



# Effect of the different chromatic filters of the dental operating microscope on the volumetric shrinkage, surface hardness, and depth of cure of bulk fill composite

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## Abstract

**Aim.** Evaluate the effect of different chromatic filters of the dental operating microscope on the volumetric shrinkage, surface micro-hardness, and depth of cure of bulk-fill composite.

**Methods.** Bulk fill composite specimens of 4 mm depth, 4 mm width, and 4 mm length were prepared. Five groups were designed based on a light source under which composite samples were condensed. Group 1: dental chair light without filter, Group 2: microscopic light without filter, Group 3: microscopic light with a yellow filter, Group 4: microscopic light with a green filter, Group 5: dental chair light with a red filter. After condensation, the samples were subjected to curing using Bluephase NM curing light. The parameters like volumetric shrinkage, surface hardness, and depth of cure were measured for all the samples. The results were subjected to statistical analysis using one-way ANOVA, followed by post-hoc Tukey tests.

**Results.** Group-2 showed the highest mean volumetric shrinkage (14.514%), surface micro-hardness (58.065 kg/m<sup>2</sup>), depth of cure (0.831%), whereas group-5 showed the least volumetric shrinkage (7.386%), surface micro-hardness (46.536 kg/m<sup>2</sup>), and depth of cure (0.789%). Working time was 40 seconds for group-2, whereas the remaining groups were allowed to complete 1-minute condensation. A statistically significant difference was shown between groups 1 and 5 ( $p=0.050$ ), 2 and 5 ( $p=0.007$ ) for volumetric shrinkage. Regarding surface micro-hardness, a statistically significant difference was observed between all the groups ( $p=0.001$ ) except group-3, group-4 ( $p=0.100$ ). There was no statistically significant difference between all the groups except group 2 and 5 for depth of cure ( $p=0.016$ ).

**Conclusion.** Microscope light without filter showed the highest surface hardness and depth of cure. However, the highest volumetric shrinkage and lesser working time were also observed, which are undesirable. Use of filters during composite manipulation showed less detrimental effects on depth of cure, volumetric shrinkage and working time. Overall, composite condensed under filters showed acceptable properties.

**Keywords:** bulk fill composite, intensity, microscopic light filters, surface hardness, volumetric shrinkage

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## Introduction

Today's dentistry is more focused on the attention to detail. Micro restorative dentistry is an emerging trend in this perspective. Many anterior as well as posterior esthetic restorations, warrant the use of magnification [1]. Dental Operating microscopes (DOM) are provided with different chromatic filters for versatile applications. Literature suggests that the mechanical properties of composite resin can be influenced by different light source [2,3]. There is a linear relationship between light intensity and polymerization shrinkage, i.e., the higher the intensity of light, the higher the polymerization shrinkage [4-6]. Also, the degree of conversion (DC) of composite resin can determine the mechanical properties, chemical stability, and longevity of a restoration. Efficient polymerization is important for obtaining the optimal physical properties of the material and achieving improved clinical performance of resin composite restorations [7]. The hardness of the light-cured resin composites depends on several factors: the composition of the organic matrix, the type and amount of filler particles, and the degree of polymerization. An examination of the resin composite micro-hardness was used to evaluate the rate of polymerization [8,9].

While the relative degree of cure of the external surface of a restoration can usually be evaluated with simple techniques, the cure of the inner layers of resin is not similarly accessible to evaluation. It was recognized that, unlike chemically activated resins, an adequate cure of the entire visible light activated restoration cannot be assumed, based on external surface properties [10]. It has been shown that inadequate polymerization would result in a reduction in physical properties [11]. A number of different techniques have been employed to measure the properties of the polymerized resin composite which include scraping away the unset material and measuring the remaining specimen, measuring top and bottom hardness and measuring top and bottom degree of conversion of double bonds in the polymer [12,13]. Micro-hardness (MH) is an indirect measure of a material's depth of cure (DOC). It provides valuable information on the DOC when measured on the top and bottom surfaces of a specimen. The depth at which a composite resin achieves 80% of its surface hardness is generally considered the maximum depth at which the composite should be used [14,15].

Despite advances in the composite resin itself, compensation for volumetric shrinkage (VS), post-cure density, and surface hardness are the considerable challenges that play a significant role in durability. It is claimed that bulk-fill composites can obtain an optimal degree of conversion even at the bottom of the cavities [16,17]. But little is known about the effect of microscope filters on the properties of the bulk-fill composite. The study aims to evaluate the effect of microscopic filters on the surface hardness, depth of cure, volumetric shrinkage of the bulk-fill composite.

## Methods

Forty molds of 4 mm width, 4 mm length, 4 mm depth were used to condense the Tetric-N-Ceram bulk fill (IvoclarVivadent, shade A2) composite. Manipulation of composite specimens was carried under respective microscopic filters (Magna, Labomed) in a dark environment to prevent the deleterious effects caused by the daylight and then cured with Bluephase NM curing light (Ivoclar, Vivadent).

Based on the type of light source under which composite specimens were prepared, five groups were designed.

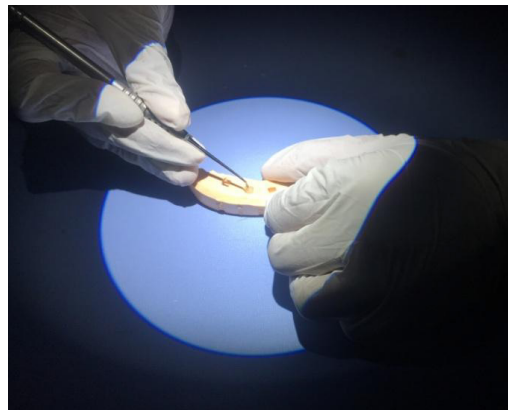
Group 1: composite condensed under dental chair light.

Group 2: composite condensed under microscopic light without the filter (Figure 1).

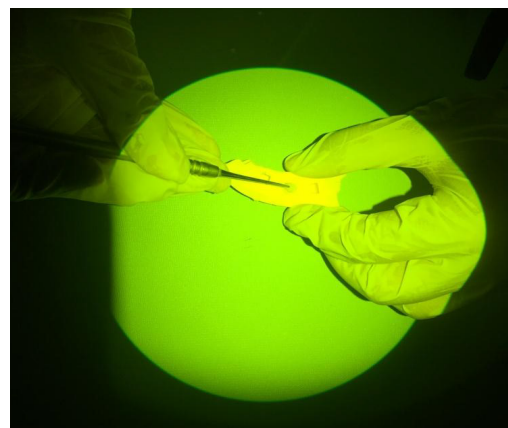
Group 3: composite condensed under microscopic light with a yellow filter (Figure 2).

Group 4: composite condensed under microscopic light with green filter (Figure 3).

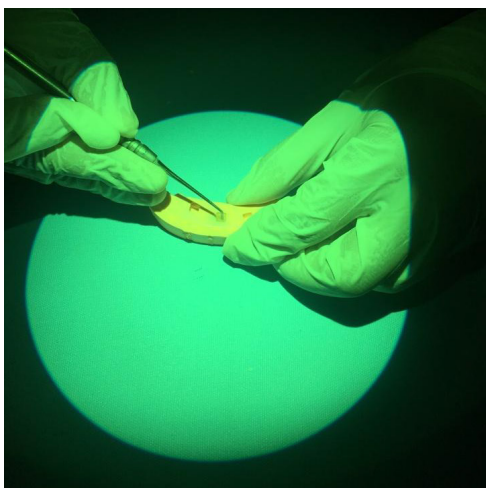
Group 5: composite condensed under dental chair light with a red filter (Figure 4).



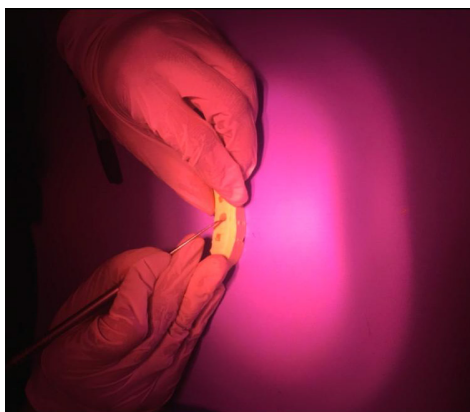
**Figure 1.** Composite condensed under microscopic light without the filter.



**Figure 2.** Composite condensed under microscopic light with a yellow filter.



**Figure 3.** Composite condensed under microscopic light with green filter.



**Figure 4.** Composite condensed under dental chair light with a red filter.

Each group contains a total of 8 specimens. The distance between the illuminant and sample was maintained at 30 cm and was kept constant. After condensation for 1 minute with a plastic filling instrument, we covered the composite specimen surface with a mylar strip and placed the curing light upon it. The size of the illuminated area was 8cm. The irradiance on the surface of the specimen with microscopic light was 1 lakh lux, and with the placement of filters, it was 75,000 lux. Under the chair light, irradiance on the sample's surface was 30,000 lux, and with a red filter, it reduced up to 20%. Bluephase NM (Ivoclar) was used to cure the samples with an intensity of 800 mW/cm<sup>2</sup> and a wavelength range of 430-490 nm for 15 sec. Later, each specimen was removed from the mold, stored in artificial saliva for seven days, and placed in an amber bottle. Amber bottles were stored in a humidifier until testing. Initially, we calculated the volumetric shrinkage using a micrometer. Later all the samples were

tested for top and bottom hardness using Vickers micro-hardness tester and calculated the depth of cure.

#### *Measurement of volumetric shrinkage*

Three sides of the post-cured composite specimen (length, width, height) were measured using a micrometer. All three values multiplied to obtain the volume of the post-cured composite specimen. The difference in the mold and post cured composite specimen volume was calculated, and that value was taken as volumetric shrinkage.

#### *Measurement of micro-hardness*

The top and bottom surface hardness of each 4-mm increment specimen were measured using the Vickers micro-hardness tester (Daksh quality system, India). The measuring indenter, the Vickers pyramid, was pressed to the composite sample using a load of 100 grams for 20 sec. The surface Vickers hardness was measured at three points of each specimen to minimize measurement errors within a sample.

The average of the three micro-hardness values was taken to obtain a single value of Vickers micro-hardness.

Equation 1: Vickers hardness of the material (VHN) = (1.8544P)/D<sup>2</sup>

In which VHN represents Vickers's hardness of the material (kg/m<sup>2</sup>), P is the predetermined load applied on the sample (kg) and D is the average diagonal distance (mm) of the square resulting from the indentation of the pyramid tip of Vickers hardness tester.

#### *Depth of cure measurement*

After determining the top and bottom micro-hardness, the depth of cure of each sample was calculated according to Equation 2.

Equation 2: Depth of cure = bottom micro-hardness/top micro-hardness

*Working time* was measured simultaneously using a stopwatch while condensing the composite into the molds until resistance to condensation was observed.

#### **Statistical analysis**

The collected data were subjected to descriptive analysis and followed by Mann-Whitney u test to measure the outcome variables in different groups. One way ANOVA was performed to know the mean comparison within and between the groups of outcome variables followed by Tukey post hoc test for multiple group comparisons. The statistical significance level was set as p<0.05. The analysis was performed using SPSS software version 20.0 IBM (NY, USA).

#### **Results**

Group-2 showed the highest mean volumetric shrinkage (14.514%), whereas group-5 showed the lowest (7.386%) among all the groups (Table I). A statistically significant difference is demonstrated between group 1 and 5 (p=0.050), 2 and 5 (p=0.007) (Table II).

**Table I.** Comparison of mean values of volumetric shrinkage, surface hardness, depth of cure of all the groups.

Group	Mean Volumetric Shrinkage (%)	Mean Surface Micro-Hardness (kg/m <sup>2</sup> )	Mean Depth of Cure (%) (Bottom/Top Surface Hardness)
Group-1	12.868	51.994	0.811
Group-2	14.514	58.065	0.831
Group-3	12.055	50.966	0.800
Group-4	10.842	50.434	0.803
Group-5	7.386	46.536	0.789

**Table II.** Multigroup comparison of volumetric shrinkage.

VS (%)			
Group		Mean Difference	P-value
1	2	-1.646	.914
	3	0.813	.993
	4	2.026	.834
	5	5.483	<b>.050*</b>
2	3	2.459	.714
	4	3.672	.342
	5	7.128	<b>.007*</b>
3	4	1.213	.970
	5	4.670	.139
4	5	3.457	.402

VS-volumetric shrinkage; \*-significant difference; %-percentage

The mean Surface micro-hardness (SH) of group-2 was highest (58.065 kg/m<sup>2</sup>). The least values were observed in group-5 (46.536 kg/m<sup>2</sup>) (Table I). A statistically significant difference was observed between all the groups (p=0.001) except group-3, group-4 (p=0.100) (Table III).

**Table III.** Multigroup comparison of surface micro-hardness.

SH (kg/m <sup>2</sup> )			
Group		Mean Difference	P-value
1	2	-11.529	<b>&lt;0.001*</b>
	3	-4.430	<b>&lt;0.001*</b>
	4	-3.898	<b>&lt;0.001*</b>
	5	-5.458	<b>&lt;0.001*</b>
2	3	7.099	<b>&lt;0.001*</b>
	4	7.631	<b>&lt;0.001*</b>
	5	6.071	<b>&lt;0.001*</b>
3	4	0.532	.100
	5	-1.028	<b>&lt;0.001*</b>
4	5	-1.560	<b>&lt;0.001*</b>

SH-surface micro-hardness; \*-significant difference; kg/m<sup>2</sup>-kilogram/meter<sup>2</sup>

The highest mean DOC was obtained for group-2 - 0.831% (Table I). All the groups showed a mean DOC of 0.80 or more, whereas group-5 showed the lowest value of 0.789%. But there was no statistically significant difference between all the groups except groups 2 and 5 (p=0.016). (Table IV).

**Table IV.** Multigroup comparison of depth of cure.

DOC (%)			
Group		Mean Difference	P-value
1	2	-.020	.524
	3	.011	.900
	4	.009	.958
	5	.023	.406
2	3	.031	.124
	4	.029	.182
	5	.043	<b>.016*</b>
3	4	-.003	1.000
	5	.011	.900
4	5	.014	.815

DOC-mean depth of cure; \*-significant difference; %-percentage

For group-2 samples, the average working time recorded was 40 sec, whereas the remaining groups showed 1 minute working time.

### Discussion

Bulk-filling techniques are popularized due to the introduction of materials with improved curing, controlled polymerization contraction stresses, and reduced cuspal deflection [18-22]. By this approach, the number of increments required to fill a cavity is decreased compared to traditional incremental techniques. In contrast to the 2-mm incremental technique for conventional composites, manufacturers recommend 4-5-mm increments of the bulk-fill resin composites. The bulk-fill method undoubtedly simplifies the restorative procedure and saves clinical time in cases of deep, wide cavities.

The incident light influences the properties of these bulk-fill composites. The use of a microscope, combined with co-axial illumination (MLMCI), improves the dentist's ability to prepare, bond, restore, and adjust composite restorations, compared to use unaided vision and non-co-axial, shadow forming overhead lighting [23,24]. A co-axial light axis is coincident with the visual axis of the dentist's eyes, resulting in shadow-free illumination [25,26]. DOM are provided with different types of filters and are used for observation and photomicroscopy. Each microscope filter placed in the light path serves a different purpose and is placed either over the illuminator or in a filter slot that lies in the light path. The dental operating microscope used in



this study has inbuilt yellow and green filters. We added a red filter to the dental chair to compare the effects of the different lights (dental chair light and microscopic light) with and without filters.

The higher the light intensity, the higher the degree of conversion, and higher the polymerization shrinkage [27]. High polymerization shrinkage in group 2 could be because of the high intensity of DOM light without filter while condensing, followed by curing light intensity. Similarly, low polymerization shrinkage in group 5 could be because of the low intensity of dental chair light with a filter. Groups without filters showed higher volumetric shrinkage values when compared to groups with filters.

Micro-hardness is an essential parameter for the physical and mechanical behavior of composite resin restorations. The hardness of the light-cured resin composites depends on several factors: the composition of the organic matrix, the type and amount of filler particles, and the degree of polymerization and distance between the composite and tip of curing light [28]. Since all the factors except the degree of polymerization are made constant, and it could be the only factor that changed properties. The degree of polymerization, in turn, depends upon the light source and its intensity. Greater SH in Group-2 is because of the higher intensity of the light source, which increased the DC.

Similarly, Group-5 specimens were subjected to a lower intensity of light, giving lower SH values. Similar results were shown by Kassim et al., where the DOC and SH increased with an increase in light intensity up to 1500 mW/cm<sup>2</sup> [29]. There is no statistically significant difference between groups 3 and 4, which could be because of manipulation under similar conditions except for the change in filters. A significant difference was observed for group 2 (without filter) with group 3 and group 4 (both with filters); this might be because of a 35% decrease in the microscopic light intensity. According to the manufacturer's specifications, the microscopic light intensity is nearly 1 lakh lux, which decreased to 75,000 lux approximately with the filters.

SH is not an adequate indicator of complete material polymerization. The hardness of the bottom surface should be close to the hardness of the top surface. A value of over 0.80 in the bottom to top surface micro-hardness indicates adequate DOC. The DOC is the depth up to which the light can cure the material. The presence of unreacted monomer within the resin-based composite (RBC) bulk may also attenuate the irradiating light, preventing the formation of free radicals and thereby reducing the DOC. All the groups showed a considerable DOC (>0.8) except group-5 (0.78), which is because of lower hardness values in the case of Group 5. The chemical composition of the filler and matrix can have significant effects on the degree of conversion of RBCs. Tetric N Ceram bulk-fill composite has prepolymerized fillers (PPF) containing barium glass

and silica minerals. New types of photo-initiators such as Ivocerin and Benzoyl Germanium are used in the composition of PPF of bulk-fill RBCs instead of the standard type camphor quinone (CQ) [30]. The higher capability of these materials in creating free radicals per molecule unit can improve the light sensitivity of RBCs [31]. These changes have a positive effect on the light absorbance ability and DC of RBCs.

All the parameters were lower for group 5 when compared with group 1. Groups 1 and 5 showed significant differences for SH and VH. The difference could be because of the reduction of the intensity of the chair light after placing the filter. The working time is less in Group 2 because of the high intensity of light, causing the rapid formation of a highly cross linked polymeric network in surface layers of composite resin. The remaining groups showed an adequate working time.

## Conclusion

Microscope light without filter showed the highest surface hardness and depth of cure. However the highest volumetric shrinkage and lesser working time were also observed, which are undesirable. Use of filters during composite manipulation showed less detrimental effects on depth of cure, volumetric shrinkage and working time. Overall, composite condensed under filters showed acceptable properties.

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