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Depth of cure of two bulk-fill composite systems

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MAJ Benjamin L. Thompson, DMD  
AEGD-2 Fort Hood, TX  
Uniformed Services University  
Date: 05/08/2017

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<b>Initiator</b>	
1. USU Principal Author (Last, First, Middle Initial)	Thompson, Benjamin, L
2. Academic Title	Comprehensive Dentistry Resident
3. School/Department/Center	Fort Hood AEGD-2
4. Phone	440-420-9234
5. Email	benjamin.l.thompson22.mil@mail.mil
6. Clearance	<input checked="" type="checkbox"/> Paper <input type="checkbox"/> Article <input type="checkbox"/> Book <input type="checkbox"/> Presentation <input type="checkbox"/> Other
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Signature	
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Depth of cure of two bulk-fill composite systems

A Thesis

Presented to the Faculty of the Advanced Education in General Dentistry, Two-Year Program,  
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In Partial Fulfillment of the Requirements for the Degree of

Master of Science in Oral Biology

By

Benjamin L. Thompson, MAJ, DC, USA

May 08, 2017

Effects on depth of cure using two light apertures and two light sources

A REPORT ON

Research project investigating the correlation between depth of cure of two bulk-fill composite systems (Sonic Fill 2 vs. Filtek Flow) using two light sources (Bluephase Style vs. Demi Ultra), and two light apertures (4 mm vs. 10 mm).

By

Benjamin L. Thompson, MAJ, DC, USA

D.M.D., Case Western Reserve University- 2010

Staffed By

John King, MAJ, DC, USA

D.M.D., Arizona School of Dentistry and Oral Health - 2007

Fort Hood, Texas

May 08, 2017

## ABSTRACT

**Purpose:** The purpose of this study is to compare the depth of cure between SonicFill II and Filtek Flow bulk-fill composite systems using two light sources (Bluephase Style vs. Demi Ultra), and two light apertures (4 mm vs. 10 mm).

**Methods:** Eight composite sample groups were made in total. Four Sonicfill II groups and 4 Filtek Flow groups split up between using two curing light sources (Bluephase Style vs. vs. Demi Ultra), and two light apertures (4 mm vs. 10 mm). Each sample was made by expressing the composite into a stainless steel mold. The composite was compacted with a flat end composite instrument and covered with a mylar strip. The composite resin was condensed with a glass slide to displace excess resin. The glass slide was then removed and the specimens immediately polymerized with a curing light for 20 seconds. Each specimen was polymerized at a distance of 0 mm utilizing a clamp to hold the curing light. The curing light was connected to a power cord to provide continuous, consistent operation. The uncured resin was then scraped with a plastic instrument starting from the deepest point on the underside of the mold until polymerized resin was reached. The composite resin was removed from the mold and the length of the remaining polymerized material measured with a caliper and divided by 2, according to the ISO standard.

**Results:** Significant difference were found between the two composite-brands (Sonic Fill 2 vs. Filtek Flow),  $p < 0.0001$ . Significant difference were found between the two light apertures (4 mm vs. 10 mm),  $p < 0.0001$ . Significant difference were found between the two light sources (Bluephase Style vs. Demi Ultra),  $p < 0.0072$ .

**Conclusions:** Filtek Flow had an overall greater depth of cure than SonicFill II. The Demi Ultra curing light had a greater depth of cure than the Bluephase Style curing light. The 10mm light aperture had a greater depth of cure than the 4mm light aperture.

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## INTRODUCTION

The typical composite resin is made from four basic components: 1) an organic hydrocarbon synthetic resin oligomer with potential to polymerize, 2) inorganic filler materials 3) a silane coupling agent that acts to bond the resin with the filler particles 4) a photoinitiator that propagates polymerization of the oligomer, typically camphorquinone. The bis-GMA monomer, having a high molecular weight and low polymerization shrinkage, is the most commonly used oligomer in composite resin.

The composite resin matrix changes from a viscous liquid to a solid restoration as it polymerizes. The photoinitiator camphorquinone is activated to initiate polymerization by a visible blue light in the range of 400-520 nm. The more popular curing units in use today generate light using light emitting diodes (LED). Many offices still use the previous generation of quartz-tungsten-halogen (QTH) lights to cure composites, but LED's have several advantages. LEDs have the benefits of being lighter, cable-free, having a longer lasting light, producing less lateral heat, and emitting greater irradiance. Differences in composite properties have been noted depending on the type of curing light used for photoinitiation. Munoz, et al, found that an LED curing light provided a greater surface hardness for hybrid composites compared to a QTH curing light, but the reverse was true for microhybrid composites.<sup>1</sup> Photoinitiation begins as the camphorquinone within composite absorbs photons emitted by the curing light. The activated camphorquinone then combines with an amine molecule to generate free radicals. The free radicals open the double bonds of the resin monomers and silane molecules coat the filler particles allowing a chain of new bonds to be created between the groups. The propagation reaction continues until no free, adjacent bonds are available to continue polymerization. The time required for polymerization is highly dependent upon the intensity of the curing light, in an

inverse relationship. The greater the intensity of light, the less time required to achieve proper curing. Previous studies by Caughman, Rueggeberg, and Oliveira have proposed that  $16.8 \text{ J/cm}^2$  is required for a 1-mm increment and  $24 \text{ J/cm}^2$  for 2-mm increments to achieve a maximum cure of the composite.<sup>2-4</sup> After the curing light is removed from composite additional post-cure polymerization continues, further increasing the degree of conversion of monomers to polymers as evidenced in studies by Koplin and De.<sup>5,6</sup> This post-light curing polymerization is also referred to as “dark phase” curing.

An incremental layering technique to apply photo-curable resin-based composites (RBCs) is widely recommended to overcome problems related to polymerization shrinkage and to ensure adequate polymerization. However, disadvantages associated with this technique, such as incorporation of voids, a greater risk on contamination between layers and an extended chair time, still remain a practical complication. Recent advances in RBC technology, especially with regard to new monomers, translucency, initiator systems and filler technology address these shortcomings and have led to the popularization of bulk-fill RBCs.

In addition to the shortcomings related to volumetric shrinkage due to polymerization, and the associated stress build up in RBCs, the degree of conversion is another limiting factor when placing restorations. Studies suggest that an increment thickness of 2 mm should not be exceeded for RBCs with conventional chemistry.

For the military dentist, placing multiple small increments of 2 mm generally means increased operational time and can be difficult to place in small cavities. Bulk-fill RBCs have been developed in order to overcome the time consuming incremental cavity filling technique with conventional RBCs. This newly developed kind of RBC's claim is to allow the use of material

increments up to 5 mm in thickness, with low volumetric polymerization shrinkage and resulting low polymerization shrinkage stress.

Bulk-fill RBCs are classified as low- or high-viscosity. The low mechanical properties of the former require finishing a restoration by adding a “capping layer” made of regular RBCs.

Regarding conventional RBCs, the changes made in bulk-fill RBCs to enlarge the depth of cure addressed primarily the fillers, which generally increased in size in all materials and decreased in load in low-viscosity bulk-fill composites. This involves a lower total filler–matrix interface compared with regular composites, reducing light scattering and increasing the transmittance for blue light in the depth.

SonicFill (Kerr Corporation) is a composite resin material that the manufacturer claims to address many of the problems listed above. SonicFill is a single- step, bulk-fill composite resin system that, according to the manufacturer, has “...ultraefficient curing characteristics that ensure an optimal, full 5 mm depth of cure in 20 seconds.” Sonic activation purportedly lowers the viscosity of the material to allow for easy adaptation to cavity walls. The manufacturer also claims that, after placement, the composite resin returns to a “non-slumping state” which allows for easy contouring.

Filtek™ Bulk Fill Posterior Restorative has a reported depth of cure of 5 mm. According to the manufacturer it has: excellent adaptation without additional expensive dispensing devices, better in vitro wear resistance than market-leading bulk fill materials, excellent handling and sculptability, and nanofiller technology with two innovative methacrylate monomers which act to lower polymerization stress without compromising wear.

## PURPOSE

The purpose of this study is to compare the depth of cure between SonicFill II and Filtek Flow bulk-fill composite systems using two light sources (Bluephase Style vs. Demi Ultra), and two light apertures (4 mm vs. 10 mm).

## HYPOTHESIS

Research questions: Do SonicFill II and Filtek Flow achieve the depth of cure claimed by their manufacturers? Will the depth of cure be different between the two light sources? Will the depth of cure be different between the two light apertures?

Null hypothesis #1: SonicFill II and Filtek Flow depth of cure will have no difference as the depth of cure claimed by their manufacturers.

Null hypothesis #2: The depth of cure will have no difference between the two light sources.

Null hypothesis #3: The depth of cure will have no difference between the two light apertures.

## MATERIALS AND METHODS

All 8 groups of composite were shade A2. All groups of composite were determined to be clinically usable regarding expiration dates. The composite in this study was used well before the expiration date.

Group 1: SonicFill II with 4 mm light aperture cured with Demi Ultra curing light

Group 2: Filtek Flow with 4 mm light aperture cured with Demi Ultra curing light

Group 3: SonicFill II with 4 mm light aperture cured with Bluephase Style curing light

Group 4: Filtek Flow with 4 mm light aperture cured with Bluephase Style curing light

Group 5: SonicFill II with 10 mm light aperture cured with Demi Ultra curing light

Group 6: Filtek Flow with 10 mm light aperture cured with Demi Ultra curing light

Group 7: SonicFill II with 10 mm light aperture cured with Bluephase Style curing light

Group 8: Filtek Flow with 10 mm light aperture cured with Bluephase Style curing light

The Demi Ultra curing light according to the manufacture has a wavelength of 450 nm–470 nm, and has curing modes of 5, 10, and 20 seconds. The Demi Ultra also has proprietary C.U.R.E.<sup>™</sup> Technology (Curing Uniformity and Reduced Energy) which reportedly provides uniform depth of cure with industry-leading low temperatures. Enhanced collimation delivers more predictable curing power that is less sensitive to the positioning of the tip, while the more uniform beam generates a more consistent depth of cure. The power output is 1,100 to 1,330 mW/cm<sup>2</sup>.

The Bluephase Style curing light according to the manufacture is a polywave LED with halogen like broadband spectrum of 385-515 nm. It has a wide halogen-like light spectrum with a wavelength range between 380 and 515 nm. The energy released in this spectrum is capable of activating all the different types of photoinitiators, unlike the spectra of the first and second generation of LED devices, which were only effective on camphorquinone.<sup>18</sup> The power output is max of 1,100 mW/cm<sup>2</sup>.

Each sample was made by expressing the composite into a stainless steel mold. The standard mold for determining depth of cure was 4mm in diameter and 10 mm vertically. Also other groups was made with a 10mm diameter and 10 mm vertical height. The composite was compacted with a flat end plastic instrument and covered with a mylar strip. The composites were condensed with a glass slide to displace excess resin. The glass slide was then removed and the specimens immediately polymerized with a curing for 20 seconds. Each specimen was polymerized at a distance of 0 mm utilizing a clamp to hold the curing light. The curing light was connected to a power cord in order to provide continuous, consistent operation. The uncured resin was then scraped with a plastic instrument starting from the deepest point on the underside of the mold until polymerized resin was reached. The polymerized composite resin was removed from the mold and the length of the remaining polymerized material measured with a caliper and divided by 2, according to the ISO standard.

Figure 1. Demi Ultra curing light setup

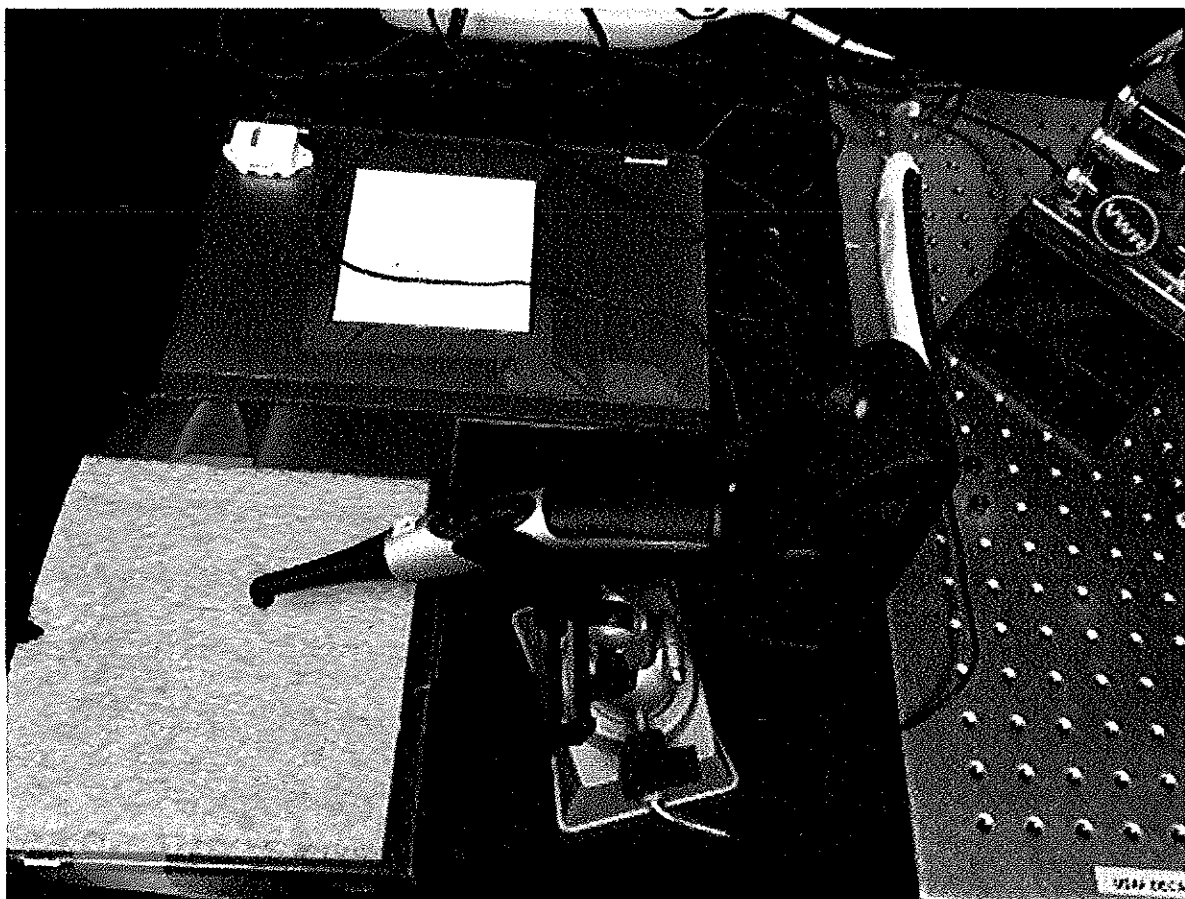


Figure 2. Bluephase Style curing light setup



Figure 3. The 4mm and 10mm light aperture molds.

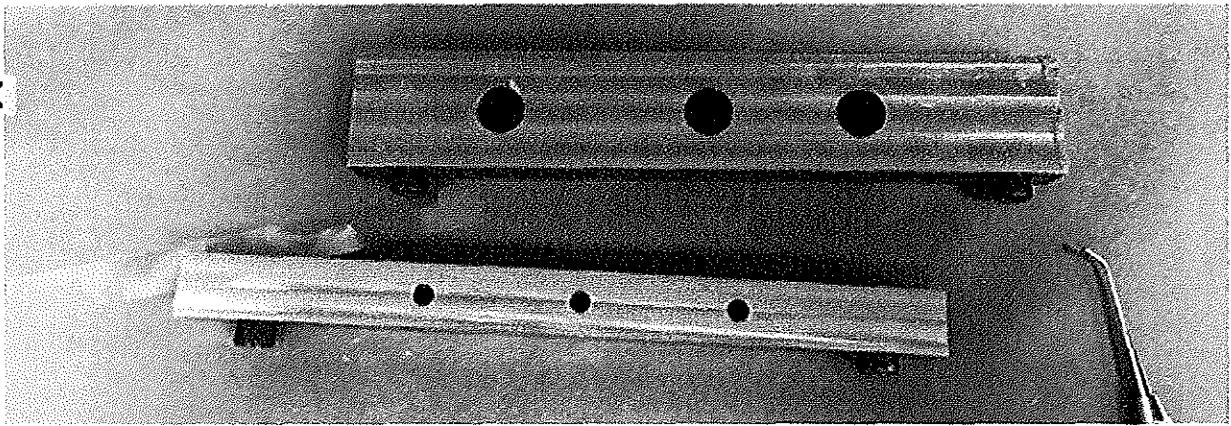


Figure 4. Mold with composite placed.

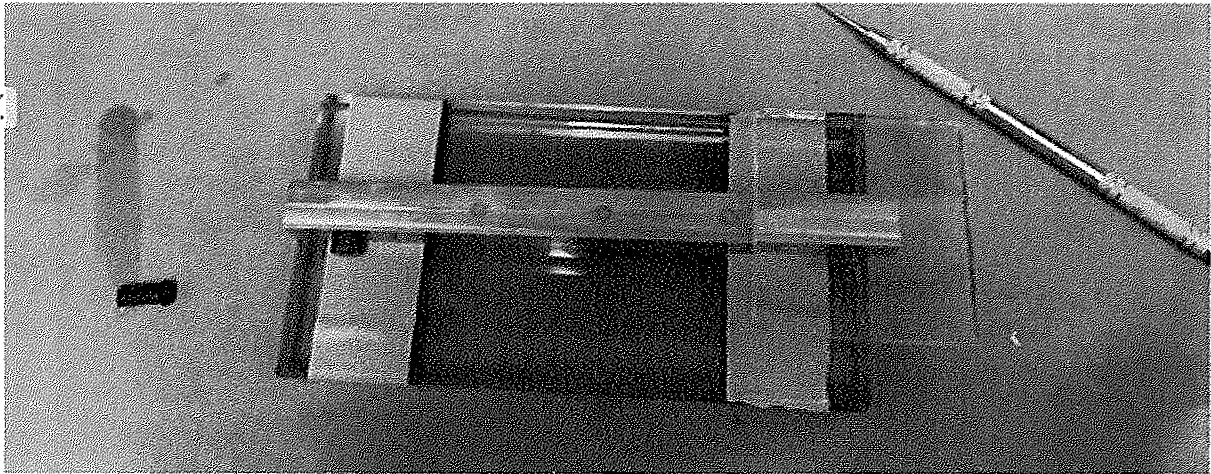


Figure 5. Curing composite samples



Figure 6. Cured composite samples.

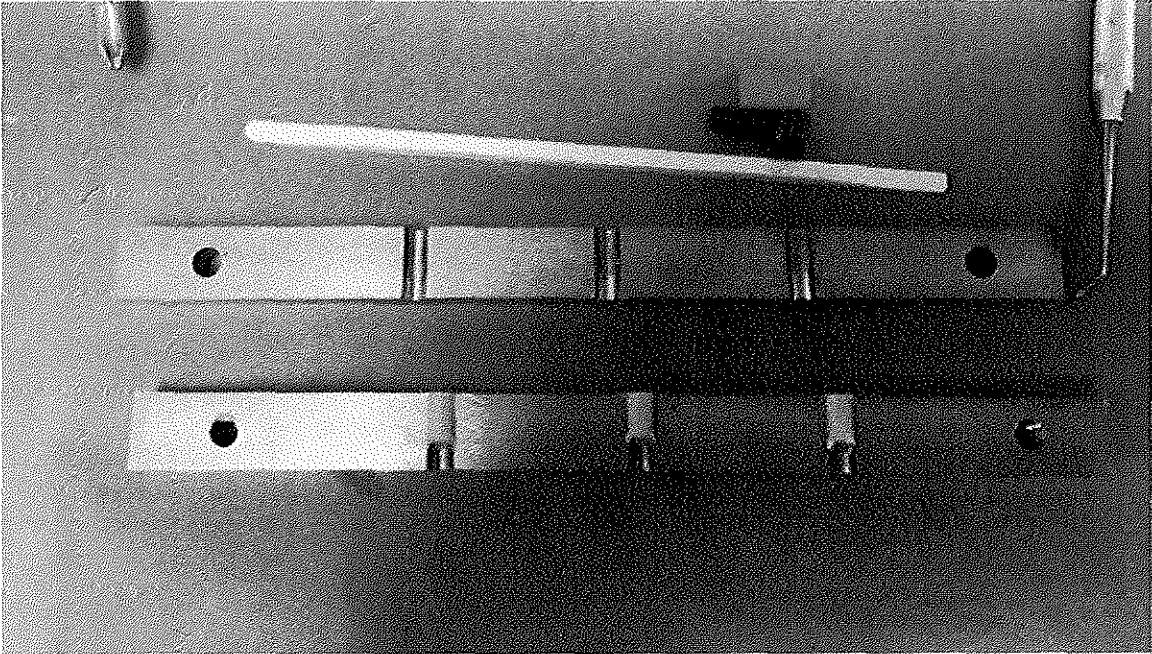
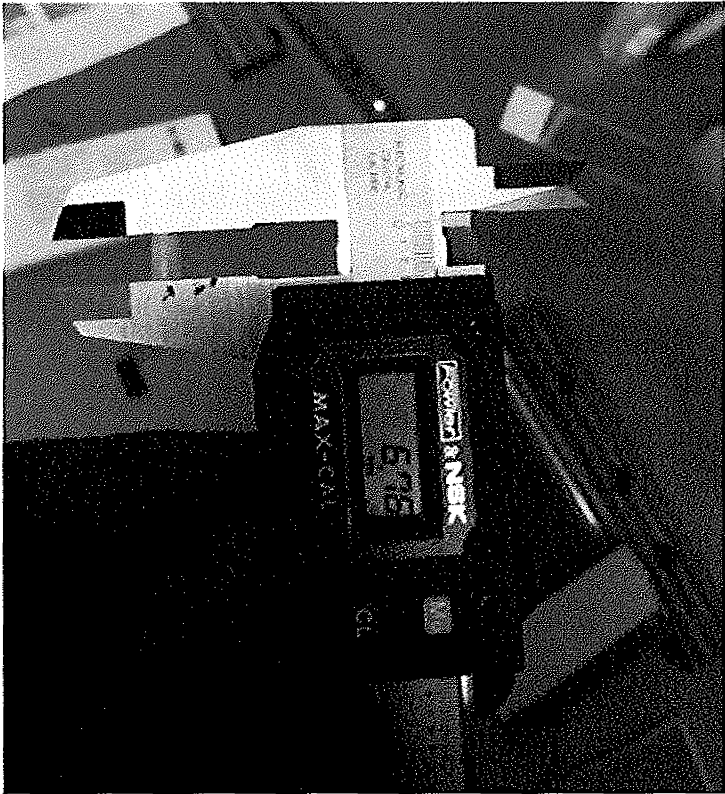


Figure 7. Removing uncured composite.



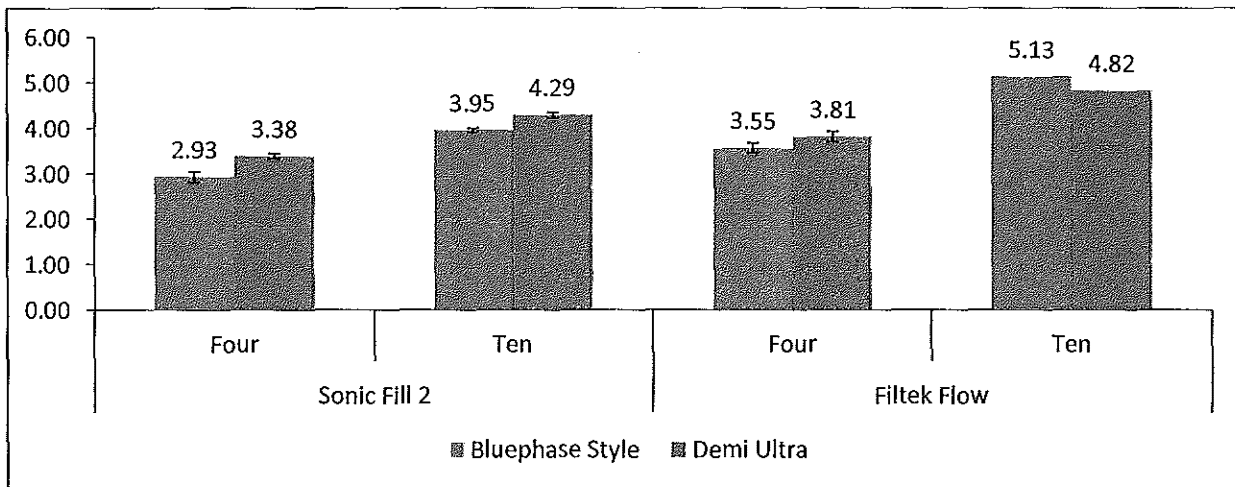
Figure 8. Measuring sample with digital caliper.



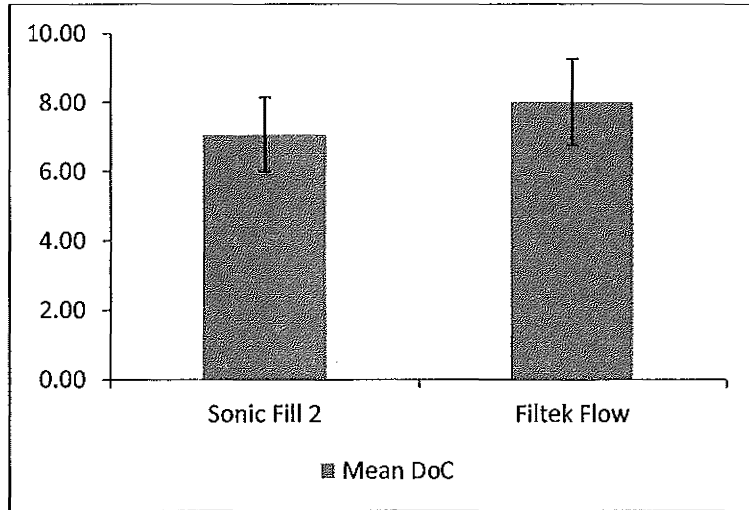
## RESULTS

Significant differences were found between the two composite-brands (Sonic Fill 2 vs. Filtek Flow),  $p < 0.0001$ . Filtek Flow had a greater depth of cure than SonicFill II. Significant differences were found between the two light apertures (4 mm vs. 10 mm),  $p < 0.0001$ . The 10 mm light aperture had a greater depth of cure than the 4 mm light aperture. Significant differences were found between the two light sources (Bluephase Style vs. Demi Ultra),  $p < 0.0072$ . Demi Ultra curing light group had a greater depth of cure than the Bluephase Style group.

**Figure 1.**



**Figure 2.**



**Figure 3.**

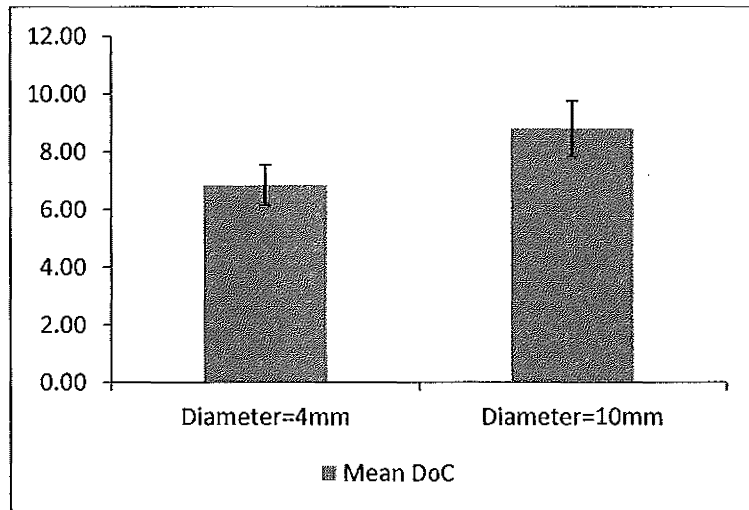
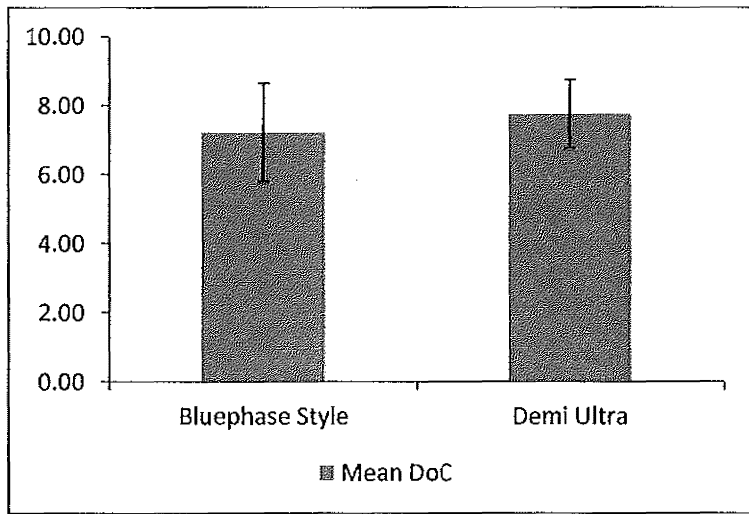


Figure 4.

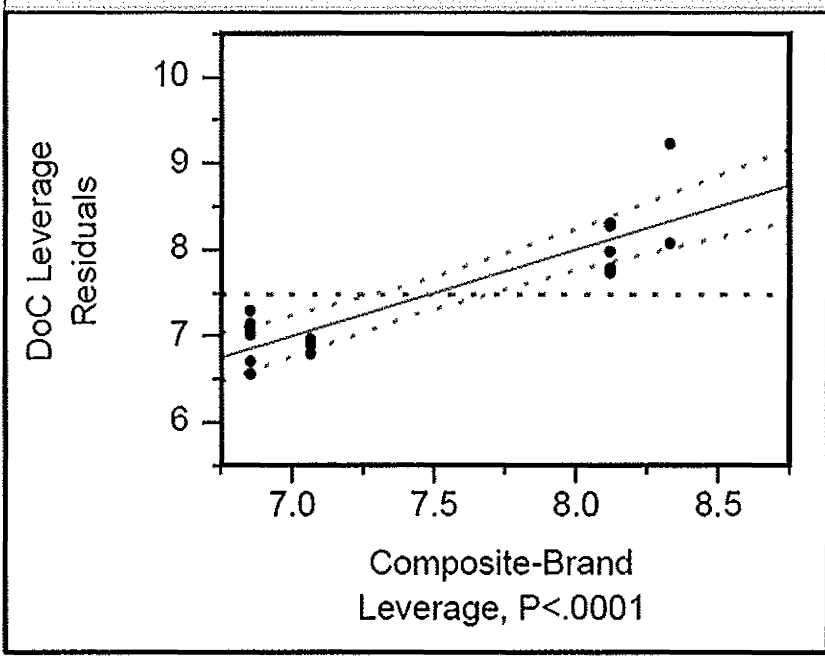


**Effect Tests**

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Composite-Brand	1	1	6.955408	53.8484	<.0001 *
Diameter	1	1	18.271519	141.4571	<.0001 *
Light-Source	1	1	1.278223	9.8959	0.0072 *

**Composite-Brand**

**Leverage Plot**



**Least Squares Means Table**

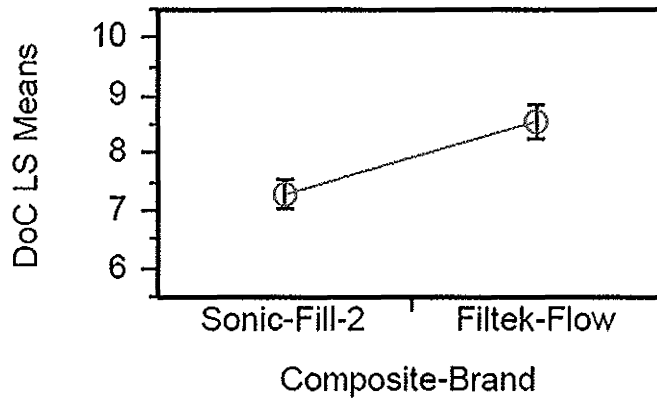
## Response DoC

### Composite-Brand

#### Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
Sonic-Fill-2	7.2837821	0.11509927	7.06733
Filtek-Flow	8.5507051	0.13496586	8.00958

#### LS Means Plot



#### LSMeans Differences Student's t

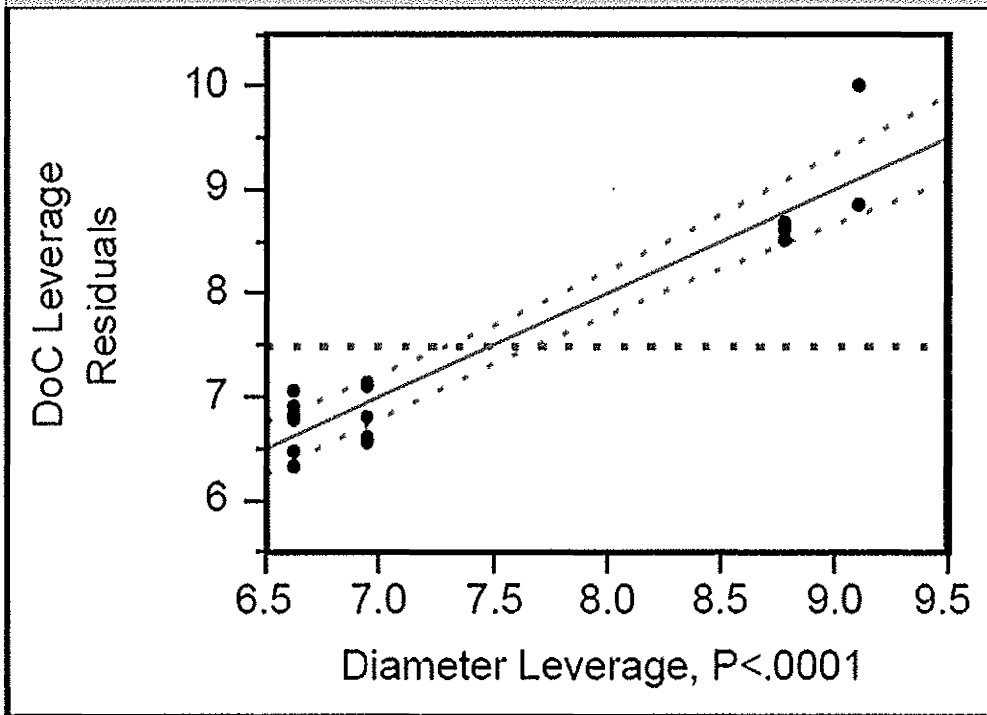
$\alpha = 0.050$   $t = 2.14479$

Level		Least Sq Mean
Filtek-Flow	A	8.5507051
Sonic-Fill-2	B	7.2837821

Levels not connected by same letter are significantly different.

## Diameter

### Leverage Plot



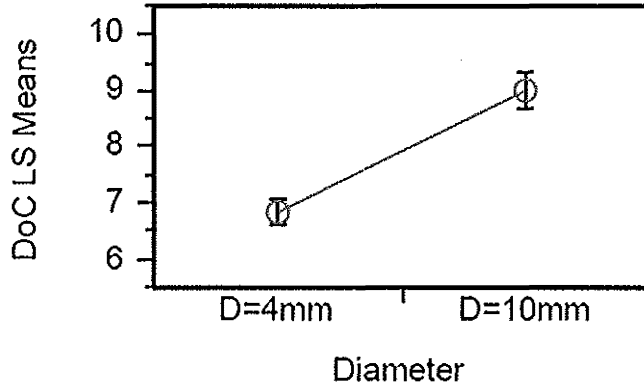
### Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
D=4mm	6.8350000	0.10374908	6.83500
D=10mm	8.9994872	0.14951834	8.78833

## Response DoC

### Diameter

#### LS Means Plot



#### LSMeans Differences Student's t

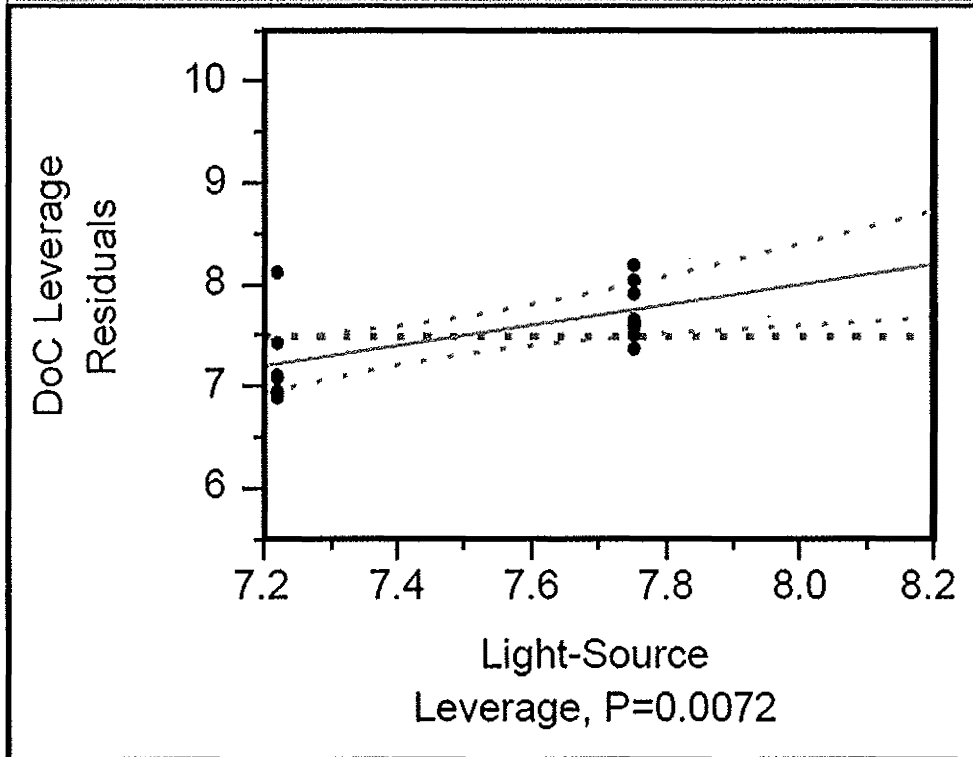
$\alpha = 0.050$   $t = 2.14479$

Level	Least Sq Mean
D=10mm A	8.9994872
D=4mm B	6.8350000

Levels not connected by same letter are significantly different.

## Light-Source

### Leverage Plot



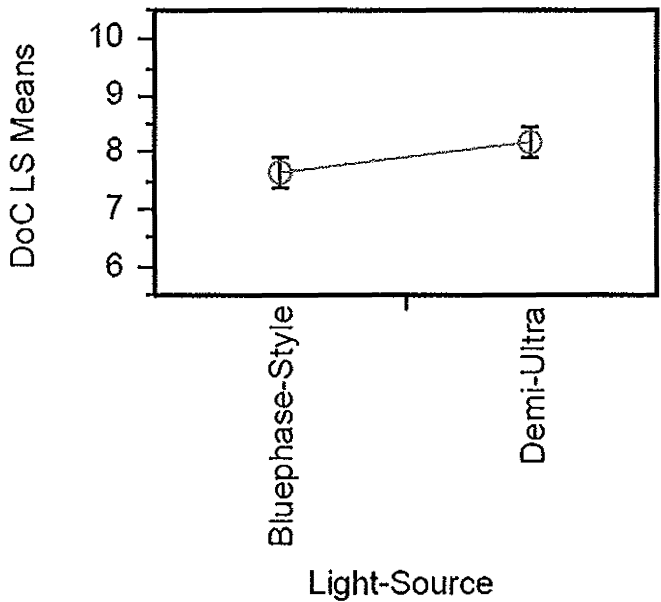
### Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
Bluephase-Style	7.6507621	0.12432143	7.21963
Demi-Ultra	8.1837251	0.12432143	7.75259

**Response DoC**

**Light-Source**

**LS Means Plot**



**LSMeans Differences Student's t**

$\alpha = 0.050$   $t = 2.14479$

Level		Least Sq Mean
Demi-Ultra	A	8.1837251
Bluephase-Style	B	7.6507621

Levels not connected by same letter are significantly different.

## DISCUSSION

Filtek Flow had a greater depth of cure than SonicFill II. This may be due to the Filtek Flow having less filler content than SonicFill II. Filtek Flow has 76.5% by weight.<sup>19</sup> By contrast, SonicFill II has a filler content of 83% by weight.<sup>17</sup> Filtek Flow is also more translucent than SonicFill II which could also attribute to the greater depth of cure.

SonicFill II had a shallower depth of cure than claimed by the manufacturer. The manufacturer claims a 5 mm depth of cure. The manufacturer also recommends a buccal and lingual cure in addition to the occlusal cure. In this benchtop study, only an occlusal cure was done which may account for the less than 5mm depth of cure.

Filtek Flow also had a lower depth of cure than the 5 mm claimed by the manufacturer.

However, the 10 mm light aperture Bluephase Style group exceeded the manufacturer's claim with an average 5.13 mm depth of cure. The 10 mm light aperture allowed for significantly more light to enter the composite sample than the 4 mm group. This partially explains why this group showed a depth of cure comparable to the manufacturers claim. Of note, the Bluephase Style curing light demonstrated a lower power output than the Demi Ultra curing light.

The 10 mm light aperture group having a greater depth of cure than the 4 mm light aperture is easily explained. The 10 mm light aperture allows significantly more light from the curing unit to enter the composite sample than the 4 mm group.

The Demi Ultra curing light group having a greater depth of cure than the Bluephase Style group is also simply clarified. The Bluephase Style curing light has a lower power output than the Demi

Ultra curing light. The Demi Ultra curing light has a power output of 1,100 to 1,330 mW/cm<sup>2</sup>.  
Conversely, the Bluephase Style group has a max power output of 1,100 mW/cm<sup>2</sup>.

## CONCLUSION

The results of this in-vitro study lead one to conclude:

1. Filtek Flow had a greater depth of cure than SonicFill II.
2. SonicFill II had a lower depth of cure than claimed by the manufacturer.
3. Filtek Flow had a lower depth of cure than claimed by the manufacturer except for the 10 mm light aperture Bluephase Style group.
4. The 10 mm light aperture had a greater depth of cure than the 4 mm light aperture.
5. Demi Ultra curing light group had a greater depth of cure than the Bluephase Style group.

Null hypothesis #1: SonicFill II and Filtek Flow depth of cure will have no difference as the depth of cure claimed by their manufacturers. Null hypothesis #1 was rejected.

Null hypothesis #2: The depth of cure will have no difference between the two light sources.

Null hypothesis #2 was rejected.

Null hypothesis #3: The depth of cure will have no difference between the two light apertures.

Null hypothesis #3 was rejected.

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