DENTAL ADVISOR
Product insights you can trust.

Biomaterials Research Report
Matt Cowen, B.S., John M. Powers, Ph.D.
DENTAL ADVISOR Biomaterials Research Center
Ann Arbor, MI 48104
matt@dentaladvisor.com
Number 167 – January 2024

Laboratory Evaluation of Monet Laser Curing Light

M. Cowen, J.M. Powers

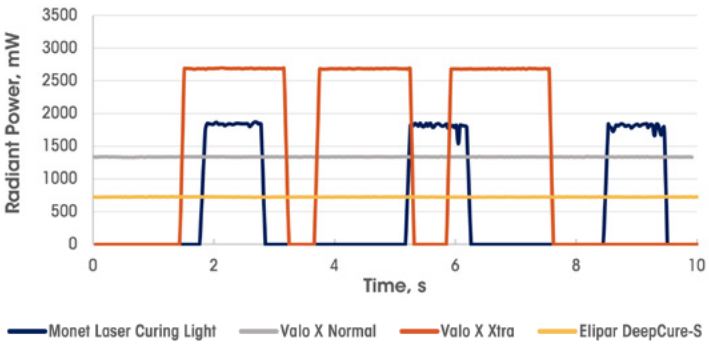
Introduction:

The ***Monet Laser Curing Light*** (AMD Lasers) is the first composite curing light using laser diode technology which solves the challenge of beam collimation in curing light technology. Even the best curing lights on the market typically lose over half of their effective light energy received by the composite when separated by as little as 8-10 mm from the surface of the composite while the ***Monet Laser Curing Light*** would have no significant drop in energy from any clinically significant distance. In clinical situations in which it is difficult to have ideal placement of the curing light, the loss of that much energy means that the composite must be cured for twice the typical time or longer to reach the required energy suggested by the composite manufacturer.

In this study, we compared the ability of the ***Monet Laser Curing Light*** to polymerize 3 different bulk-filled composites compared to popular curing lights on the market, the ***Elipar Deep Cure-S*** (3M) and ***Valo X*** (Ultradent). Each of these lights have different power outputs, and wavelengths of light that is emitted. It is important to consider each of these factors when choosing how long to cure any given composite as each composite may have different requirements for achieving the desired depth of cure. We tested the claims that the ***Monet Laser Curing Light*** could cure bulk-filled composites in three 1-second exposures similar to how other curing lights cure in 10 or 20 seconds. We also tested the performance of the curing lights at 2 mm and 10 mm distances from the surface to compare the effect that the superior beam collimation has on composite curing.

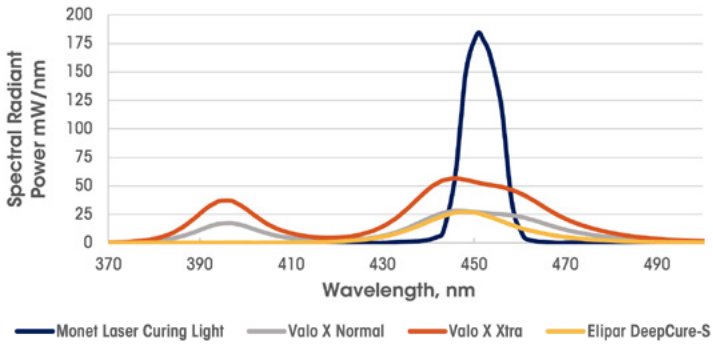
Comparison of Radiant Power:

Radiant Power Over 10 Seconds



This graph shows the total radiant power output of the curing lights. The ***Valo X*** has a pulse mode (Xtra) that is designed to deliver the same total power over 3 pulses as it does with the normal mode over 10 seconds. The ***Monet Laser Curing Light*** activates for 1 second per button press to ensure safe use with such a concentrated light source. As you can see from the Spectral Radiant Power graph, some of the power output from the ***Valo X*** in the UV range is not useful in curing the composites used in this study.

Spectral Radiant Power



This is the spectral radiant power of the curing lights. Camphorquinone (CQ) is the most common photoinitiator in composites and reacts to light in the 430 – 510 nm range with an absorption peak around 468 nm. The peak of the ***Monet Laser Curing Light*** is closer to the peak of CQ which means more of the light output is applied to activating CQ. The ***Valo X*** has an LED in the UV range which means that some of the power output won't significantly affect the curing of a composite which only contains a CQ photoinitiator.

The Composites:

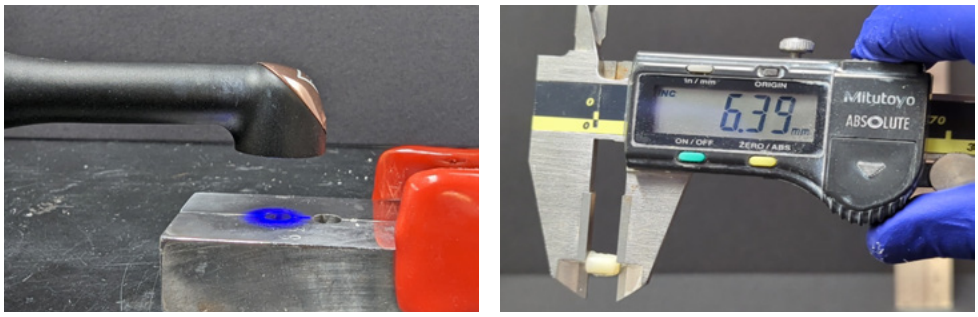
Composite	Instructions
3M Filtek One Bulk Fill (3M)	For 4 mm increment depth in one curing direction, cure for 20 seconds with LED light over 1000 mW/cm²
OMNICHROMA Flow Bulk (Tokuyama Dental)	For 3.6 mm increment depth in one curing direction, cure for 20 seconds with LED light over 1000 mW/cm²
SonicFill 3 (Kerr)	Cure for 10 seconds with LED light over 1000 mW/cm² from a single occlusal cure

3M Filtek One Bulk Fill and ***SonicFill 3*** also suggest curing for three 10 second exposures (buccal, lingual, occlusal) for class 2 restorations or posterior restorations. In this study, to directly compare the curing performance of the curing lights, we only cured from one direction.

Depth of Cure Testing Methods:

ISO 4049 Depth of Cure Method:

The most common method for measuring depth of cure is based on the ISO 4049 standard for polymer-based restorative materials. This method takes a cylinder of composite cured in a metal mold, gently removes the soft uncured composite with a plastic spatula and measures the height of the remaining cylinder before dividing the height by half. This is because there is a gradient of composite that is cured, with the most polymerization at the top, until just barely enough polymerization at the bottom to keep its form. This test method was developed more than 4 decades ago to test the first composites on the market, and for the most part, does a good job of estimating the depth of cure in a quick test. However, there are now many factors that affect polymerization in modern composites as bulk-filled composites were developed to increase the depth of cure with secondary initiators or polymerization accelerators, which have been able to increase the depth of cure but is not captured by this simple "scrap-back" estimation method.



ISO 4049 "Scrap-back" Test Method: Half of cured composite = depth of cure

This is the ***Mini Gig*** (MSC15-W, Ultradent Products, Inc.) spectroradiometer with integrating sphere which accurately measures radiant power and spectral emission (wavelengths of light).

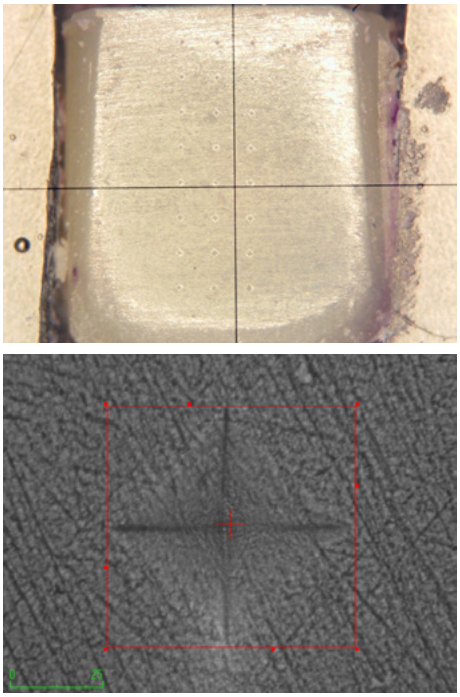
Hardness Depth of Cure Method:

In an attempt to directly measure the depth of cure of composites, a common quantitative method is used by measuring the hardness of the composite at different depths as the hardness of the composite is correlated to the polymerization of the resin. For hardness testing, a diamond indenter is pressed into the surface with a defined force and the resulting size of the dent made in the composite is measured. A larger indent means that the composite resisted the force less, resulting in a lower hardness measurement. A ratio of 80% of the maximum hardness of a given composite is a common standard used for clinically acceptable hardness.

Dental Advisor Method:

In this study, we combined these two tests by curing composite in a mold according to ISO 4049, and then let the cylinder cure for 24 hours in 35°C water as composite can continue curing over that time. Then the cylinder was mounted, and the hardness measured every 0.5 mm from the top of the cylinder. The values are compared to a reference hardness of the composite cured under ideal circumstances, and the depth of cure was determined to be the point in which the composite at a given depth is at 80% of the maximum hardness of the composite.

In this study, we also measured the depth of cure at a 2 mm distance and 10 mm distance from the surface to measure the effect the beam collimation had on curing the composites.



Hardness Method: Larger indents = lower hardness

Depth of Cure Results:

3M Filtek One Bulk Fill:

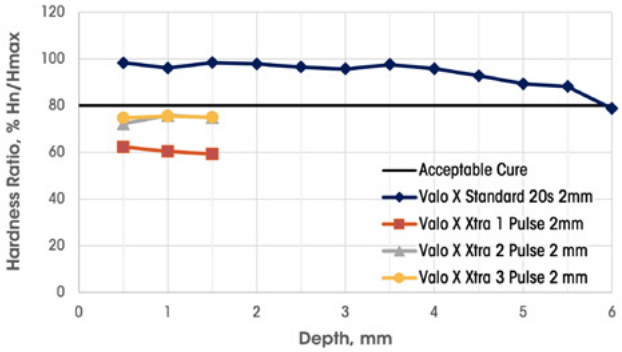
For ***3M Filtek One Bulk Fill***, the hardness depth of cure method showed a greater depth of cure compared to the ISO method for this composite. The ***Monet Laser Curing Light***'s three 1-second curing exposures were roughly equivalent to 20 seconds of curing with the ***Elipar DeepCure-S*** and ***Valo X*** with this composite. This testing suggests ***3M Filtek One Bulk Fill*** is effective at curing with short exposure times.

In all of the test results, there was no significant difference in curing depth from 2 or 10 mm with the ***Monet Laser Curing Light*** as expected. For hardness ratio testing, any differences lower than about 0.3 mm is within the range of error of the test as the measurements are made every 0.5 mm of depth, and the depth of cure is simulated by a mathematical regression line in between these indents.

OMNICHROMA Bulk Flow:

For ***OMNICHROMA Flow Bulk***, this composite appears to require longer exposure times in order to fully polymerize or reach an acceptable hardness, but once the composite reaches a threshold of enough light energy, it will continue curing to a greater depth. This may be due to the initiator technology as some composites include inhibitors to slow polymerization to lower shrinkage stresses. In any case, after three 1-second cures, the ***Monet Laser Curing Light*** was able to effectively cure to over a 3.5 mm depth described in the manufacturer IFU. We would suggest 4 or 5 seconds of total curing exposure for this composite as a safety margin if curing this composite in bulk to account for any inefficiencies in curing light placement during the light curing procedure. This is an important example that although a composite may appear to be hard and in one piece, it may not be fully polymerized, even on the surface.

OMNICHROMA Depth of Cure by Hardness Ratio



SonicFill 3:

For ***SonicFill 3***, the hardness depth of cure and ISO depth of cure is in closer alignment, similar to traditional composites. ***SonicFill 3*** in particular requires multiple exposures from different directions in order to cure in bulk-filled cases though the instructions state that 10 seconds of curing is sufficient for occlusal curing. For this composite, the ***Monet Laser Curing Light*** after two 1-second esposures cured to a greater depth than 10-second exposures for the ***Valo X*** and ***Elipar DeepCure-S***.

3M Filtek One Bulk Fill

	Distance	ISO DoC	Hardness DoC
Elipar DCS 20 seconds	2 mm	3.6	5.7
	10 mm	3.2	5.5
Monet Laser Curing Light 1 exposure	2 mm	2.6	3.1
	10 mm	2.6	3.1
Monet Laser Curing Light 2 exposures	2 mm	3.0	4.6
	10 mm	3.0	4.3
Monet Laser Curing Light 3 exposures	2 mm	3.3	5.5
	10 mm	3.3	5.3
Valo X 20 seconds	2 mm	3.4	5.1
	10 mm	3.0	4.7
Valo X Xtra 1 exposure	2 mm	2.4	2.7
	10 mm	2.0	2.2
Valo X Xtra 2 exposures	2 mm	2.7	3.7
	10 mm	2.4	3
Valo X Xtra 3 exposures	2 mm	3.0	4.1
	10 mm	2.6	3.3

OMNICHROMA Bulk Flow

	Distance	ISO DoC	Hardness DoC
Elipar DCS 20 seconds	2 mm	4.0	6.5
	10 mm	3.6	5.5
Monet Laser Curing Light 1 exposure	2 mm	0	0
	10 mm	0	0
Monet Laser Curing Light 2 exposures	2 mm	2.6	0
	10 mm	2.6	0
Monet Laser Curing Light 3 exposures	2 mm	3.0	3.9
	10 mm	3.0	3.6
Valo X 20 seconds	2 mm	3.7	6.0
	10 mm	3.3	5.1
Valo X Xtra 1 exposure	2 mm	2.0	0
	10 mm	2.0	0
Valo X Xtra 2 exposures	2 mm	2.7	0
	10 mm	2.4	0
Valo X Xtra 3 exposures	2 mm	2.8	0
	10 mm	2.4	0

SonicFill 3

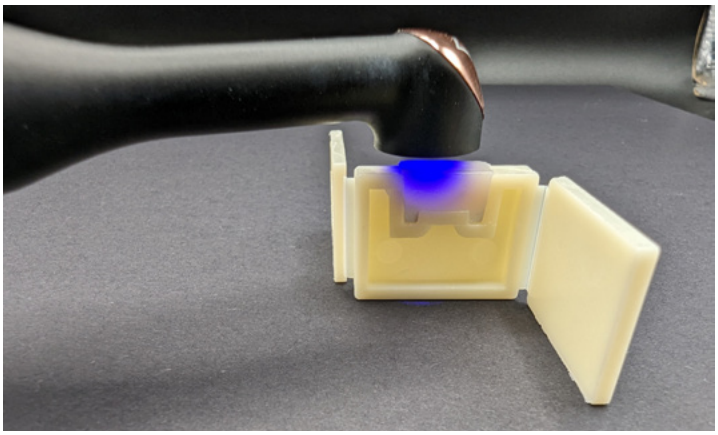
	Distance	ISO DoC	Hardness DoC
Elipar DCS 20 seconds	2 mm	2.7	2.7
	10 mm	2.3	2.5
Monet Laser Curing Light 1 exposure	2 mm	2.1	1.5
	10 mm	2.1	1.3
Monet Laser Curing Light 2 exposures	2 mm	2.4	2.8
	10 mm	2.4	2.5
Monet Laser Curing Light 3 exposures	2 mm	2.6	2.9
	10 mm	2.6	3
Valo X 20 seconds	2 mm	2.6	2.6
	10 mm	2.3	1.8
Valo X Xtra 1 exposure	2 mm	2	0
	10 mm	1.6	0
Valo X Xtra 2 exposures	2 mm	2.2	2.2
	10 mm	1.9	1.8
Valo X Xtra 3 exposures	2 mm	2.4	2.4
	10 mm	2.1	1.6

MOD Filling Simulation:

Another useful curing test is with a mold from Ultradent, that simulates an MOD filling which is 11 mm across the top surface, up to 7 mm deep at the proximal box and 5 mm deep at the center. We cured composite in these molds from the top surface only to visualize differences in beam width and depth of cure, and then soaked the composite in acetone for 18 hours which turns uncured composite into a chalky white color to reveal areas of under-cured composite. Of course, if this restoration were to be performed clinically, then the proximal boxes should be cured from different directions rather than just occlusally.

The ***Monet Laser Curing Light*** suggests that for composite restorations wider than 8 mm multiple exposures should be performed, so one set of three 1-second exposures were performed over each proximal box compared to 20 second exposures from the ***Valo X*** and ***Elipar DeepCure-S*** for each composite.

The ***Monet Laser Curing Light*** shows over 5 mm depth of cure for ***3M Filtek One Bulk Fill***, about 5 mm depth of cure for ***OMNICHROMA Flow Bulk*** and



This is the Ultradent MOD mold with the sides exposed revealing the cured composite. The ***Monet Laser Curing Light*** has a low powered aiming light for help with aiming the ***Monet Laser Curing Light*** before exposure. As this is a laser, wearing proper safety eyewear is important as should be done with all curing lights.

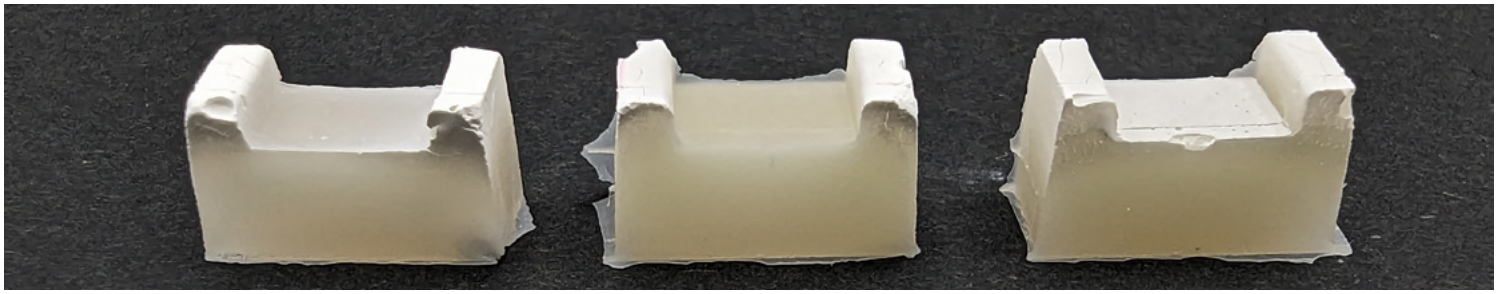
3M Filtek One Bulk Fill:

Monet Laser Curing Light
2 x 3 1-second exposures

Elipar DeepCure-S
20 seconds

Valo X
20 seconds

OMNICHROMA Bulk Flow:



Monet Laser Curing Light
2 x 3 1-second exposures

Elipar DeepCure-S
20 seconds

Valo X
20 seconds

SonicFill 3:

Monet Laser Curing Light
2 x 3 1-second exposures

Elipar DeepCure-S
20 seconds

Valo X
20 seconds