Relative Microhardness and Flexural Strength of Different Bulk Fill Resin Composite Restorative Materials

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Abstract:Aim: to find out if there is a significant difference in the curing efficiency at the claimed 4 mm depth and in the mechanical properties between the tested paste- form bulk fill resin composite materials. **Materials and Methods:** Three paste-consistency bulk-fill resin composites were used in this study (Filtek bulk fill- 3M; X-trafil- Voco; and SonicFill bulk-fill- Kerr). For the microhardness testing, standardized disc-shaped resin composite samples (6mm X 4mm) were prepared. For the Flexural Strength testing, standardized resin composite samples with the dimensions of (2mm x 2mm x 25mm) were fabricated.All samples were light cured following the manufacturers' instructions using high intensity LED light-curing unit.Five samples were prepared from each material for each test with a total of 30 samples (15 for each test). Both tests were run at baseline after preparing the specimens without storage. Vickers microhardness values of the top and bottom surfaces were recorded. Three-point flexural strength test values were recorded. One-way ANOVA test statistics was done to compare between the mean values for the 3 materials with p value less than 0.05. Least significance test was followed to compare between each two materials in case statistical significance was found. **Results:** 3M had statistically significant lower surface microhardness values on both surfaces (top and bottom) at $p < 0.05$. All the three bulk fill resin composite materials showed sufficient relative microhardness values (>0.80) at 4 mm depth. 3M had the lowest mean flexural strength value and SonicFill had the highest mean flexural strength value but the difference is not statistically significant at $p < 0.05$.**Conclusion:**Microhardness values of paste consistency bulk fill materials can differ compared to each other but all showed sufficient depth of cure at 4 mm depth and no significant difference in their flexural strength.

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Key Words: Bulk fill, flexural strength, relative microhardness, depth of cure.

1.Introduction:

Resin composite restorative materials have considerable improvements in their chemical composition over the past years (Didem, 2014). In regards to depth of cure of resin composite, a study on the curing effectiveness using halogen and LED units on different types of resin composites was done and found that incremental use of composite on restorative procedure must not exceed 2.5 mm for each increment (Ceballos, 2009). Newly fabricated resin composites with modified chemical composition called "bulk fill composites" have been introduced into the market. The practicality of the new material is in claiming that it can be light-cured in up to 4 mm thickness at once which will minimize the clinical application time compared to regular composite with which placement and curing of 2 mm increment thickness is required (Czasch & Ilie, 2013).

The ideal dental restorative material should have close characteristics to natural tooth structure as for its optical and mechanical properties (Wang, 2003). Leprince*et al.*2014 did a study to evaluate the physico-mechanical properties of some of the currently available paste and flowable forms bulk fill composites comparing them to commercially available nano-hybrid composites also in paste and flowable forms. They concluded that bulk fill composite had the advantages of time saving and easy handling, in contrast it has limitations in the mechanical properties when compared to nano-hybrid composites (Leprince, 2014). Another study by Didem*et al.*2014 investigated the mechanical properties of different types of nano-hybridbulk fill composites and concluded that SonicFill system had the highest score among the tested materials and can be used as an alternative to regular composite for posterior teeth restoration (Didem, 2014).

Kim *et al.*2015 studied the effect of resin thickness on the microhardness and optical properties of different bulk fill composites and concluded that the microhardness decreased with the increasing in the thickness of the resin (Kim, 2014).

Nowadays bulk fill composites become widely used amongst practitioners. However, only few studies were published on comparing thelight-curing efficiency and mechanical properties of the commercially available bulk fill composite. Therefore, the aim of the present study is to find out if there is a significant difference in the curing efficiency at the claimed 4 mm depth and in the mechanical properties between the tested paste- form bulk fill resin composite materials.

2.Materials and Methods:

Materials Used:

Three paste-consistency bulk-fill resin composites were used in this study:

1. Filtek bulk fill- 3M.
2. X-trafil- Voco.
3. SonicFill bulk-fill- Kerr.

The materials names, specifications, and manufacturers are described in details in table (1).

Table (1): Materials specifications, manufacturers and compositions.

Material	Composition	Shade	Manufacturer
Filtek Bulk Fill, Posterior restorative	**The resin matrix:** AUDMA, UDMA, and 1, 12-dodecane-DMA. **The filler:** Non-agglomerated/non-aggregated 20nm silica filler, a Non-agglomerated/non-aggregated 4 to 11 nm zirconia filler, an aggregated zirconia/silica cluster filler (20nm silica and 4 to 11 nm zirconia particles), and a ytterbium trifluoride filler consisting of agglomerate 100 nm particles. (Khalil Yousef, 2015)	A2	3M ESPE, St. Paul, USA
SonicFill, nanohybrid composite restorative	**The resin matrix:** (1-methylethylidene) bis (4, 1-phenyleneoxy-2, 1-ethanediyloxy-2, 1-ethanediyl) bismethacrylate. (1-methylethylidene) bis [4, 1-phenyleneoxy (2-hydroxy-3, 1-propanediyl)] bismethacrylate. 2, 2'-rthylenedioxydiethyl dimethacrylate. **The filler:** Glass, oxide, and Silicon dioxide. (Khalil Yousef, 2015)	A2	Kerr Corporation, Orange, CA, USA
X-trafil light-curing posterior filling material	**The resin matrix:** Bis-GMA, UDMA, TEGDMA **The filler:** Barium-boron-alumino-silicate glass (2-3 µm) 86% by weight. (Abed, 2015)	Universal	Voco GmbH, Cuxhaven, Germany

AUDMA: Aromatic urethane dimethacrylate; Bis-GMA: bisphenolAglycidyaldimethacrylate; UDMA: urethane dimethacrylate; TEGDMA: triethyleneglycoldimethacrylate.

Samples Preparation:

For the microhardness testing, standardized disc-shaped resin composite samples were prepared from split Teflon mold with an internal diameter of 6 mm and thickness of 4 mm. The mold consisted of two parts with an outer metallic ring to assist reassembling of the two parts together. A glass slide with overlying celluloid Mylar strip was placed under the mold against which the composite material was packed inside the mold in one increment over which another celluloid strip was placed and a glass slide with hand pressure to ensure flat surface and removal of extra material. All samples were light cured following the manufacturers' instructions and using high intensity Elipar™ LED light curing unit (3M ESPE)and the surface facing the light-curing unit was marked with a small dot using a permanent pen.

For the Flexural Strength testing, standardized resin composite samples with the dimensions of (2mm x 2mm x 25mm) were fabricated .A glass slide with overlying celluloid strip was placed under the mold against which the composite material was packed inside the mold in one increment over which another celluloid strip was placed and a glass slide with hand pressure to ensure flat surface and removal of extra material. The samples were cured at 3 sections (right, left, and then center) to ensure proper curing of the whole length of the rectangular samples. Samples were cured at each section following the manufacturers' instructions using high intensity Elipar™ LED light curing unit (3M ESPE).

The output of the light-curing unit was continuously measured throughout the samples preparation using LED radiometer by Demetronto ensure a constant output of 1,375 mw/cm^2. Five samples were prepared from each material for each test with a total of 30 samples (15 for each test). Both tests were run at baseline after preparing the specimens without storage.

Samples Testing:

Relative microhardness was measured by doing the surface microhardness test on both sides of the samples (top and bottom) to give indication about the depth of cure by calculating the ratio of bottom/top hardness. A minimum value of 0.80 have to be reached in order to consider the bottom surface adequately cured(Moore, 2008). Surface microhardness of the samples was determined using Vickers Microhardness tester (MicroMet 6040 Wilson Microhardness; BUEHLER, U.S.A.) using a Vickers diamond indenter by applying 3 indentations at least 1 mm apart on each surface and a load of 50 grams for 10 seconds. The diagonal lengths of the indentations were measures by built in scaled microscope with (20X objective lens) and the Vickers values were automatically converted into microhardness values. The mean values of the 3 indentations for the 5 samples on each surface were calculated.

The three-point flexural strength test was done using a universal testing machine (Esthetic 5944 Flexural strength; INSTRON, U.S.A.)at a crosshead speed of 0.5 mm/minute until failure. The maximum fracture load (F, in N) of each sample was recorded and a built in computerized program automatically calculated the flexural strength in MPa. The mean flexural strength values from the 5 samples for each material were calculated.

Statistical Analysis:

One-way ANOVA test statistics was done to compare between the mean values for the 3 materials with *p* value less than 0.05. Least significance test was followed to compare between each two materials in case there were statistical significant results.

3.Results:

The general mean microhardness values for the top and bottom surfaces of the 3 indentations and 5 samples for each material was calculated and presented in table (2)and illustrated in figure (1). 3M had statistically significant lower surface microhardness values on both surfaces (top and bottom). There was no statistically significant difference between Voco and SonicFill at $p < 0.05$. All the three bulk fill resin composite materials showed sufficient relative microhardness values (>0.80) at 4 mm depth.

Table (2): Mean microhardness values and standard deviations of the top and bottom surfaces and the percentage of the bottom to top values for the 3 bulk fill resin materials. One-way ANOVA test statistics was done to compare between the mean values for the 3 materials with *p* value less than 0.05. Least significance test was followed to compare between each two materials. [a,b]materials having different superscripted letters are significantly different from each other.

Material	**Top**	**SD +/-**	**Bottom**	**SD +/-**	***P*-value**	**Bottom/ Top**
3M	50.86^a	2.99	48.88^a	3.51	< 0.001 Significant	0.96
Voco	74.72^b	7.80	63.54^b	4.55		0.85
Sonic Fill	74.66^b	1.93	69.32^b	5.79		0.93

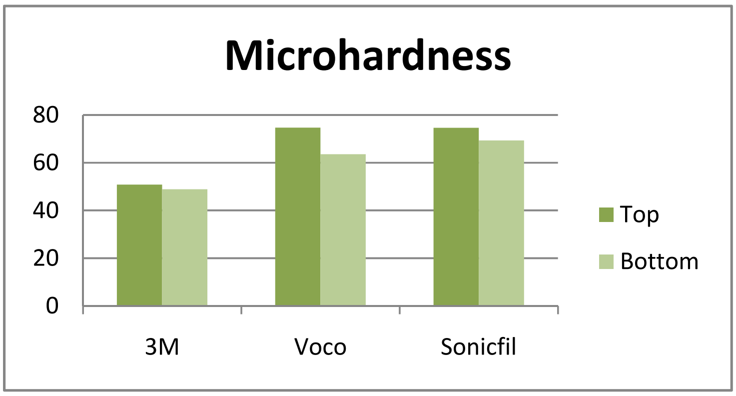

Figure (1): Bar chart illustrating the mean microhardness values of the top and bottom surfaces for the 3 bulk-fill resin composite restorative materials.

The general mean flexural strength for the 3 materials were calculated and presented in table (3)and illustrated in figure (2). The results showed that 3M had the lowest mean flexural strength value and SonicFill had the highest mean flexural strength value but the difference is not statistically significant at $p < 0.05$.

Table (3): Mean flexural strength values and standard deviations for the 3 bulk fill resin composite materials. One-way ANOVA test statistics was done to compare between the mean values for the 3 materials with p value less than 0.05.

Material	**Flexural strength (MPa)**	**SD +/-**	***P*-value**
3M	134.18	37.65	0.185 None significant
Voco	159.2	29.06	
Sonic Fill	173.9	29.22	

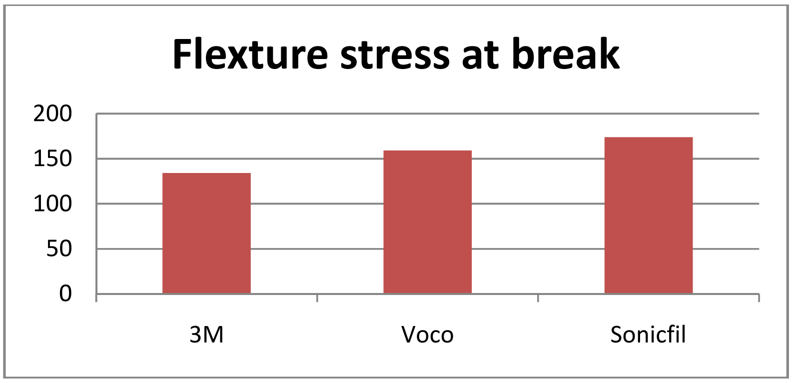

Figure (2): Bar chart illustrating the mean values of the flexural strength at break for the 3 bulk-fill resin composite restorative materials.

4.Discussion:

The mean microhardness values for the 3 resin composite materials shows that 3M had the lowest mean microhardness values on both surfaces the top and bottom which was statistically significant from Voco and SonicFill materials. This result is in agreement with a study by Alrahlahet el who used Vickers hardness profile to determine the post-cure depth of cure of five different bulk fill composite materials and found that the results were statistically significantly different (Alrahlah, 2014).

The bottom/top hardness ratio is > 0.80 for all the three materials at 4 mm thickness. This result is in agreement with the results of Kim et al who tested the relative microhardness of four different bulk fill resin composite materials and found that all 4 were properly cured in 4 mm bulk (Kim, 2015).Alshali*et al.* also found that bulk fill resin composite materials bottom/top microhardness ratio was comparable to conventional resin composite restorative materials at the recommended manufacturer thickness (Alshali, 2015).Another study investigated the influence of increment thickness on Vickers microhardness of four bulk fill resin composites found that increasing the increment thickness will result in decrease in the Vickers microhardness values for the conventional resin composites but remained constant for the bulk fill resin composites (Flury, 2014). A study on the physic-mechanical characteristics of different commercially available bulk-fill composites found that the mechanical properties of most of the bulk fill resin composites were lower compared to the conventional high viscosity material and that they were comparable to conventional flowable composite (Leprince, 2014). This can be explained because the study was done on different bulk fill resin composite with different consistencies (paste and flowable) and did not only compare the high viscosity paste like materials to the highly filled nano-hybrid composites.

The flexural strength results showed that 3M had the lowest mean flexural strength value and SonicFill had the highest mean flexural strength value but the difference is not statistically significant at $p < 0.05$. A study by Czasch et al on 2 different bulk fill resin composites (Surefil® SDR™ flow and Venus® bulkfill) found that there was a statistical significant difference between the 2 materials in their flexural strength values (Czasch, 2013). A study comparing the physical properties of SonicFill bulk fill resin composite material to other different bulk fill materials showed SonicFill had a statistically significant higher flexural strength values compared to the other bulk fill resin composite materials tested in that study (Ibarra, 2015). Different bulk fill resin composites with different filler content and consistency can have different flexural strength values, this is in agreement with a study by Goracci et al who compared the flexural strength of 5 different bulk fill resin composites and found that EverXPosterios and SonicFill had significantly higher flexural strength values to other resin composites tested (Goracci, 2014).

Conclusion:

Within the limitation of this study, all the tested bulk-fill resin composite materials has sufficient cure at 4 mm depth when light cured following the manufacturer's recommendation. 3M had significant lower surface microhardness values and insignificantly lower flexural strength values. Microhardness values of paste consistency bulk fill materials can differ compared to each other but all showed sufficient depth of cure at 4 mm depth and no significant difference in their flexural strength.

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