranda, Professor, 3. Eduardo José Souza-Junior, 4.Dr.Flávio Henrique Baggio Aguiar, Professor, 5. Dr. Débora Alves Nunes Leite Lima, Professor, 6. José Roberto Lovadino, Professor, Piracicaba Dental School, State University of Campinas, Department of Restorative Dentistry, Paulo, Brazil.

**References**


**Address for Correspondence**

Eduardo José Souza-Junior
Av. Limeira, 901, Areião,
Zip-code: 13.414-903, Piracicaba,
São Paulo, Brazil
Ph: +55 11 8163 5558
E-mail: edujcji@gmail.com

Source of Support: Nil, Conflict of Interest: None Declared