Surface Roughness of Bulk Fill Composite after Simulated Toothbrushing with Different Dentifrices

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Abstract

AIM: The aim of the current in vitro study was to evaluate the changes in surface roughness of bulk fill composites after simulated toothbrushing with different dentifrices.

MATERIALS AND METHODS: Three types of bulk fill resin composites were used in this study; 27 specimens of each composite resin were randomly divided into three main groups (n = 9). Each main group was further subdivided into three subgroups (n = 3). Each group was subjected to simulated toothbrushing with three different dentifrices. One-way analysis of variance was used to evaluate the effect of brushing using dentifrices on the surface roughness of each type of composite resin, followed by Tukey’s test at a significance level of p ≤ 0.5%.

RESULTS: Results revealed that different effects on composite surface roughness were detected after simulating toothbrushing with different dentifrices. Lacalut toothpaste abrades more with Tetric N-Ceram, Bulk Fill SDR then Filtek Bulk Fill. Crest 3D toothpaste abrades more with Tetric N-Ceram, Bulk Fill SDR then Filtek Bulk Fill. BlanX toothpaste abrades more with Tetric N-Ceram, Bulk Fill SDR then Filtek Bulk Fill.

CONCLUSION: Chemical composition of both resin composites and dentifrices plays an important role in influencing the degree of surface roughness of bulk fill composite resin restorations.

Introduction

The drawbacks of amalgams, in particular the lack of esthetics and presence of mercury have largely contributed to the popularity and increased use of resin-based composites (RBCs) for tooth restorations [1]. The RBCs have undergone tremendous research and development in the last 40 years to improve their performance, mechanical properties, and clinical handling [2]. These developments have primarily focused on improving the mechanical properties such as hardness, compressive strength, flexural strength, fracture toughness, and reducing polymerization shrinkage [3]. Bulk-fill composite resin is among the recent development in dental composites. These types of resin composite can be placed in a 4 mm thick bulk in the cavities and cured in one step instead of the current incremental fill technique where the increments of 2 mm is placed and cured [4]. Bulk-fill composite seems to improve the bad effect of the polymerization shrinkage, improve the cavity adaptation, and degree of conversion (DC %). It was also reported that bulk fill composites have superior physical and mechanical properties to resist high masticatory forces in oral cavity [5], [6]. Many studies have focused on the mechanical properties of the bulk-fill composites [4], [6], [7], [8] and there were little literatures focused on the behavior of these composites when subjected to tooth brush abrasion. Like enamel and dentin [9], restorative materials are also subjected to wear especially in the posterior occlusal surfaces. The degree of wear depends on the type of restorative material [8], [9]. The wear and abrasion of the restorative materials in the oral environment can be a result of different factors. These include direct contact between the tooth and the restorations during mastication, oral habits, toothbrushing with abrasive particles, and also due to chemicals in the dietary form [10]. The wear and abrasion can lead to an adverse effect on the mechanical properties of the materials and also leads to an increased surface...
Materials and Methods

Before starting this in vitro study, the ethical approval was obtained from the Scientific Research Unit of Al-Farabi College for Dentistry and Nursing. The research proposal was approved by Institutional Review Board (IRB) at Al-Farabi College for Dentistry and Nursing in Riyadh, Saudi Arabia under no. (IRB No.: Alf. dent-2020023).

Selection of composite resin

Three types of resin composites were used in this in vitro study. Selection criteria for the composite brands include that they could be of bulk fill category with same curing time and same depth of cure.

1. The Bulk Fill SDR Posterior Bulk Fill Flowable Based composite (Dentsply Caulk 38 West Clarke Avenue Milford, DE 19963, USA).
2. Tetric N-Ceram Bulk Fill (Ivoclar Vivadent AG Bendererstrasse 2. FL-9494 Schaan Principality of Liechtenstein).
3. Filtek Bulk Fill Posterior Restorative (3M, ESPE, Elipar, Filtek Scotchbond. Canada).

The specifications of each composite resin brand are described in Table 1.

The composite resin specimens were made using a silicone matrix with orifices of 5 mm in diameter and height. The matrix was positioned on a glass plate and filled with composite resin. A polyester strip was then placed on the composite resin followed by a glass plate to obtain a flat surface. The composite resin was then light cured with the light emitting diode unit Radii-cal (SDI, Australia) for 20 s at a distance of 1 mm from the surface of the specimen. Toothbrushing with dentifrices was applied on the composite resin surface that was in contact with the polyester strip. Twenty-seven specimens were used in this study.

Table 1: Specifications and manufacturers of bulk fill resin-based composites

| Composite resin Location | Composition Description | Manufacturer |
|--------------------------|-------------------------|--------------|
| SDR Posterior Bulk Fill Flowable Base | Barium-alumino-flouro-borosilicate glass | Dentsply Caulk 38 West Clarke Avenue Milford, DE 19963, USA. |
| Tetric N-Ceram bulk fill | Urethane dimethacrylate, ytterbium, trifluoro, ethoxyethyl bisphenol A dimethacrylate, and Bis-GMA | Ivoclar Vivadent AG Bendererstrasse 2 FL-9494 Schaan Principality of Liechtenstein. |
| Filtek Bulk Fill Posterior Restorative | Non-agglomerated/non-aggregated 20 nm silica filler, a non-agglomerated/ non-aggregated 4–11 nm zirconia filler, an aggregated zirconia silica cluster filler (comprised of 20 nm silica and 4–11 nm zirconia particles) and a ytterbium trifluoro filler consisting of agglomerate 100 nm particles | 3M, ESPE, Elipar, Filtek Scotchbond. Canada. |

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of each resin composite type where fabricated and stored in distilled water at room temperature for 24 h to complete the polymerization and simulate conditions of the oral cavity environment.

**Experimental groups**

The 27 specimens of each composite resin were randomly divided into three main groups (n = 9). Each main group was further subdivided into three subgroups (n = 3). Each group was subjected to simulated toothbrushing with three different dentifrices: BlanX sensitive teeth toothpaste, Crest 3D white Brilliance toothpaste, and Lacalut aktiv medical toothpaste. The composition of each dentifrice is listed in Table 2.

**Evaluation of surface roughness**

The initial surface roughness of each specimen was measured with a contact profilometer device (MarSurf PS1-Mahr GmbH. Göttingen-Germany). Three consecutive measurements of the specimen were taken in different regions (one central, one right, and one left) for obtaining the mean average from the three measurements. The roughness of the surfaces was measured again after surfaces of resin composites subjected to simulated toothbrushing.

**Simulated toothbrushing**

The simulated toothbrushing was done manually by one operator using (Oral-B 40) rotary toothbrushing machine. This is done throughout the experiment to ensure proper standardization and decrease variables. Operator's errors were avoided by excluding any major changes in readings. Each specimen was fixed in the center (orifice) of an acrylic plate (55 mm × 25 mm × 4 mm), respectively, for the diameters and height, enabling the test surface to remain 1 mm beyond the edge of the orifice which housed the specimen. Utility wax was applied to fix the specimens. Each plate was placed in an acrylic tank which was attached to the specimen in the brushing machine and to always ensure readability in the same direction (perpendicular to the brushing), a mark with a diamond bur mounted in a high-speed hand piece was made on the border of each specimen.

**Statistical analysis**

The values of surface roughness were collected, organized, and tabulated. One-way analysis of variance was used to evaluate the effect of brushing using dentifrices on the surface roughness of each type of composite resin, followed by Tukey’s test at a significance level of p ≤ 0.5%.

**Results**

Results revealed that different effects on composites surface roughness were detected after simulating toothbrushing with different dentifrices. Regarding The Bulk Fill SDR Posterior Bulk Fill Flowable Based composite (Dentsply) results revealed that the mean differences in surface roughness after simulating toothbrushing using different toothpastes were as follow: Lacalut toothpaste (0.33), Crest 3D White (0.39), and BlanX (0.58). There was no statistical significant difference between values of Lacalut toothpaste (0.33) and Crest 3D White (0.39), but there was a statistical significant difference between them and BlanX (0.58) as p ≤ 0.5%. Regarding Filtek Bulk Fill Posterior Restorative composite (3M, ESPE, E) results revealed that the mean differences in surface roughness after simulating toothbrushing were as follow: Lacalut toothpaste (0.78), Crest 3D White (0.33), and BlanX (0.30). There was no statistical significant difference between values of

| Toothpaste | Composition | Manufacturer |
|------------|-------------|--------------|
| BlanX Sensitive Teeth Toothpaste | Hydroxyapatite, Potassium Chloride, Sodium Fluoride, Arctic Lichen, Aqua, Glycerin, Hydrated Silica, Sorbitol, Potassium BlanX Sensitive Chloride, Silica, PEG-32, Cellulose Gum, Zinc Hydroxyapatite, Xylitol, Cedrena islandica extract, Ussia barbara extract, Eugenia Teeth Caryaophylitus Flower Oil, Mentha Piperita Oil, Mentha Viridis Leaf Toothpaste Oil, Sodium Monofluorophosphate, Sodium Myristoyl Sarcosinate, Sodium Methyl Cocosyl Taurate, Zinc Citrate, Sodium Fluoride, Sodium Saccharin, Menthol, Titanium Dioxide, Benzyl Alcohol, Phenoxethanol, Sodium Benzoylate, Eugenol, Limonene. | Sensodyne, UAE |
| Crest 3D White Brilliance | Sodium Fluoride 0.243%, glycine, hydrated silica, sodium hexametaphosphate, water, PEG-6, flavor, trisodium phosphate, sodium lauryl sulfate, carrageenan, cosaminopropyl betaine, sodium g saccharin, PEG-20M or PEG-23M, xanthan gum, sucralose, mica, titanium dioxide. | The Procter and Gamble Manufacturing Company, USA |
| Lacalut Aktiv Medical Toothpaste | Aqua, Hydrogenated Starch Hydrolysate, Aluminium Hydroxide, Lacalut Medical Hydrated Silica, Silica, Poloxamer 188, Sodium Laurel Sulfate, Aroma, Hydroxyethyl cellulose, Aluminium Lactate, Titanium Dioxide, Toothpaste Allantoin, Aluminum Fluoride, Sodium Saccharin, Chlorhexidine Digluconate, Bisabolol, Limonene. | Lacalut, China |

Table 2: Specifications and manufacturers of toothpastes
Crest 3D White (0.33) and BlanX (0.30), but there was a statistical significant difference between them and Lacalut toothpaste (0.78) as p ≤ 0.5%. Regarding Tetric N-Ceram bulk fill (Ivoclar Vivadent) results revealed that the mean differences in surface roughness after simulating toothbrushing were as follow: Lacalut toothpaste (0.59), Crest 3D White (0.81), and BlanX (0.81). There was no statistical significant difference between values of Crest 3D White (0.81) and BlanX (0.81), but there was a statistical significant difference between them and Lacalut toothpaste (0.59) as p ≤ 0.5%. Regarding the effect of Lacalut toothpaste on the surface roughness of different bulk fill resin composites, results revealed that mean difference values vary according to type of composite used as follow: Bulk Fill SDR (0.33), Filtek Bulk Fill (0.78), and Tetric N-Ceram (0.59). These results are shown in Table 3.

Table 3: Effect of Lacalut toothpaste on surface roughness on the 3 types of composite

| SDR          | Sample no. | 1    | 2    | 3    | Mean | Difference |
|--------------|------------|------|------|------|------|------------|
| SDR          | Pre        | 0.270| 0.391| 0.669| Pre  | 0.45      |
|              | Post       | 0.856| 0.598| 0.694| Post | 0.78      |
| Filtek Bulk Fill | Pre    | 0.741| 0.408| 0.493| Pre  | 0.54      |
|              | Post       | 1.311| 1.780| 0.884| Post | 1.32      |
| Tetric N-Ceram | Pre   | 0.249| 0.707| 0.466| Pre  | 0.48      |
|              | Post       | 1.027| 1.164| 1.021| Post | 1.07      |

Regarding the effect of Crest 3D White toothpaste on the surface roughness of different bulk fill resin composites, results revealed that mean difference values were as follow: Bulk Fill SDR (0.39), Filtek Bulk Fill (0.33), and Tetric N-Ceram (0.81). These results are shown in Table 4.

Table 4: Effect of crest 3D white toothpaste on surface roughness on the 3 types of composite

| SDR          | Sample no. | 1    | 2    | 3    | Mean | Difference |
|--------------|------------|------|------|------|------|------------|
| SDR          | Pre        | 0.278| 0.589| 0.339| Pre  | 0.40      |
|              | Post       | 0.731| 0.629| 1.038| Post | 0.79      |
| Filtek Bulk Fill | Pre    | 0.600| 0.530| 0.419| Pre  | 0.51      |
|              | Post       | 0.745| 0.839| 0.957| Post | 0.84      |
| Tetric N-Ceram | Pre   | 0.511| 0.279| 0.619| Pre  | 0.46      |
|              | Post       | 1.843| 0.980| 1.000| Post | 1.27      |

Regarding the effect of BlanX toothpaste on the surface roughness of different bulk fill resin composites, results were as follow: Bulk Fill SDR (0.58), Filtek Bulk Fill (0.30), and Tetric N-Ceram (0.81). These results are shown in Table 5.

Table 5: Effect of BlanX toothpaste on surface roughness on the 3 types of composite

| SDR          | Sample no. | 1    | 2    | 3    | Mean | Difference |
|--------------|------------|------|------|------|------|------------|
| SDR          | Pre        | 0.213| 0.313| 0.399| Pre  | 0.3       |
|              | Post       | 1.024| 0.780| 0.844| Post | 0.88      |
| Filtek Bulk Fill | Pre    | 0.249| 0.607| 0.504| Pre  | 0.45      |
|              | Post       | 0.580| 0.640| 1.049| Post | 0.75      |
| Tetric N-Ceram | Pre   | 0.268| 0.259| 0.410| Pre  | 0.31      |
|              | Post       | 1.129| 1.021| 1.215| Post | 1.12      |

Statistical significant differences among all variables are summarized in Table 6 and illustrated in Figure 1.

Table 6: Differences (D) between variables

| Toothpaste | Composite | Mn   | SDR | Filtek Bulk Fill | Tetric N-Ceram | BlanX | Crest 3D white | Lacalut | 3M ESPE | SDR | Filtek Bulk Fill | Tetric N-Ceram | BlanX |
|------------|-----------|------|-----|-----------------|---------------|-------|--------------|---------|---------|-----|-----------------|---------------|-------|
|            |           |      |     |                 |               |       |              |         |         |     |                 |               |       |

Discussion

The present study evaluated the influence of toothbrushing abrasion on the surface roughness of three commercial bulk fill composite resins. Restorative material surfaces in the oral environment are subjected to various factors, which can modify the surface roughness. Toothbrushing using dentifrices is one of the oral hygiene procedures that play a significant role in reducing plaque and caries among other benefits. Previous studies have reported that amount of wear by toothbrush dentifrice abrasion depends on toothbrush quality, toothbrushing habits, type of dentifrices used, the load applied, slurry dilution, and oral temperature [28]. It is also reported that wear resistance of a composite depends mainly on shape, size, load of inorganic filler, and to little extent on the organic matrix components [29]. The mechanical characteristics of the composite resins can be evaluated by surface roughness measurements after they subjected to simulated toothbrushing [30]. In the present study, a medium type of rotary toothbrush was selected with different dentifrices and the results revealed statistical significant differences in the values of composite resin surface roughness. This result disagreed with the study of Oliveira et al. where they reported that toothbrush type did not affect the resin composite wear or surface roughness when used with a wet medium type [30]. In addition, some authors reported that soft type toothbrushes abrade more when compared to medium or hard types of brushes [31]. In the present study and regarding influences of surface roughness, a significant difference was observed among all groups of tested bulk fill resin composites. Results of the present study are in agreement of other studies that reported that Filtek Bulk Fill Posterior Restorative (3M, ESPE) are more resistant to wear and surface roughness than The Bulk Fill SDR Posterior.
and Bulk Fill Flowable Based composite (Dentsply). Although the mentioned later two types of composite fillers have same average cluster size, it is clear that the non-aggregated zirconia/silica cluster filler presented in Filtek Bulk Fill Posterior Restorative (3M, ESPE) can resist the toothbrushing abrasion more effectively than triethylene glycol dimethacrylate (TEGDMA) presented in Bulk Fill SDR (Dentsply) [32]. Notably, in the present study, the Tetric N-Ceram bulk fill (Ivoclar Vivadent) demonstrated more statistical significant differences in surface roughness compared to other two types of composites. This finding was in agreement with the results of Mitra et al. [33]. They clarified that urethane dimethacrylate (the main composition of Tetric N-Ceram bulk fill) showed less resistant to wear and surface roughness among the tested composite groups. This could be better explained due to the fact that mean distance between adjoining particles is less than coarse filler particles. This structure favors protection against wear of the matrix and ensures better performance of the material [34]. Quirynen and Bollen [35], [36] reported that surface roughness values in composite materials should be below 0.4 μm to prevent adhesion of plaque and microorganisms. The roughness of the restoration can be detected by tongue if the surface roughness value is above 0.7 μm [37]. In the current study, the initial Ra values of all the tested composites were around the threshold limit of 0.4 μm but after final brushing cycles, most of the tested groups exhibited values above 0.7 μm. Although the filler loading in all types of composites used in this study was 82% by weight, it was clear that chemical composition and arrangement of fillers answer why Tetric N-Ceram bulk fill (Ivoclar Vivadent) demonstrated more statistical significant differences in surface roughness values (less resistance to wear and surface roughness) compared to other two types of bulk fill resin composite. There was a clear correlation between surface roughness and chemical composition for all composite types and dentinives used in the present study. In previous studies by Kanter et al. [38] and Mandikos et al. [39], they were concluded that composites which wear more showed increased surface roughness. This was in agreement with the findings of our study but was conflicting with the outcomes of the studies by Wang et al. [28] and Garcia et al. [15] where they concluded that there was no significant relationship between the degree of wear resistance of resin composite and their surface roughness.

**Conclusion**

Under limitation of the present study, the results revealed that chemical composition of bulk fill resin composites and abrasive materials incorporated within the dentinives plays an important role in influencing the degree of surface roughness of bulk fill composite restorations. The degree of toothbrush abrasion depends on variety of factors such as type of resin composite, the chemistry and method of polymerization, type of toothpaste, and the nature of the toothbrush used. Further studies should be done to clarify the relation between wear resistance and surface roughness of different esthetic restorative materials.

**Recommendations**

Under limitation of the present study, the results revealed that:

1. Lacalut toothpaste abrades more with Filtek Bulk Fill then Tetric N-Ceram and finally Bulk Fill SDR so it is not recommended that patient of Filtek Bulk Fill composite restoration to use Lacalut toothpaste for rotary toothbrushing using medium type of toothbrush.
2. Crest 3D White toothpaste abrades more with Tetric N-Ceram then Bulk Fill SDR and finally Filtek Bulk Fill so it is not recommended that patient of Tetric N-Ceram composite restoration to use Crest 3D White toothpaste for rotary toothbrushing using medium type of toothbrush.
3. BlanX toothpaste abrades more with Tetric N-Ceram then Bulk Fill SDR and finally Filtek Bulk Fill so it is not recommended that patient of Tetric N-Ceram composite restoration to use Crest 3D White toothpaste for rotary toothbrushing using medium type of toothbrush.

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