Surface quality and color stability of posterior composites in acidic beverages

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Abstract

Context: Consumption of acidic beverages has been reported to alter the physical and esthetic properties of resin composites, which in turn can affect clinical success.

Aims: This study aimed to evaluate the effect of acidic beverages on surface roughness and color stability of Filtek™ Bulk-Fill posterior restorative composite in comparison with Filtek P60 posterior restorative composite.

Settings and Design: Ninety composite discs were used for surface change analysis and another ninety were used for color change analysis.

Materials and Methods: Ninety Filtek P60 and Filtek Bulk-Fill composite discs were fabricated and divided into three subgroups according to the solutions – artificial saliva (control group), orange juice, and Coca-Cola® (test groups). The samples were immersed in each beverage for 10 min each day for 56 days. To measure the surface roughness, a profilometer was used, and the surface was qualitatively analyzed using a scanning electron microscope. A reflectance spectrophotometer was used for assessing the color change.

Statistical Analysis Used: Two-way analysis of variance was used to compare the surface alteration and color change values between the two composite groups and their respective three subgroups. Tukey’s multiple post hoc test was performed for pair-wise comparison.

Results: Filtek P60 had exhibited higher color change than Filtek Bulk-Fill in all immersion solutions. Coca-Cola resulted in highest staining in both the composites.

Conclusions: The surface roughness and color change of both composites increased significantly in acidic beverages and more in Coca-Cola. Bulk-fill exhibited better surface quality and color stability than P60.

Keywords: Bulk-Fill composite; Coca-Cola; discoloration; orange juice; surface roughness

INTRODUCTION

Tooth-colored restorations are in demand due to increased concerns about facial esthetics among patients. Resin composites had been the choice of materials due to their improved strength, reasonably good esthetic appearance, cost-effectiveness as compared to ceramics, and adhesiveness to tooth. These composite resins are placed incrementally to achieve higher degree of conversion and to minimize polymerization shrinkage. Few drawbacks of incremental cure are void formation, increased risk of moisture contamination, cohesive failure between layers, and prolonged chair time. To address these drawbacks, “bulk-fill” composites have been developed. These bulk-fills can be placed in layers at a thickness ranging from 4 to 5 mm that simplifies the restorative procedure and saves time.[1,2] Physical properties such as polymerization shrinkage and marginal adaptation of restorative bulk-fill resins are comparable with that of incremental resin composites...
with the additional advantage of low polymerization shrinkage.\cite{3,4}

The ideal requirements of composite restorations are surface smoothness, color stability, dimensional stability, sealing ability, wear resistance, etc. Surface irregularities >0.2 \(\mu\)m result in plaque accumulation and discoloration of the restoration’s surface or margins. This can lead to caries and periodontal inflammation.\cite{5} Thus, an ideal composite resin should maintain smoother surface with color stability.

Earlier research revealed the increased consumption of sugary drinks\cite{6,7} and the effects of various beverages such as milk; coffee; tea; red wine; Coca-Cola\cite{8}; and juices of orange, lemon, pineapple, cherry, and carrot.\cite{8-14} Acidic beverages such as orange juice, pineapple juice, and Coca-Cola alter the surface quality and the physical properties of composite resins and thus may affect the clinical performance of the restorations.\cite{11,15} Many researchers have studied the effects of various beverages on color stability of bulk-fill resins, but very few studies have reported specifically about acidic beverages on their surface quality and color stability.\cite{16-18}

Thus, the primary objective of this study is to determine the effect of acidic beverages on surface roughness and color stability of a bulk-fill composite in comparison with another posterior micro-hybrid composite.

**MATERIALS AND METHODS**

**Materials**

Two posterior composite resins, a microhybrid composite, Filtek™ P60 (3M ESPE, St Paul, MN, USA), and a bulk-fill composite, Filtek Bulk-Fill (3M ESPE, St Paul, MN, USA); restorative bulk-fill; and two acidic beverages were studied; orange juice, Tropicana Orange Delight (Schreiber Dynamix Dairies Private Limited Pune, India) and a carbonated beverage, Coca-Cola (Hindustan Coca-Cola Beverages Pvt. Ltd., Pune, India).

**Methods**

**Grouping of the specimens**

One hundred and eighty composite discs were prepared for this study. Group I consisted of Filtek P60 \((n = 90)\) and Group II consisted of Filtek Restorative Bulk-Fill \((n = 90)\). Of these, 45 of each composite type were meant for surface smoothness evaluation and other 45 were for color evaluation.

**Experimental groups**

- **Group 1: Filtek P60 \((n = 45)\)**
  - Subgroup AS: Immersion in artificial saliva (control)
  - Subgroup OJ: Immersion in orange juice
  - Subgroup CC: Immersion in Coca-Cola

- **Group 2 Filtek Bulk-Fill \((n = 45)\)**
  - Subgroup AS: Immersion in artificial saliva (control)
  - Subgroup OJ: Immersion in orange juice
  - Subgroup CC: Immersion in Coca-Cola

**Specimen fabrication**

In Group I, Filtek P60 composite was inserted into the mold in two increments of thickness 1.5 mm and light cured (Blue Phase C8 LED, Ivoclar Vivadent, Schaan Liechtenstein, USA). In Group II, Filtek Bulk-Fill composite was placed into the mold as a single increment (thickness 3 mm) and light cured. The dimensions of the discs were 10 mm in diameter and 3 mm in thickness. A calibrated radiometer (Blue phase, Ivoclar Vivadent, Schaan Liechtenstein, USA) was employed to verify the efficacy of the light-curing unit. After complete curing, each specimen was polished with a multistep polishing system, Sof-Lex (3M ESPE, St. Paul, MN, USA) in a sequential manner. The polishing procedure was standardized by applying light pressure for 15 s.

**Baseline evaluation**

Surface roughness and color of composite discs were estimated before they were immersed in test and control solutions. Surface roughness was estimated with a contact stylus profilometer (Mitutoyo SJ 301, Tokyo, Japan). The stylus was made to run in three directions for each specimen, and those three values were averaged and recorded as baseline values for that specimen. Baseline color was estimated by using a spectrophotometer (JSCO V-770, Gretag Macbeth TM, Spectroscan, Switzerland). \(L^\ast\), \(a^\ast\), and \(b^\ast\) values at baseline were registered for each specimen as \(L^\ast_i\), \(a^\ast_i\), and \(b^\ast_i\), respectively.

**Immersion of specimens in treatment solutions**

All the specimens were stored in artificial saliva (E Saliva, Entod Pharmaceuticals, Yash Pharma Laboratories, Uttarakhand, India) throughout the test period of 56 days. Specimens in each subgroup were taken out and immersed in freshly poured test beverage, i.e., either orange juice or Coca-Cola. The pH of test beverages was measured every time using a pH meter (Elico Ltd., Hyderabad, Telangana, India). The discs were kept in a light-proof box at 37°C for 56 days to mimic the clinical condition.

**Final evaluation**

The final surface roughness was measured and recorded for all the specimens. The difference between initial and
final Ra values was noted as change in surface roughness. Five specimens from both test and control groups of each composite resin were evaluated with a scanning electron microscope, (JOEL JSM 5600, Joel Inc., Peabody, MA, USA) for qualitative analysis.

The final L*, a*, and b* values were estimated by the spectrophotometer and were denoted by L*₁, a*₁, and b*₁, respectively. Color change was calculated by using the following formula: 
\[
\Delta E = (\sqrt{(L_{f}^{*} - L_{i}^{*})^2 + (a_{f}^{*} - a_{i}^{*})^2 + (b_{f}^{*} - b_{i}^{*})^2})
\]
where \(\Delta E\) is color change, L*₁ is final L*, L*ᵢ is initial L*, a*₁ is final a*, a*ᵢ is initial a*, b*₁ is final b*, and b*ᵢ is initial b* value.

Statistical analysis
Two-way analysis of variance was used to analyze the surface alteration and color change between the two groups and their three subgroups. Tukey’s multiple post hoc analysis was performed for pair-wise comparison of surface roughness and color change values of two groups and their respective three subgroups. Probability value was set at \(P \leq 0.05\).

RESULTS

Surface roughness analysis
The bar graph [Figure 1] showed that final surface roughness bulk-fill composite (IIA) in artificial saliva is lowest and microhybrid in Coca-Cola (IC) is highest among all the groups. Tukey’s multiple post hoc analysis [Table 1] revealed that there was an insignificant surface alteration in both composites in artificial saliva. There was a significant surface degradation in all the acidic beverages (IB, IC, IIB, and IIC), and microhybrid composite exhibited more roughening than bulk-fill composite. Coca-Cola resulted higher roughening than orange juice in both groups of composites. This can be observed in scanning electron microscopic images of Group I and Group II [Figure 2].

Color change analysis
Tukey’s multiple post hoc analysis [Table 2] exhibited an insignificant difference between the two composites in artificial saliva. In acidic beverages, intergroup comparison of two composites revealed a significantly higher discoloration in microhybrid than bulk-fill. Coca-Cola caused more discoloration than orange juice.

DISCUSSION
One of the ideal requisites of an esthetic restorative material is smooth surface and color stability. This color

![Table 1: Mean and standard deviation values of increased surface roughness (Ra) after 8 weeks' immersion](image)

| Subgroup A | Subgroup B | Subgroup C |
|------------|------------|------------|
| AS         | OJ         | CC         |
| Group I    |            |            |
| Filtek P60 | 0.036±0.009 | 0.328±0.011 | 0.673±0.032 |
| Group II   | 0.021±0.005 | 0.243±0.009 | 0.567±0.030 |
| Filtek Bulk-Fill | 0.33±0.42 | 12.12±0.68 | 28.15±0.89 |

*Pair-wise comparison by Tukey's post hoc analysis: P<0.05; Different upper case alphabets indicate significant difference in rows and different lower case alphabets indicate significant difference in columns. SD: Standard deviation, AS: Artificial saliva, OJ: Orange juice, CC: Coca-Cola

![Table 2: Mean and standard deviation values of color change (ΔE) after 8 weeks' immersion](image)

| Subgroup A | Subgroup B | Subgroup C |
|------------|------------|------------|
| AS         | OJ         | CC         |
| Group I    |            |            |
| Filtek P60 | 0.72±0.61  | 13.87±2.20 | 32.10±1.79 |
| Group II   | 0.33±0.42  | 12.12±0.68 | 28.15±0.89 |

*Pair-wise comparison by Tukey's post hoc analysis: P<0.05; Different upper case alphabets indicate significant difference in rows and different lower case alphabets indicate significant difference in columns. SD: Standard deviation, AS: Artificial saliva, OJ: Orange juice, CC: Coca-Cola

![Figure 1: Scanning electron microscopic image of composites](image)
stability depends on various factors such as resin matrix composition; type and particle size of fillers; concentration of initiators, activators, and inhibitors; unreacted monomer activation; hydrophilicity of resin matrix; degree of conversion; degree of water sorption; pH of beverage; presence of pigments; and surface roughness. Baseline surface evaluation depicted rougher surfaces in microhybrid when compared with restorative bulk-fill. The reason could be wider range of particle sizes (10 to 1500 nm) in microhybrid composite.

Acidic beverages result in surface degradation of restorations, which, in turn, results in surface roughening and color change. Several researchers observed that acidic beverages cause roughening of the composite restorations irrespective of the composite type. The effect of the beverage depends not only on the pH but also on the pigments present in it. An earlier study reported high discoloration of various composite resins with coffee than with Coca-Cola because of yellow pigments in the coffee even if the pH of Coca-Cola is lower than that of coffee.

In this study, Coca-Cola resulted in high surface roughness than orange juice in both the composites due to its high acidic nature. It was also observed that Coca-Cola resulted in more structural defects than orange juice. This observation was similar to earlier studies where microhybrid composites exhibited higher degradation with Coca-Cola than with orange juice. Higher surface roughening in microhybrid than bulk-fill composite was also similar to an earlier study. In contrary, an earlier researcher observed high surface roughness in bulk-fill than microhybrid. The reason could be smaller sample size and different immersion protocol in their study. In the present study, 10-min immersion was employed for better clinical relevance.

Regarding color stability, bulk-fill exhibited low discoloration than microhybrid. This observation is similar to an earlier study where bulk-fill exhibited less discoloration than microhybrid. The composite resins containing Bis-GMA exhibited higher discoloration than composites containing UDMA. Bulk-fill contains aromatic dimethacrylate, additional fragmentation molecules, urethane dimethacrylate, and 1,12-dodecanedimethacrylate, whereas Filtek P60 contains bisphenol-A-diglycidyl-dimethacrylate, urethane dimethacrylate, and ethoxylated bisphenol-A-glycol-dimethacrylate.

Few researchers reported that bulk-fills exhibited less discoloration than packable composite after 1-month immersion in coffee, coke, and red wine. Microhybrids were found to be less color stable in Coca-Cola and lemon juice than nanohybrids.

In this study, discoloration by orange juice is less than the discoloration caused by Coca-Cola. The reason could be due to the low pH of Coca-Cola. This is similar to an earlier study where nanohybrid and giomer were tested. Both the beverages resulted in significant color change, and orange juice effect was less when compared to that of Coca-Cola. In contrary, few researchers observed more discoloration with orange juice than with Coca-Cola. The difference in the results could be attributed to the compositional difference of bulk-fill when compared to microhybrids and conventional nanohybrids.

Earlier researchers reported better clinical performance of bulk-fill composites than earlier composites, especially in terms of marginal discoloration. From the observations of this study, a positive correlation can be drawn between the color change and surface roughness in composite resins as well as acidic beverages.

CONCLUSIONS

Based on observations of this study, it can be concluded that:

1. The surface roughness of a bulk-fill composite had increased significantly after 8 weeks’ immersion in acidic beverages
2. The color change of bulk-fill composite when immersed in acidic beverages for 8 weeks was significant
3. The performance of a bulk-fill composite was significantly better than that of conventional posterior composite in terms of surface quality and color stability
4. Coca-Cola resulted in higher surface roughness and discoloration than orange juice.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.
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