Comparative Evaluation of the Surface Hardness of Different Esthetic Restorative Materials: An In Vitro Study

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Aim: The aim of this study was to evaluate the surface hardness of a newly developed fiber-reinforced composite and bulkfill composites. Materials and Methods: Fiber-reinforced composite and other commercially available bulkfill composites were used. Fifteen cylindrical specimens (5 mm × 5 mm) were made from each material in metal template. Molds were filled in one increment for both bulkfill composites and fiber-reinforced composite and cured using Ivoclar blue phase light-curing unit at a wavelength of 850 mW/cm². A dark container was used to store specimens to keep dry at room temperature for 24 h before testing. Vickers hardness number (VHN) on the top and bottom surfaces of each specimen was measured by a microhardness tester. Data for VHN were analyzed by using analysis of variance (ANOVA) and pair-wise Newman–Keuls test. Results: No significant difference was observed in Vickers hardness test. The mean value of VHN on the top and bottom surfaces showed significant difference from each other. Fiber-reinforced composite showed the highest VHN as compared with other materials. Conclusion: Fiber-reinforced composite has the highest Vickers hardness ratio indicating highest degree of conversion and better clinical performance.

Keywords: Depth of cure, incremental fill composite, resin composite, surface hardness

Introduction

In 1990s, amalgam is being widely used as a universal filling material and composite restorations introduced as a new era of minimally invasive dentistry. Dental composites have some mechanical properties as compared to tooth of enamel and provide a long shelf life period.¹ Different types of composites, including conventional, microfilled, hybrid, flowable, packable, and nanofilled, have been introduced. Insufficient depth of cure is one of the major disadvantages of resin-based composite material; because of this reason, composite restorations in large cavities, especially class II restorations,² are added in layers of maximum 2 mm thickness and cured, that is, incremental placement technique. Recently, bulkfill composites were introduced for posterior bulk fill placement. The bulkfill composite material can be placed in 4 mm thickness bulk and can be cured in one step rather than multiple steps as incremental placing technique.³ Different properties of bulkfill composite resins were examined by many studies; properties such as microleakage, polymerization shrinkage, and degree of conversion were studied extensively. All of such studies indicated that bulkfill composite resins have no significant

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difference in properties as compared to conventional dental composite resins[4-6].

Degree of conversion is the major factor that influences physical and mechanical properties of dental composites. The degree of conversion in dental composite restoration is influenced by different factors. These factors include power density and wavelength of curing light, irradiation time, tip size of light source, contents of organic matrix, inorganic filler quantity and distribution, type of photoinitiator used, and color of the composite resins.

Variations in composition of material and its viscosity whether flowable or nonflowable are the factors that affect the physical and mechanical properties of different available bulkfill composites. Fiber-reinforced composite restorations contain fibers aimed at enhancing their physical properties. In composite matrix, the fibers are ideally bonded to the resin via an adhesive interface.

Different types of laboratory investigations have been introduced to evaluate dental composite resins; flexural strength and flexural modulus tests are used as an indicator for material durability under stress. These tests can also be used to correlate with the clinical longevity of composite restorations. Fracture toughness test is an alternative method to examine the material’s ability under stress without fracture and crack propagation inside the material before failure.[7] Also, Vickers hardness assay can be used for testing surface hardness and the mode of failure of the material. The longevity strength and the sustainability of composite restoration especially in stress-bearing area depend on the surface hardness of the material.

Thus, the aim of study was to evaluate the surface hardness of the fiber-reinforced composite and two different bulkfill composite restoration materials. The null hypothesis was that there is no significant difference in clinical performance of fiber-reinforced composite and other bulkfill composites.

**Materials and Methods**

The bulkfill dental composite materials used for this study were as follows: Filtek Bulk Fill (FB, 3M ESPE, St. Paul, Minnesota), Tetric EvoCeram Bulk Fill (TECB, Ivoclar Vivadent AG, Schaan, Liechtenstein), and a fiber-reinforced bulkfill dental composite resin, EverX Posterior (EXP, GC Europe NV, Leuven, Belgium).

A total of 45 samples were prepared [Figure 1]. They were divided into three experimental groups (n = 15). Metal template was prepared; it had inner diameter of 8 mm and thickness of 2 mm. Metal templates were placed on Mylar strips (Primo Dental Products MS500 Mylar Matrix Strips, 4” Long × 3/8” Wide) placed on a glass slab [Figure 2] and were filled in one increment [Figure 3]. After that Filtek Bulk Fill (FB, 3M ESPE) was filled in 15 samples and other 15 samples were prepared with Tetric EvoCeram Bulk Fill (TECB).
Other 15 samples were prepared using fiber-reinforced bulkfill dental composite resin, EverX Posterior (EXP, GC Europe NV) [Figure 4]. On the upper surface, a Mylar strip was placed and the material was flattened with a glass slide. Glass slab was removed after removal of excess material, and cured using light-emitting diode (LED) [Figure 5] (Cromalux Mega-Physik, Rastatt, Germany; 850 mW/cm²) for 40 s and the light cure tip kept at a distance of 1 mm. The specimens were then removed from the molds after which finishing and polishing done in the mold [Figure 6]. The top surface was marked with an indelible marker [Figure 7]. All samples were kept dry at room temperature in lightproof containers for 24 h.

Vickers hardness test was done using a 50-g load and dwell time was 15 s. In each sample, three indentations were made on both the top and the bottom surfaces. The formula to calculate the Vickers hardness ratio of the top and bottom surfaces is as follows:

\[
\text{Vickers hardness ratio} = \frac{\text{bottom VHN mean value} \times 100}{\text{Top VHN mean value}}
\]

**Statistical analysis**

The statistical analysis of data was performed by using a two-way analysis of variance (ANOVA) test, Bonferroni test, and Student’s *t* test. All the data collected were analyzed using Statistical Package for the Social Sciences (SPSS) software program, version 14.0 (SPSS, Chicago, IL, USA).

**Results**

The test was conducted on three experimental groups. Table 1 shows the Vickers hardness mean value of top and bottom surfaces. Group I fiber-reinforced composite showed greater hardness as compared to Group II (Tetric EvoCeram Bulk Fill composite) with a *P* value 0.001 (both top and bottom surfaces). *P* Value was highly statistically significant.
Table 2 shows the intergroup comparison on top and bottom surfaces of the depth of cure. The difference in top and bottom surface hardness was statistically significant in both the groups. The difference in mean depth of cure was not statistically significant between Groups I and II.

**DISCUSSION**

Surface hardness shows abrasion resistance that prevents the materials from the creation of permanent deformities, increasing the scratch and abrasion resistance seen if the microhardness is high. So the material efficiently prevents from various forces.[8,9] Greater depth of cure and lower polymerization-induced shrinkage stress are the features of bulkfill composite materials; it is due to technology such as “polymerization modulators,” which allows certain amount of flexibility and optimized network structure during polymerization. Recently introduced are bulkfill composites for class I and class III restorations.

These composite resins have excellent handling characteristics and can be placed in 4 mm increments with minimal polymerization stress. According to various studies, silver amalgam and gold alloys have been used with clinical success for a century, especially as a posterior restorative material because of their good mechanical properties.

Recent, bulkfill composite materials have been introduced due to the high esthetic properties of composite resins. The main mechanical property of composite resin is compressive strength. Low-compressive strength in a restorative material tends to lead the tooth failure, fracture, and periodontal problems or extraction of the broken tooth.[10,11] Vickers hardness ratio is related to the depth of cure (80%) and the degree of polymerization. A high degree of polymerization is an important factor for achieving superior physical and mechanical properties. Marginal microleakage, discoloration, and decreased bonding strength of resin composite restorations[12] are caused by inadequate polymerization.

In this study, hardness and depth-of-cure values in fiber-reinforced composites were higher than the other two composite samples when cured with LED light. A metal template was used because the material does not stick to the mold and can be easily molded after polymerization. A bulk insertion technique was adopted in this study and a maximum of 2 mm thickness.[13]

The result of this study depends on different factors, such as composition of organic matrix, amount and type of filler particles, and also on degree of conversion. Several studies have suggested that microfilled composites are challenging to cure because the small filler particles cause light to scatter, thus decreasing the effectiveness of the curing light. The result obtained in this study is that the fiber-reinforced composite tested may be used as a restorative material in stress-bearing areas. The outcomes examined with this study should be followed by adequate clinical trials.

**Table 1: Descriptive statistics and comparative analysis of top and bottom surface hardness values**

| Vickers hardness number | ANOVA P value |
|-------------------------|--------------|
| Fiber-reinforced composite | Tetric EvoCeram Bulk Fill composite | BEAUTIFIL-Bulk material |
| Top surface | 96.12 | 60.17 | 73.27 | 0.001 |
| Bottom surface | 90.07 | 55.12 | 68.12 | 0.001 |
| VHR (%) | 93.70 | 91.6 | 92.97 | _ |

ANOVA = analysis of variance

**Table 2: Descriptive statistics and comparative analysis of depth of cure**

| Intergroup comparison using Student’s t test |
|---------------------------------------------|
| Fiber-reinforced composite | Tetric EvoCeram Bulk Fill composite | Top = 60.17 | 0.000 |
| | | Bottom = 55.12 | 0.000 |
| | BEAUTIFIL-Bulk material | Top = 73.27 | 0.032 |
| | | Bottom = 68.12 | 0.004 |
| Tetric EvoCeram Bulk Fill composite | Fiber-reinforced Composite | Top = 96.12 | 0.000 |
| | | Bottom = 90.07 | 0.000 |
| | BEAUTIFIL-Bulk material | Top = 73.27 | 0.022 |
| | | Bottom = 68.12 | 0.006 |
| BEAUTIFIL-Bulk material | Fiber-reinforced composite | Top = 96.12 | 0.032 |
| | | Bottom = 90.07 | 0.004 |
| | Tetric EvoCeram Bulk Fill composite | Top = 60.17 | 0.022 |
| | | Bottom = 55.12 | 0.006 |
by long-term clinical studies to assure the performance of the material under routine clinical conditions.

**CONCLUSION**

In this study, superior fracture resistance, high flexural strength, modulus, and higher microhardness values were reported by fiber-reinforced composite everX Posterior compared to other bulkfill composite resins.

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**Conflicts of interest**

There are no conflicts of interest.

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