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ORIGINAL RESEARCH

In vitro Comparison of Compressive Strength of Bulk-fill Composites and Nanohybrid Composite

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ABSTRACT

Objectives: The objective of this study is to measure and compare the compressive strength of two bulk-fill posterior composites (Smart dentin replacement or SDR and Filtek bulk fill) with universal nanohybrid composite (Filtek Z 250XT).

Materials and methods: In this *in vitro* study, three different types of posterior composites are used as follows: Group 1 – SDR (Dentsply, Konstanz, Germany); group 2 – Filtek bulk-fill (3M ESPE, St. Paul, MN, USA); group 3 – Filtek Z-250XT (3M ESPE, St. Paul, MN, USA). Ten cylindrical samples of 6 mm height and 4 mm diameter in each group were made using a split brass mold. The composites filled in the brass mold were photopolymerized using light-emitting diode (LED) light-curing unit and the cured samples were stored in water at 37°C for 48 hours before testing. The compressive strength of the stored samples was tested using universal testing machine (Instron 3366, UK) at a cross-head speed of 0.5 mm/minute. The compressive strength was calculated by dividing the maximum load with area of the samples.

Results: Results are statistically analyzed using one-way analysis of variance (ANOVA) with Tukey's *post hoc* test. Analysis showed that SDR and Filtek bulk-fill have greater compressive strength than Filtek Z-250 ($p < 0.05$). However, there is no statistical difference between compressive strength of SDR and Filtek bulk-fill composites ($p > 0.05$).

Keywords: Compressive strength, Filtek bulk-fill, Nanohybrid, Smart dentin replacement.

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INTRODUCTION

The aim of a dental restorative material is to simulate the biological, functional, and esthetic properties of healthy tooth structure. Silver amalgam and gold alloys, which have a long record of clinical success, have been used as dental restorative materials for more than 100 years, especially as a posterior restorative materials because of their good mechanical properties.[1] Because of high esthetic properties of composite resins, their use in restorative dentistry has greatly increased in past decades. Even though marked advances have been made in the properties of dental composites over the years, no basic change in monomer systems has occurred since Dr. Bowen introduced bisphenol A-glycidyl methacrylate (bis-GMA) in 1962.[2] Manufactures of dental composite resins are making constant efforts to improve the mechanical and physical properties of their product. Unfortunately, none of the available dental composite resins are able to meet both esthetic required for anterior tooth and functional needs of posterior restorations.[2] Thus, manufactures are trying to increase the filler content and decrease the size of particles to improve the physical properties.

Recently, there have been several attempts to utilize nanoparticle-sized fillers in dental composites, and some of these attempts have given good tooth-colored restorative materials called nanocomposites. Nanocomposites have superior compressive strength, diametrical tensile strength, fracture resistance, wear resistance, low polymerization shrinkage, high translucency, high polish retention, and more esthetics.[3,4]

Mechanical properties of posterior composites have a significant role in the efficacy and longevity of the tooth and its restoration.[5] It is said that compressive strength is the most important mechanical property of posterior restorative materials. A restorative material with lower compressive strength than the tooth tends to fail, fractures, and it ends with periodontal problems or extraction of the broken tooth.[6,7]

The characteristic of an ideal dental composite restorative would be that it can be effectively cured in a single increment, facilitating placement. Therefore, producing bulk-fill dental composites is a worthwhile pursuit. Although currently marketed bulk-fill composites are designed to be used either as complete restoratives or as liners requiring an occlusal capping material, the ultimate

goal is to produce the former to maximize convenience. Most manufacturers recommend their bulk-fill composites for depths up to 4 mm, although some suggest 5 mm is acceptable. The SDR and Filtek bulk fill are recently introduced bulk-fill composite resins into the market. Their mechanical properties vary relative to those of flowable nanocomposites. The aim of this study is to evaluate and compare the compressive strength of recently developed bulk-fill composites with nanohybrid composite resin.

MATERIALS AND METHODS

The present study includes three different types of composite resins, the compositions of which are presented in Table 1. Composite resins of respective group were applied and packed inside the brass spilt mold (6 × 4 mm) using incremental technique, and each layer was light-cured according to manufacturer's instructions (20 seconds light-emitting diode (LED) light with output 550 mW/cm^2). The last increment of composites is covered with a mylar strip. A glass slab (1-mm thick) is then placed over composites and pressure is applied to force the material into the mold and to expel the excess material. After removing the glass slab, the composites were then light-cured from above and bottom surfaces through the mylar strip as per the manufacturer's instructions using the LED light-curing unit. In order to have maximum curing, each specimen was postcured 10 minutes after preparation for 20 seconds with LED light in all directions.

Table 1: Name and product details of the materials used

Materials	*Type and composition*
Group 1 Smart dentin replacement (SDR) (Dentsply)	Bulk-fill composite. SDR™ patented urethane dimethacrylate (UDMA) resin Dimethacrylate resin Difunctional diluents barium and strontium alumino-fluoro-silicate glasses (68% by weight, 45% by volume) Photoinitiating system Colorants
Group 2 Filtek bulk fill (3M ESPE)	Bulk-fill composite AUDMA, UDMA, and 1, 12-dodecane-DMA 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 trifluoride filler consisting of agglomerate 100 nm particles. Inorganic filler loading is about 76.5% by weight (58.4% by volume).
Group 3 Filtek Z 250XT (3M ESPE)	Universal nanohybrid composite bis-GMA, UDMA, bis-EMA, PEGDMA and TEGDMA . Surface-modified zirconia/silica with a median particle size of approximately 3 μm or less. Non-agglomerated/non-aggregated 20 nm surface-modified silica particles. The filler loading is 82% by weight (68% by volume).

PEGDMA: Polyethylene glycol dimethacrylate; TEGDMA: Triethylene glycol dimethacrylate; Bis-EMA: Ethoxylatedbisphenol A dimethacrylate; UDMA: Urethane Dimethacrylate; BisGMA: Bisphenol A-glycidyl methacrylate

After completion of the polymerization process, the specimens were conditioned for 48 hours in distilled water at 37°C. The cylindrical specimens were transferred on to the Instron testing machine (Instron 3366, UK) individually and subjected to compressive testing at crosshead speed of 1.0 mm/minute. The data were assessed with help of one-way analysis of variance (ANOVA) and Tukey's test. A p-value <0.05 was considered statistically significant.

RESULTS

Data received in the present study are subjected to statistical analysis using one-way ANOVA and the intergroup comparison is done with the help of Tukey's test. Compressive strength of groups 1 and 2 is significantly higher compared with that of group 3 ($p < 0.05$). However, no significant difference in compressive strength was observed between groups 1 and 2 ($p \geq 0.05$). The statistical analysis of intergroups is shown in Tables 2 and 3. The graphical representation of results is shown in Graph 1.

DISCUSSION

With the rapid development and awareness regarding the esthetic needs among the patient community, there is an ever-increasing need for better tooth-colored restorative materials to replace missing tooth structure and to modify tooth color and contour, thus enhancing facial esthetics. In the last few decades, the increasing request for esthetic dentistry has led to the invention of composite resin materials for direct restorations with better physical and mechanical properties, esthetics, and longevity.[2] The most traditional dental composites for restorative purposes are hybrid and microfill composites. Hybrid composites consist of fillers with different average particle sizes and exhibit superior mechanical properties though they are esthetically inferior compared with microfills.

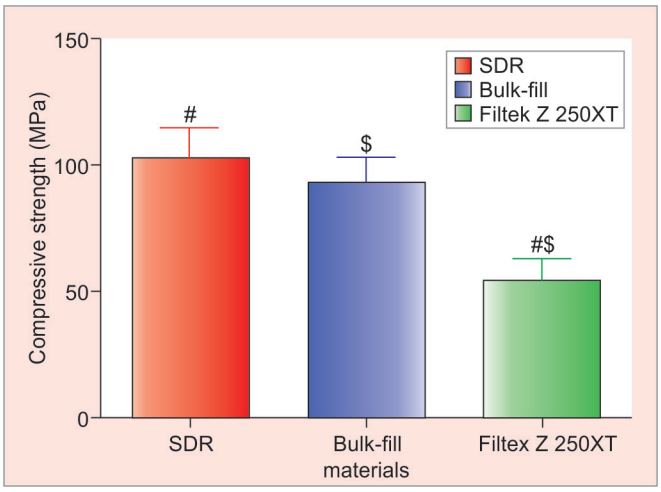
Table 2: Mean and standard deviation values for compressive strength using one-way

Groups	*No. of specimens*	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
1	10	100	11	83	120
2	10	94	9.8	84	110
3	10	55	8.6	44	65

Table 3: Intergroup comparison of compressive strength between groups using Tukey's test

Groups	*Mean difference*	*T*	*p-value*
1 and 2	9.5	2.3	>0.01
1 and 3	49	13	<0.01
2 and 3	39	9.4	<0.01

T = Tukey's test. p < 0.001 very highly significant; p > 0.05 not significance



Graph 1: The groups with similar symbols represent a statistically significant difference in compressive strengths (SDR and Filtek Z 250XT, Filtek bulk-fill and Filtek Z 250XT)

Microfill composites were introduced in the market to overcome the problems of poor esthetic properties. Unfortunately, the mechanical properties are considered low for application in regions of high occlusal force due to lower filler loading. In order to overcome the drawbacks of these systems, nanocomposites have been developed and marketed in recent years.[8] Nanofilled composites are believed to offer good wear resistance, strength, and ultimate esthetics due to their excellent palatability, polish retention, and lustrous appearance.[2]

Recently, there has been increasing popularity among dental practitioners of so-called bulk-fill materials, which are claimed to enable the restoration build-up in thick layers, up to 4 to 5 mm. This new material class includes flowable and higher viscosity paste material types. There currently exists a growing trend in the use of bulk-fill materials among practitioners due to a more simplified procedure.[9] Manufacturers claim that bulk-fill materials have greater depth of cure and lower polymerization-induced shrinkage stress due to technology like "polymerization modulators," which they say allow a certain amount of flexibility and optimized network structure during polymerization.[10] Filtek bulk-fill and SDR composites are recently introduced bulk-fill composite resins for class II and I restorations. These composites resins have excellent handling characteristics typical of a flowable composite, but can be placed in 4 mm increments with minimal polymerization stress.

Compressive strength is used for evaluation of the mechanical properties of dental restorative materials. Since most of the masticatory forces fall into the category of compressive forces, assessment of the durability of restorative materials in such conditions is of great importance.[11] With this back ground, the present study investigated the compressive strength of two recently introduced bulk-fill composites and compared them with nanohybrid composite. The results showed that both bulk-fill composites exhibited better compressive strength comparable to nanohybrid composite resins.

Smart dentin replacement is a one-component, fluoride-containing, visible light-cured, radiopaque resin composite restorative material. The compressive strength of dental composite restorative material depends on many factors, such as polymerization shrinkage, water sorption, degree of polymerization, and depth of cure, especially in light cure composite resins where the light does not reach into the deepest parts of the cavity.[12] The SDR is manufactured using a stress-decreasing resin technology. This means that a substance described as a "polymerization modulator" is chemically embedded in the backbone of the polymerizable resin. The polymerization modulator synergistically interacts with the camphorquinone photoinitiator so as to result in a slower elasticity modulus development, allowing for stress reduction without a decrease in the rate of polymerization or degree of conversion compared with conventional nanocomposites. Because of this unique technology, it has higher compressive strength than nanohybrid composite (Filtek Z 250XT). The SDR has a high filler loading (68% by weight, 45% by volume) which helps to improve compressive strength.[13] In SDR, the organic matrix mainly consists of urethane dimethacrylate resin and dimethacrylate resin which exhibits remarkably low viscosity and water resorption, thus helping to flow better in cavities without internal voids. This further helps in increasing compressive strength of the material compared with nanohybrid composite (Filtek Z-250XT).[14]

Filtek bulk-fill posterior restorative material is a visible, light-activated restorative composite optimized to create posterior restorations simpler and faster. This bulk-fill material provides excellent strength and low wear for durability. In our study, Filtek bulk fill showed better compressive strength compared with nanohybrid composite (Filtek Z250XT) because of special filler loading technology. In this material, the fillers are a combination of a 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 trifluoride filler consisting of agglomerate 100 nm particles. The inorganic filler loading is about 76.5% by weight (58.4% by volume).[15]

There is no statistically significant difference in the compressive strength between group 1 SDR and group 2 (Filtek bulk-fill). The bulk-fill technology has several advantages: (1) Fewer voids may be present in the mass of the material, since all of it is placed at one time; (2) the technique would be faster than placing numerous increments if curing times were identical; (3) it may be easier

than numerous increments.[13,16] On the contrary, there are many questions in the minds of dentists about bulk-fill technology because there are very little published data. Therefore, the clinical success will only be discovered after long periods of use by dentists. However, further studies evaluating the long-term clinical success of bulk-fill resin-based composites are needed.

CONCLUSION

The continual development of newer technology will improve the ability of scientists, manufacturers, and clinicians to create a more ideal composite. Considering the limitations of this *in vitro* study, the following can be concluded:

- Bulk-fill composites have shown superior compressive strength than nanohybrid composites. Both SDR and Filtek bulk-fill (groups 1–2) have shown better compressive strength compared with nanohybrid composite resin (group 3).
- There is no statistically significant difference in compressive strength between SDR (group 1) and Filtek bulk fill (group 2).
- Due to the ability to place restorations with a single increment (up to 4 mm), ease of use, and by further studies, the SDR and Filtek bulk-fill system may be an alternative for posterior restorations.

REFERENCES

1. Moezzyzadeh M. Evaluation of the compressive strength of hybrid and nanocomposites. J Dent Sch 2012;30(1):24-29.
2. Hegde MN, Hegde P, Bhandary S, Deepika K. An evaluation of compressive strength of newer nano composite. J Conserv Dent 2011 Jan;14(1):36-39.
3. Moszner N, Klapdohr S. Nanotechnology for dental composites. Int J Nanotechnol 2004 Jan;1(1/2):130-141.
4. Mota EG, Oshima HM, Burnett LH Jr, Pires LA, Rosa RS. Evaluation of diametrical tensile strength and knoop microhardness of five nanofilled composites in dentin and enamel shades. Stomatologija 2006;8(3):67-69.
5. Banava S, Salehyar S. In vitro comparative study of compressive strength of different types of composite resins in different periods of time. Iran J Pharm Res 2008;4(1):69-74.
6. Jung M, Eichelberger K, Klimek J. Surface geometry of four nanofiller and one hybrid composite after one-step and multiple-step polishing. Oper Dent 2007 Jul-Aug;32(4):347-355.
7. Papadogiannis Y, Lakes RS, Palaghias G, Helvatjoglu M. Fatigue of packable dental composites. Dent Mater 2007 Feb;23(2):235-242.
8. Sideridou ID, Karabela MM, Vouvoudi ECh. Physical properties of current dental nanohybrid and nanofill light-cured resin composites. Dent Mater 2011 Jun;27(6):598-607.
9. Campodonico CE, Tantbirojn D, Olin PS, Versluis A. Cuspal deflection and depth of cure in resin-based composite restorations filled by using bulk, incremental and transtooth illumination techniques. J Am Dent Assoc 2011 Oct;142(10): 1176-1182.
10. Surefil SDR. Flow Product Brochure. Dentsply International; 2010 [accessed 2015 Aug 22]. Available from: http://www.surefilsdrflow.com/sites/default/files/SureFil_Brochure.pdf.
11. Mohandesi JA, Rafiee MA, Barzegaran V. Compressive fatigue behavior of dental restorative composites. Dent Mater J 2007 Nov;26(6):827-837.
12. Badr SBY, Ibrahim MA, El Banna M. Compressive strength and compressive fatigue limit behavior of two fluoride releasing materials. Adv Med 2013;2(3):30-36.
13. Czasch P, Ilie N. *In vitro* comparison of mechanical properties and degree of cure of bulk fill composites. Clin Oral Invest 2013;17(1)227-235.
14. Accessed 2015 Aug 22. Available from: http://dentsplymea.com/sites/default/files/SDR_OPL_factfile_3p.pdf.
15. Accessed 2015 Aug 22. Available from: http://multimedia.3m.com/mws/media/976634O/filtek-bulk-fill-posterior-restorative-technical-product-profile.pdf.
16. Christensen GJ. Advantages and challenges of bulk-fill resins. Clin Rep 2012 Jan;5(1):1-5.