INTRODUCTION

Resin-based restorative materials have improved to such an extent that they can now be considered reliable, and are appropriate for use in posterior teeth with acceptable long-term longevity(1). Conventional composite resins normally achieve their hardening state through a polymerization process, in which monomers such as Bis-GMA, UDMA and TEGDMA, among others, are able to form a large three-dimensional network or polymer chain(2). During this process, and as a result of it, a dimensional change occurs with volumetric reduction- a phenomenon known as polymerization shrinkage, which commonly varies between 1-6%(3). The most commonly associated problems produced by this volumetric change may include microleakage(4), which is a resultant of the possible adhesive or cohesive failures of the bonding interphase during polymerization that leads to the formation of secondary caries(5). Cuspal deflection is another associated issue, which involves micro movements of the cusps associated to a bonded layer of resin material, and corresponds to the formation of cuspal fractures and microcracks(6).

Given the problems associated with the use of conventional composite resins in the different restorative techniques for posterior teeth, the focus of various dental companies during recent years has been the development of monomers that are capable of dissipating the stress generated during polymerization shrinkage, as well as incorporating inorganic filler particles with optical transluency properties superior to conventional composites, with the ability to transmit light and achieve acceptable conversion rates at depths close to 4-5mm. This group of resins are called bulk-fill resin composites(7).

The possibility of incorporating a greater thickness of a composite resin into a tooth cavity preparation means that composite bulk-fill resins have become a more attractive focus than conventional composite resins for the restoration of posterior teeth, which is mainly due to the crucial reduction of restorative clinical time, as well as the reduction of bubbles or impurities between each composite resin layer as in the case of posterior restorations performed with stratification composite resins, which have shown a considerable increase in restorations of posterior teeth through compactable bulk-fill composite resins(8). This has allowed more research and development in the field, including studies oriented towards the in vitro evaluation of the biomechanical behavior, as well as the phenomenon of polymerization shrinkage stress, depth of cure and degree of conversion. Studies such as Ilie et al(9), and Leprince et al(10), have demonstrated that compactable bulk-fill composite resins have lower physical-mechanical properties than conventional composite resins, which is related to their flexural strength, the monomer’s degree of conversion and elastic modulus. Other studies to the contrary have shown a comparable degree of conversion results with conventional composite resins(11). When it comes to depth of cure, most of the compactable bulk-fill resins obtained an acceptable degree of conversion at 4mm with extended light polymerization time and energy density; however, the degree of conversion is still lower than conventional composites(12).

Although a number of physical-mechanical tests have demonstrated that compactable bulk-fill resins have a lower performance than conventional composite resins in in vitro studies, clinical studies with short-term longevity and clinical performance analysis compared to conventional composite resins conclude that compactable bulk-fill resins are materials that can be safely used in clinical situations, demonstrating promising results that must be evaluated in the long term(13). Studies have also analyzed the optical properties of bulk-fill composites. Both flowable and high viscosity bulk-fill composite resins have superior translucency and light transmittance for blue light than conventional composite resins(14). When it comes to color, bulk-fill resins have less stability than conventional composite resins, even more so when they are subjected to drinks like coffee or are increased in thickness(15). The discoloration of this type of resin is affected by the polishing procedure and the type of liquid solution that came into contact with the bulk-fill resins(16).

According to Lefever et al(17), conventional composite resins have acceptable biomechanical properties which make them suitable for the restoration of teeth; however, many failures are currently associated with low levels of maintenance of surface properties like gloss and roughness. Since there is a lack of research regarding the optical behavior related to different surface treatments associated with finishing and polishing procedures of bulk-fill composites, the objective of this article is to evaluate the in vitro surface gloss of high viscosity bulk-fill resins subjected to different finishing and polishing materials.

The null Hypotheses of this study were as follows:
1. There are no significant differences in gloss values between the different polishing systems for the bulk-fill composite resin tested.
2. There are no significant differences in gloss values between resins for the same polishing system.
MATERIAL AND METHODS

Two bulk-fill compositeable composites were selected for the study: Tetric N Bulk Fill (Ivoclar Vivadent; Liechtenstein, Germany) color IVB, and Filtek Bulk Fill Posterior A2 (3M ESPE; St. Paul, MN).

Specimen Elaboration

80 bulk-fill composite resin discs were elaborated (10mm diameter and 2mm thickness). Each sample was created by placing a single increment of resin into a stainless steel mould. Mylar strips were positioned under and over the mould, and the excess of resin was eliminated by compression between two glass plates using finger pressure. All samples were polymerized through the glass plate using a LED curing unit (Elipar Deepcure-L, 3M ESPE) calibrated at 470mW/cm² according to the manufacturer’s instructions (Tetric N Bulk Fill: 10 seconds, and Filtek Bulk Fill Posterior: 20 seconds). The specimens were then stored in distilled water at 37°C for 24 hours.

Polishing Procedures

The first group of samples was left untreated, which constituted the control group (G1). Then, the remaining specimens were roughen with 320 grit sandpaper in order to simulate the finishing technique procedure with diamond burs. A single operator performed every step of the finishing and polishing procedures. Soft pressure of 40grs according Antonson et al. was used by the operator (calibrating the pressure). The discs were then observed by the different polishing procedures. The following polishing procedures were performed as follows:

- **Group 1 (G1):** Mylar strip, no finishing and polishing procedure.
- **Group 2 (G2):** Soflex XT: Coarse, medium, fine and superfine grit discs were applied consecutively for 20 seconds. Between each grit, the discs were cleaned with an air-water spray for 10 seconds.
- **Group 3 (G3):** Composite Politur: An initial finishing carbide bur was applied to the entire surface (H4BLQ.314.012). A pre polishing diamond bur followed by a polishing rubber were applied for 20 seconds each. After the carbide bur and between the diamond rubbers, the discs were cleaned with an air-water spray for 10 seconds.
- **Group 4 (G4):** Soflex Spiral: Coarse and medium grit discs from Soflex XT system were first applied for 20 seconds each. Then, the first finishing wheel followed by the polishing and gloss wheel were applied for 20 seconds each. Between each grit disc and wheel, the discs were cleaned with an air-water spray for 10 seconds.
- **Group 5 (G5):** ENA Shiny: Finishing diamond rubber was initially applied for 20 seconds. Shiny A diamond paste was applied with a goat hair brush for 20 seconds. Then, Shiny B was applied with a different goat hair brush for 20 seconds, and finally, Shiny C aluminum-oxide paste was used with a felt wheel for 20 seconds. Between each step, the discs were cleaned with an air-water spray for 10 seconds.

Gloss measurement

Gloss was determined by a gloss meter (Skin-Glossymeter GL 200, Courage + Khazaka Electronic GmbH with Cutometer* dual MPA 580, Courage + Khazaka Electronic GmbH) calibrated on a white surface provided by the manufacturer. The measurement area was 602.5mm with 60 degrees of angulation. Each sample was centrally placed inside a black plastic mould during the measurement in order to eliminate the influence of external and environmental light, and maintained in the same position in every measurement. Three measurements were performed in each specimen. Gloss units (GU) were calculated as the mean of the 3 measurements of each sample.

Scanning electron microscopy

Specimens were metallized with gold in sputtering equipment (Desk V. Dentaire Vacuum LLC, NJ, EE.UU.). The samples, using a slow speed and using a slow speed scanning electron microscopy (SEM) at 40X, 200X, 1000X and 3500X (Jeol JSM IT300 LV, USA Inc.) and processed by the manufacturer’s software (JSM IT300 version 1.070).

Statistical analysis

With the measurements obtained from gloss (GU units), the data base was created and statistically processed using Microsoft Excel® and SPSS Statistics® v23.0 (IBM®, USA). Homogeneity of variance and normal distribution of the samples were verified by Levene and Shapiro-Wilk tests, respectively. The mean and standard deviation of gloss were calculated, obtaining graphs to make an initial observation of the data. A two-way ANOVA model was designed in order to determine differences over means between the different levels of factors, thus determine if the type of bulk-fill composite resin and the type of polisher have an effect over gloss and to determine which combination has better in vitro performance, followed by a stratified ANOVA and Tukey post-hoc test (α = .05).

RESULTS

Mean values and standard deviation of gloss measurement for the two bulk-fill composite resins under different polishing techniques are shown in Table 1.

Table 1:

| Group | Polishing System | Tetric N Bulk Fill Polished Mean | Filtek Bulk Fill Polished Mean | Mean for both resins |
|-------|------------------|---------------------------------|-------------------------------|----------------------|
| G1    | Mylar strips, Control Group | 82.5 (9.8) | 79.0 (4.9) | 80.7 (7.7) |
| G2    | Soflex XT | 58.3 (7.2) | 57.2 (4.5) | 57.8 (5.8) |
| G3    | Composite Politur | 74.7 (7.4) | 75.0 (6.4) | 74.8 (6.7) |
| G4    | Soflex Spiral | 53.3 (7.1) | 63.4 (7.3) | 58.4 (8.7) |
| G5    | ENA Shiny | 83.6 (4.8) | 75.5 (2.9) | 79.6 (5.7) |
| Mean  | 70.5 (14.4) | 70.0 (9.8) | - | - |

According to the ANOVA test, there were significant statistical differences over mean values between the different polishing systems (p value=0,000), but no differences were found for both bulk-fill composite resins polished by the same system (p value=0.73) (Table 2). The Tukey post-hoc test determined the differences, which can be seen in Table 3.

Table 2:

| Origin | Type III sum of squares | gl | Root mean square | F | Sig. |
|-------|------------------------|----|-----------------|---|------|
| Corrected Model | 8963.716a | 9 | 995.968 | 23.737 | .000 |
| Intersection | 394.702.910 | 1 | 394.702.910 | 9.407.017 | .000 |
| Resin | 5.007 | 1 | 5.007 | .119 | .731 |
| Polished Group | 8.241.828 | 4 | 2.060.457 | 49.107 | .000 |
| Resin * Polished Group | 716.882 | 4 | 179.220 | 4.271 | .004 |
| Error | 2.937.085 | 70 | 41.958 | - | - |
| Total | 406.603.711 | 80 | - | - | - |
| Corrected Total | 11.900.801 | 79 | - | - | - |

r² = .753 (adjusted r² = .721)

The control group (Mylar strips) obtained the highest gloss values, followed by group G5 (ENA Shiny) without significant differences, G3 (Composite Politur), and G4 and G2 without significant differences. Since the interaction was found to be significant (p=0.004), there were Resin-Polishing system combinations where the effect of each of the factors affects potency gloss values.

DISCUSSION

The first null hypothesis, "there are no significant differences in gloss values between the different polishing systems of the bulk-fill composite"
resin tested” was rejected. Significant statistical differences were found between each one system used in the study (p value=0.000). The second null hypotheses, “there are no significant differences in gloss values between resins for the same polishing system”, was accepted. No differences between bulk-fill composite resins were statistically significant when the resin was polished with the same system (p value=0.73). This finding confirms that a careful selection of polishing systems is crucial in order to obtain high gloss values for bulk-fill resin composites.

Surface gloss values (measured in GU) of natural teeth have been previously established by the American Dental Association (ADA), which is considered to be between 40 to 60 GU(19). The control group of this study, represented by the polymerization through the use of mylar strips and without polishing and finishing technique, represented the highest gloss values (mean gloss value 80.7±7.7 GU). According to Hachiya et al.(20), this kind of finished surface is not adequate, because a surface richer in polymer may be obtained, which would be highly susceptible to void formation and composite resin discoloration, and not recommended as a properly finished polished surface. Similar results were obtained with polishing pastes such as the ENA Shiny system (mean value: 79.6±5.7 GU), and for Filtek BulkFill Posterior, which was the bulk-fill composite resin with the highest gloss value (83.6±4.8 GU). Comparing this result with conventional composite resins, several studies(15), including a thorough systematic review from Kaizer et al.(22), proved that nanofilled composite resins containing “nanoclusters” obtained the highest gloss values. For this case, Filtek Bulk-Fill Posterior has the same particle technology coming from Filtek Z350 XT or Filtek Supreme from the same manufacturer (3M ESPE), even though bulk-fill composite resins have lower gloss values than conventional composite resins. In terms of SEM and GU values, Filtek Bulk-Fill Posterior Restorative has the smoothest surface (polished with ENA Shiny polishing system), which is also comparable to conventional nanofilled composite resins from the same company when it comes to the evaluation of surface roughness(23).

The lowest gloss values were obtained with impregnated aluminum oxide discs (SofLex XT) with mean values of 57.8±5.8 GU. Similar results were obtained with Soflex Spiral and ENA Shiny.

| Control Group | SofLex XT | Composite Politur | Soflex Spiral | ENA Shiny |
|---------------|-----------|-------------------|---------------|-----------|
| Control Group | -         | * *               | N.S.          | N.S.      |
| SofLex XT     | * *       | -                 | * *           | N.S.      |
| Composite Politur | N.S.   | * *               | -             | * *       |
| Soflex Spiral | * *       | N.S.              | * *           | -         |
| ENA Shiny     | N.S.      | * *               | N.S.          | -         |

*p < 0.05, ** p < 0.01, N.S. Not significant.
to be inferior to the other polishing systems in this study, they’re still within the range of natural teeth according to the ADA. Even so, the SEM images showed voids and filler particle detachment, which may increase surface roughness and reduce gloss with results that are potentially detrimental for surface maintenance (x3500 SEM magnification, Figures 3 and 4). Tetric N Ceram demonstrated irregular behavior in terms of void formation and filler particle detachment for every polishing system according to figure 4, which may influence bacteria colonization and modification of surface gloss over time.

During a study performed by O’Neill et al. (24), four high viscosity bulk-fill resins and one flowable bulk-fill composite resin were evaluated under tooth brushing after 5000, 10000 and 15000 brushing cycles. Of the studied bulk-fill composite resins, after 5000 brushing cycles, only Filtek One Bulk Fill and SDR flow maintained acceptable gloss retention (68.7±0.1 GU and 48.9±1.4 GU, respectively). After 15000 brushing cycles, only Filtek One Bulk Fill maintained gloss (43.8±4.8GU), which is still acceptable and considered to be similar to natural teeth according to the ADA. Meanwhile, SonicFill2, Tetric Evcoceram Bulk Fill, SDR flow and Admira Fusion X-tra lost gloss considerably (10.0±2.6 GU, 14.1±3.8 GU, 11.9±4.1 GU, and 2.8±0.3GU, respectively) after 15000 brushing cycles, also increasing surface roughness. This study showed that bulk-fill composites are rougher than conventional composite resins and that there is a reversed linear relationship between surface gloss and surface roughness. This would suggest that tooth brushing increases roughness and reduces gloss, increasing the possibility of biofilm retention which may be detrimental for the bonding tooth-restoration interface. This is the only published article found where gloss surface of bulk-fill composite resins were evaluated. On the contrary, a study from Rigo et al. (25) concluded that roughness is not influenced by the polishing system applied over nanohybrid bulk-fill compactable composite resins such as Tetric EvoCeram Bulk-Fill. These authors used SofLex XT aluminum oxide discs and Astropol rubber points, and concluded that SofLex XT produced a rougher surface for every bulk-fill composite tested. In the present study, similar results were found according to the SEM images. This is the only comparable variable from the Rigo et al. (25) study and ours, because Astropol is a three step rubber point, and Composite Politur are two-step diamond points. Even so, their study confirms the SEM results found in the present study.

Although there are few studies available for comparing the results obtained in relation to the gloss surface of these two bulk-fill composite resins, it must be noted that the gloss surface measurement was performed immediately after the polishing technique, so studies that evaluate the optical behavior of these resins over time are still necessary. Also, the findings showed gloss mean values that are within the gloss natural values recommended from the ADA (40-60 GU).

CONCLUSIONS

Within the limits of the present study, the authors conclude that the polishing systems that were tested obtained acceptable in vitro gloss results for both bulk-fill composite resins. Diamond paste is the system with the best performance, followed by Diamond rubber points. Aluminum oxide impregnated discs, as well as thermoplastic elastomer wheels impregnated with aluminum oxide particles had the lowest gloss behavior, although all systems have acceptable gloss values according to ADA recommendations. SEM images showed an irregular surface for each resin polished with aluminum oxide systems. The authors recommend future studies that include surface gloss and roughness over time.

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