White Paper

Monet™ Laser Curing Light

Jan. 2024

AMD Lasers, Inc.

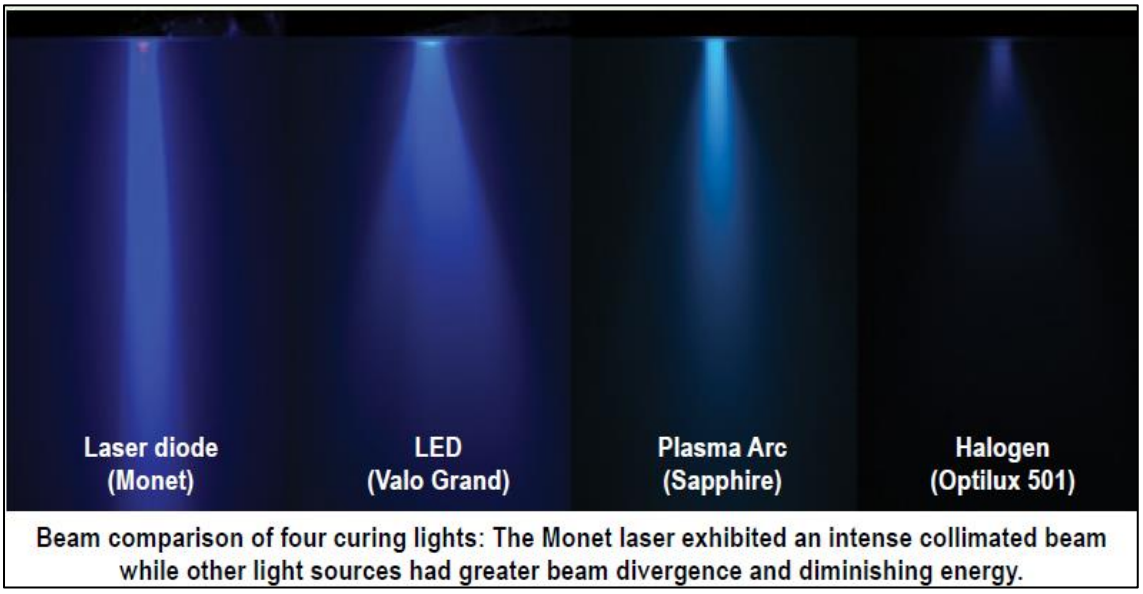
1. Introduction

The dental curing light is an essential instrument used daily in the dental practice for curing dental materials. Light-cured materials provide a unique property of hardening on command. More than 50% of dental procedures use light-cured materials including dental adhesives, restorative composites, dental cements, and others. Currently all dental materials require a light source with a wavelength between 400 to 480nm and a light intensity higher than 600mW/cm^2. The higher the light intensity into the materials, the faster the cure of the materials. The quality of the curing light will directly affect the quality of the dental procedures. The critical component for any dental curing light is the light source. Historically, the following light sources have been used in dental curing lights.

Light source	Example Image	Pros	Cons	Status
Halogen (1980 – 2012)		Best available light source at the time	Bulky, noisy, low light intensity, 6-month bulb life, generates a large amount of heat, Need more than 40 sec to cure materials	Obsolete
Gas state laser (Argon Laser) (1989-2002)		High intensity and 10 - 20 sec curing	Bulky, noisy, very expensive, high maintenance, only on the market for a few years	Obsolete
Plasma Arc (late 1990's)		High intensity and 10 – 20 sec curing	Bulky, noisy, expensive, short lifetime	Obsolete
Light emitting diode (LED) (2001 – present)		Small, handheld, high intensity, 10 sec curing, long lifetime up to 5 years or more, battery powered / portable, lower cost	Rapidly dispersing beam (light intensity decreases dramatically with distance), non-homogenous wavelength distribution within the beam (for	Introduced in 2001 by CAO Group, Inc. and now the dominant type in the market

Light source	Example Image	Pros	Cons	Status
			broad-spectrum units)	
Diode laser (2021 – present)		High intensity, collimated beam, handheld, lifetime up to 3 years or more, 1-3 sec can do majority of curing procedures, affordable price	Laser device, need to pay attention to safety while using the device	First introduced in year 2021 by AMD Lasers

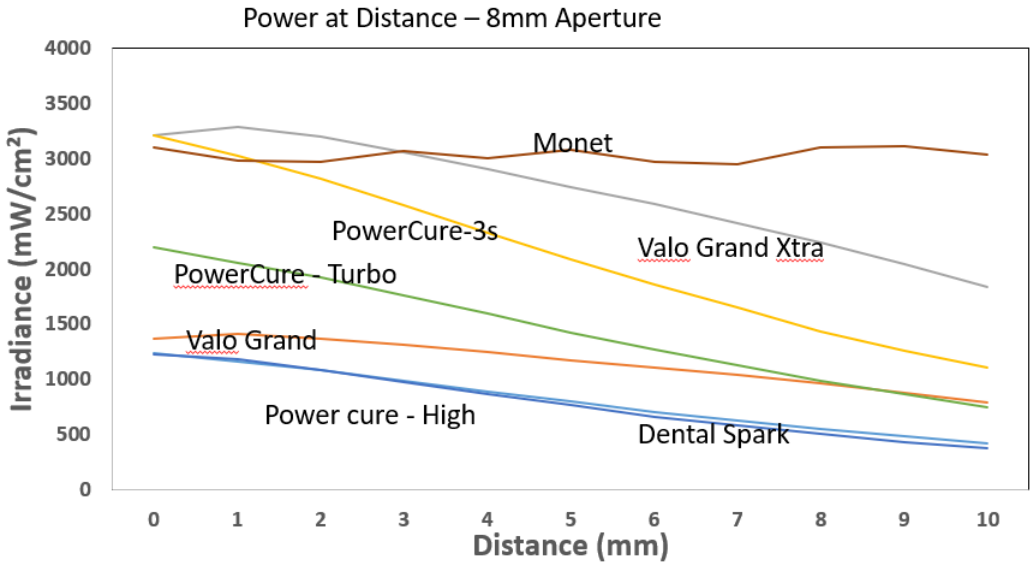
Below are images of the light beam profile of curing lights of different light source types:



Beam comparison of four curing lights: The Monet laser exhibited an intense collimated beam while other light sources had greater beam divergence and diminishing energy.

* Image courtesy of Clinician's Report, Provo, Utah, Volume 15, Issue 7 (July 2022)

The following chart shows measurements of different brands of curing lights at different distances from emitting surface, courtesy of Dr. Richard Price. The light intensity for Monet does not decrease with distance as illustrated in the chart.



(Courtesy of Dr. Richard Price)

It can be seen that the diode laser is the only light source to provide consistent light intensity over distance while other lights decrease intensity dramatically over the same distance. Consistent light intensity is one of the most important factors for dental curing to yield thorough depth of cure (DOC), manage shrinkage, address stress debonding, and achieve the degree of polymer conversion – critical factors for the quality of a restoration.

As history has demonstrated with previous light sources, acceptance of this new laser diode technology will take time since a lot of clinicians will want to see the proof of market success before making the transition. CAO Group, Inc. (CAO) developed and manufactured the world's first light emitting diode (LED) dental curing light (Ultralume), distributed to the market by Ultradent starting in 2001, as a replacement of the halogen curing light. An LED light source has the features of being small, portable, durable, and providing a high intensity. Major adoption for the LED curing light didn't ramp up until around 2007 when other major manufacturers introduced different styles of LED curing lights after 2007. Nearly all the major manufacturers in the world licensed CAO's LED technology. Through years of improvements by the many manufacturers using the licensed CAO technology, the LED curing light is currently the main light source for dental light curing. Price of LED curing light ranged from few hundred dollars to couple of thousand dollars and is a commodity product. LED lights enable a reduced curing time from the 40 sec down of halogen down to 10 seconds or less. Implementation of an LED dental curing light is estimated to save an average of $6,000 per year per dentist compared to using a halogen light. However, an LED is a dispersed light with the light intensity decreasing dramatically over distance. A good amount of light is wasted when its dispersed away from the curing target. Considering all of the requirements of dental curing, CAO has developed the world's first handheld diode laser curing light, Monet™, to overcome the issues of the LED light source. Monet was introduced in the U.S. market in 2021 and became of fastest growth product in curing light category.

It is common that clinicians will have a lot of questions about the Monet laser curing light. This white paper is offered to address the major concerns of clinicians.

2. Laser Technology

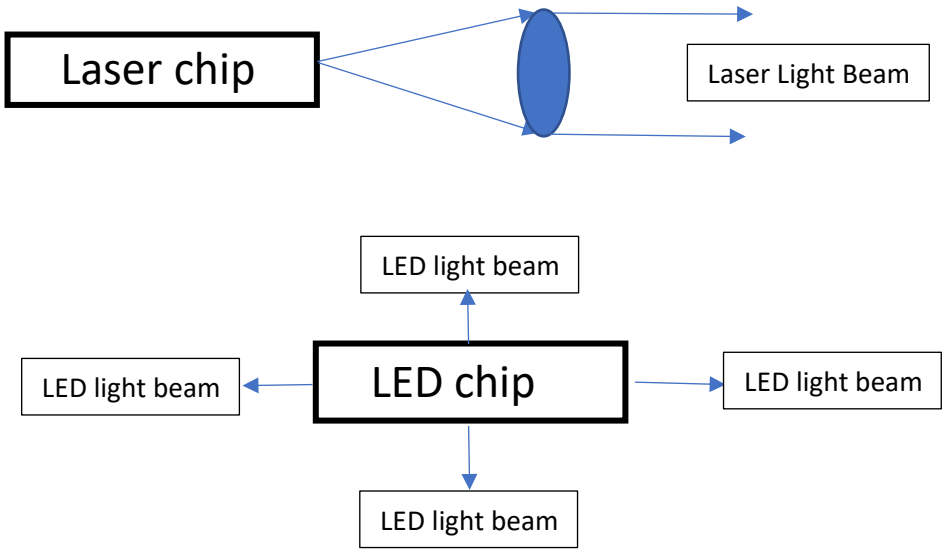
Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. Some background and information about laser light:

- Laser light is a coherent light – meaning the light is generated at a uniform time so that the light waves are synchronized,
- Laser light can be collimated (organized and focused) into a beam that can travel over a long distance without changing diameter, and
- Laser light can be focus to a very small beam size with high irradiance(intensity).

Laser light can be produced through many types of materials including gas (carbon dioxide, argon), solid state (Nd:YAG), and semiconductor. A semiconductor laser is commonly called a diode laser, or laser diode, since a semiconductor laser consists of a P-N junction (diode). The diode laser is already widely utilized in dentistry for soft tissue management and other treatments due to the advantages of being compact, durable, and lower cost.

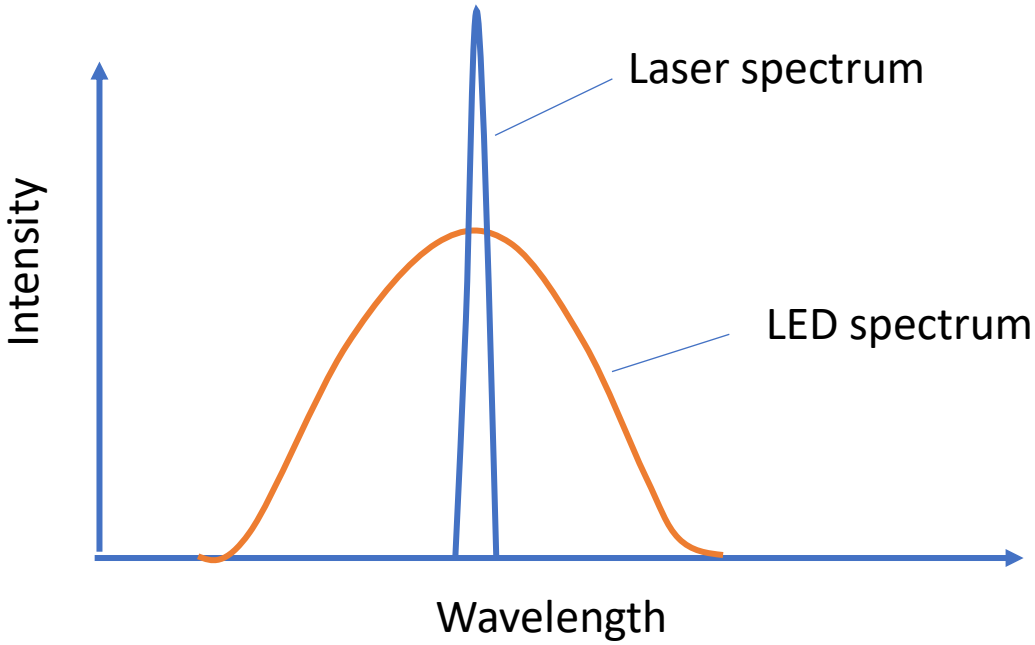
A diode is a semiconductor chip ranging in size from 300μm x 300μm up to 1mm by 1mm. Blue LEDs and laser diodes (450nm wavelength) are made of the same semiconductor materials – GaInN and AlGaInN. However a laser diode has a different internal structure from an LED. The laser diode has the beam emitting from a controlled spot of the chip to generate a point light source, while an LED has the light emitting from all surfaces and directions of the chip.

The differences of the chip structure between laser and LED are illustrated below.



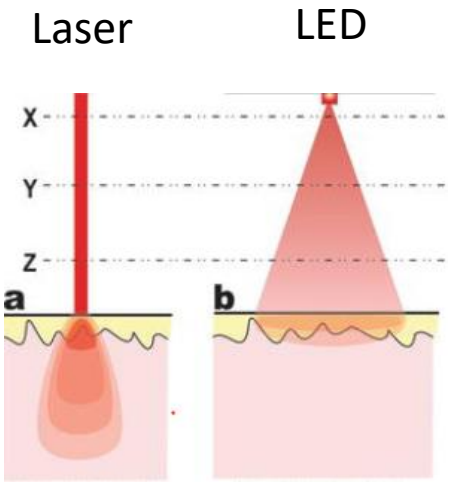
The semiconductor laser beam is a point light-source and can be collimated. The LED is a dispersed light source emitting at random times in random directions and needing a complicated optical system to have the light beam collimated. It is impossible to fully collimate an LED light source into the form-factor needed by a dental curing light.

The generic wavelength spectrums of diode laser light and LED light are shown below.



The narrow wavelength of a laser beam with its coherent behavior allows it to travel over long distances without a dramatic decrease in light intensity.

As light passes through different substances, the laser will have greater penetration than LED due to its coherent property.



It is also understood that the photo initiators in the composite resin behave differently for laser light and LED light. Initial research results showed that photo initiators in resin composite have higher absorption efficiency with coherent light than noncoherent light.

For curing materials in the preps, a highly desired light property is that the light intensity does not decrease with distance and has deep penetration through the restoration material.

Based on these physical properties of a laser beam, a laser is a preferrable light source for dental curing.

In addition to the inherent light properties, a dental curing light also needs these desirable features:

- A parallel light beam
- A large-diameter beam size that can be adjusted to different lesser diameters
- A rotatable head for different curing positions and orientations
- Ergonomics for easy, comfortable handling
- Simple operation with one button for on/off and timer
- Battery-powered operation with quick battery replacement
- A battery charging station
- A radiometer for quick qualitative confirmation of the light intensity

Monet was designed and developed based on these requirements. The full kit of the Monet light is show below:

Monet offers attachment apertures for adjusting the beam size and intensity:

Neutral density filter reduces output by 50%, for situations where high intensity or high heat may be deleterious.

Apertures of ~6 mm, 4 mm, and 2 mm reduce the diameter of the beam for tacking and other tasks.

Due to the coherent and parallel beam properties of the Monet light, the light beam is still parallel even when any of the different apertures are used.

3. Safety of Lasers

Lasers have been safely used in daily dentistry for decades now. Eye protection, as a type of PPE, is a common-sense safety precaution, not only while using lasers but also for other high intensity light emitting devices including LED curing lights. The only difference is that government agencies have mandated eye protection for lasers, but so far not for other light sources. A lack of oversight in no way diminishes the risks, as there are ample publications of acute and chronic eye damage attributed to LED curing lights.

The Monet kit provides a full set of safety glasses and a filter paddle for practitioners and the patient. Below are the safety devices provided in the Monet kit:

- Glasses for the patient
- Glasses for the assistant
- Glasses for the doctor
- Loupe insert filter for the doctor
- Filter paddle for both the assistant and doctor

Utilizing laser eye protection PPE is simple and definitely worth a few extra seconds.

4. Curing Procedures Using the Monet Laser Curing Light

Due to the collimated beam and high radiance, curing procedures using Monet are different from LED curing lights. Below is the general guideline for using the Monet laser curing light:

It is generally recommended to do a single 1 second cure with a composite layer less than 2.5mm, two 1-second cures for layers between 2.5-5mm, and three 1-second cures for layers more than 5mm. To minimize the heat, do not cure any spot for more than 3 seconds. If light is close to gingival tissues, please blew air from air syringe to tissue spot while curing. For preps larger than 8mm in diameter, two overlapping spot cures are recommended. Monet comes with unique apertures for precision control of the laser beam. For preps near gingival tissues, please use one of the beam size reducing aperture of 2, 4, or 6 size to avoid light exposure on gingival tissue. Depth of curing varies among brands of materials and shades within the same brand. Please refer the Monet curing guide for common brands on www.caogroup.com or www.amdlasers.com.

Below are general recommendations for different clinical procedures:

Procedure	Monet usage
Bonding adhesive curing	2 seconds, use multiple spot curing for larger sized preps more than 8mm diameter, and a 2-, 4- or 6-mm aperture for preps near gingival tissue
Class I	For layer technique, use 1 sec per layer For bulk fill, follow the general curing guideline
Class II	For layer technique, use 1 sec per layer For bulk fill, the follow general curing guideline
Class III	For layer technique, use 1 sec per layer For bulk fill, the follow general curing guideline
Class IV	For layer technique, use 1 sec per layer For bulk film, the follow general curing guideline
Class V	Use a 2-, 4- or 6-mm aperture depending on the prep size to avoid beam exposure on the tissue. For layer technique, use 1 sec per layer For bulk fill, follow the general curing guideline
Buildup	Do a 1 second cure for each facet. Repeat for a total of two times. Some of buildup materials are due cured which may need 3 sec cure per facet.
Sealant	For light color sealant do 3 second cure and may do multiple times due to high concentration of UV light photo initiators in some sealant materials.
Zr crown cementation using light cured resin cement	Do a 1 second cure for each facet. Repeat for a total of three times
Veneer tacking	Use the 50% reducing aperture and do a quick swipe across the surface (much less than 1 second)
Ortho bracket	1 second cures for each bracket, repeat one more time for 1 second cure of each bracket. Use the 6mm aperture if the bracket is near the gingival tissue
Clear aligner anchors	1 second for each anchor and repeat 1 more second cure
Endo canal	Using 2mm aperture and a 1 second cure
Any material, less than 2mm from the pulp chamber	Use the 50% reducing aperture and do two 1 second cures

For any other specific preps, consult with CAO's technical support for usage.

5. Results from Independent Studies

Many questions and concerns were raised when the Monet was first introduced into the market. Considerable independent research has been conducted to address various topics regarding Monet. Below are some key questions and the independent research results:

A) Is Monet's one-second cure just hype?

It is clearly expected that the faster curing by Monet was unbelievable by the clinicians since no other curing light has made this claim before.

Below is an example of a publication by Reality Now in Dec 2021 before they tested the Monet.

REALITY NOW

RATINGS & REVIEWS | practical • unbiased • trusted
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*Editor's Note: This last issue of 2021 takes a detour from specific product evaluations. Instead, it takes on two current topics that dentists have been discussing and debating. In addition, all of us at **REALITY** wish you a Happy New Year with the sincere hope that 2022 can be the year when the entire world returns to a pre-pandemic normal state.*

Topic: 1-second light curing

We have asked AMD Lasers to send us one unit to scrutinize its claim that states "1-second curing, is reality." First, please be aware that we did not give AMD permission to use "reality" in its claim, which has nothing to do with us! But more importantly, 1-second curing is not "reality" until we have had a chance to test its claims. This is fake news at this point!

Comments from our Editorial Team evaluators:

- Are you kidding???
- When will all this hype shit stop... like 1 sec vs 20, or even 40 is going to change the pt's appt time. More BS.....
- I am not aware of any in vitro research to confirm the statement and highly concerned about fast polymerization's side effects.....
- True story: About 20 years ago, a manufacturer told me his new curing light could cure composites SUB-SECOND BEFORE IT HAD A CHANCE TO SHRINK!!! I told him I always thought shrinkage was a chemical property determined by its composition, but he told me I was wrong. Suffice it to say, I never had an opportunity to use/test the light and it never actually reached the market!
- I have seen the light and although it is cool looking, I do not believe we can adequately cure in less than 5 seconds (or even 10). AMD couldn't show me any research at the time. Also, I am pretty sure it is a single wavelength that will not polymerize PDP or the new photo initiator Ivoclar uses in their products now. AMD was more interested in showing me that it can cure from across the room since it is a collimated beam.
- Fake news.....hmmmmmm....and so it continues!

BOTTOM LINE

While 1-second curing sounds great, it is highly questionable as to whether it will perform as claimed. We strongly recommend not buying this product until we have had an opportunity to test its claims.

The questions and claims in the Reality Now report were a representative collection of clinicians' concerns.

Subsequently, Reality Now has tested the Monet and made a follow-up publication in March 2022. Below are key points that Reality Now stated in that report.

> AMD Lasers has hit the market running with its Class 4 cordless laser curing light emitting curing energy at 450nm. While AMD initially claimed it would cure composites in three seconds, it has revised that downward to only one second. Although our kneejerk reaction to that claim was one of extreme skepticism, we were surprised to find that there could be some instances where this claim could actually be true.

Our results:

Light	Curing Time (sec)	Height of cured composite (mm)	Depth of cure (mm)
Monet	1	3.95	1.98
Monet	2	4.99	2.50
Monet	3	5.49	2.75
Celalux 3	10	5.68	2.84

> What we can tell you at this time is that the Monet is a well-designed, easy to use curing light that will no doubt dazzle your patients. Whether it provides major advantages over high-powered but less expensive LED curing lights is still to be determined.

After Realty Now extensively conducted field evaluation of Monet in 2023, it published a follow up report. The conclusion of the report is shown below.

REALITY NOW

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36TH anniversary | number 336

Editor's note: After reading our previous issue concerning the 1-second curing claim using the Monet laser, AMD Lasers finally agreed to send us a unit for testing.

FirstLook | Curing Lights — Lasers

What we can tell you at this time is that the Monet is a well-designed, easy to use curing light that will no doubt dazzle your patients. Whether it provides major advantages over high-powered but less expensive LED curing lights is still to be determined.

Additionally, Gordon J. Christensen identified the Monet laser curing light in his 2021 December buying guide as the new concept for 2022.

NEW CONCEPTS AND PRODUCTS FOR 2022

Angle-Correcting Screwdriver/Screw System

The shift to zirconia screw-retained implant crowns from cement-retained implant crowns ***has decreased cement-related necrosis and improved easy access to the screw***. This shift has brought new issues and technologies for implant crowns. These issues and products are discussed in *Clinicians Report* November 2021. Angle-correcting screwdriver/screw systems companies are listed on page 3.

Cone Beam *(CBCT)*

Cone beam has been identified as the most important technology now available to YOU! The majority of oral surgeons, periodontists, and endodontists now have cone beam devices in their offices. Most general dentists do not have cone beam. ***Get access to cone beam or buy one!*** A list of proven companies is on page 10.

Laser Innovations

The first blue laser diode resin curing light *(see page 11)* has impressive features, including high intensity, collimated beam, 13.2 mm wide lens, and 90° head angle for easy access to all tooth surfaces. Lasers have the potential for unique advances in dental materials such as reversible cements and endodontic applications. Keep an eye on this developing technology.

Innovative Changes in Direct Restorations

Replacing dentin with one of the new glass ionomers *(see page 12)* that seal to tooth and replacing enamel with an antimicrobial resin-based composite *(RBC)* may be the best direct restoration yet! RBC with antimicrobial fillers has the potential to help solve the problem of margin gaps and recurrent caries. This innovation is now available internationally under the brand Infinix and will be launched in the U.S. soon.

A Publication of **CR Foundation**® • 3707 N. Canyon Rd, Bldg 7, Provo UT 84604 • 801-226-2121 • www.CliniciansReport.org

Gordon J. Christensen also listed the Monet as the light to buy in his 2022 and 2023 December Buying Guide - two consecutive years.

Curing Lights, Resin

See also *Clinicians Report* July 2022: **"Curing Lights: Laser Diode versus Other Light Sources"**

CR Note: Today's highest intensity lights are very bright: **eye protection must be used**. Exercise caution to avoid overheating oral tissues and pulp by using air from syringe while curing.

Proven Products: LED curing lights

- Various models from the following companies:
  - **3M**
  - **DentLight**
  - **GC America**
  - **Ivoclar**
  - ★ **Ultradent** *(Valo models: most used, durable, high intensity)*

Monet Laser Curing Light, CAO Group

High irradiance output and collimated beam (minimal loss of energy over distance) produced **faster and deeper polymerization** than other lights tested. Eye protection is mandatory.

$2,499/Light system

See also Clinicians Report July 2022

So far, skeptics have admitted that the Monet is not just hype and is a true advanced technology to provide easier and better curing for the dental practice.

B) Is a laser able to cure all composites on the market?

Below is information from independent studies:

Gordon J. Christensen Clinician's Report published the following (Feb. 2021 Volume 14 Issue 2):

- **Compatibility testing** with over 50 brands of light-cure dental materials indicated that the monochromatic output of Monet laser curing light *(blue 450 nm)* polymerized all materials tested.

Rocha et al published a test of curing depth with the following composites in the Journal of Dentistry, 122 (2022), 104141.

Table 2
Resin-based composite resins used in the study.

RBC	Type	Manufacurer	LOT	Shade
Admira Fusion	Conventional	VOCO GmbH, Cuxhaven, Germany	1628174 2136075	A2
Estelite Σ Quick	Conventional	Tokuyama Dental Corp., Tokyo, Japan	372E48 567E71	A2
Filtek Supreme Ultra	Conventional	3 M, St Paul, MN, USA	N495920	A2B
Herculite Ultra Dentin	Conventional	Kerr Corporation, Orange, CA, USA	6115957	A2
Mosaic	Conventional	Ultradent Products Inc., South Jordan, UT, USA	BFR2M	Enamel
Mosaic	Conventional	Ultradent Products Inc., South Jordan, UT, USA	BFSRH	A2
Tetric Evoceram	Conventional	Ivoclar Vivadent, Schaan, Liechtenstein	X22943	A2
SureFil SDR flow+	Bulk-fill	Dentsply Sirona, Charlotte, NC, USA	1610081	A2
Tetric PowerFlow	Bulk-fill	Ivoclar Vivadent, Schaan, Liechtenstein	Y15023	IVA
X-tra Fil	Bulk-fill	VOCO GmbH, Cuxhaven, Germany	372E48 1749274	Universal

The results showed that all composites can be cured by Monet.

This data shows that Monet can cure the tested composites in 1 second to at least 1.5mm of depth.

Monet can cure all composites on the market.

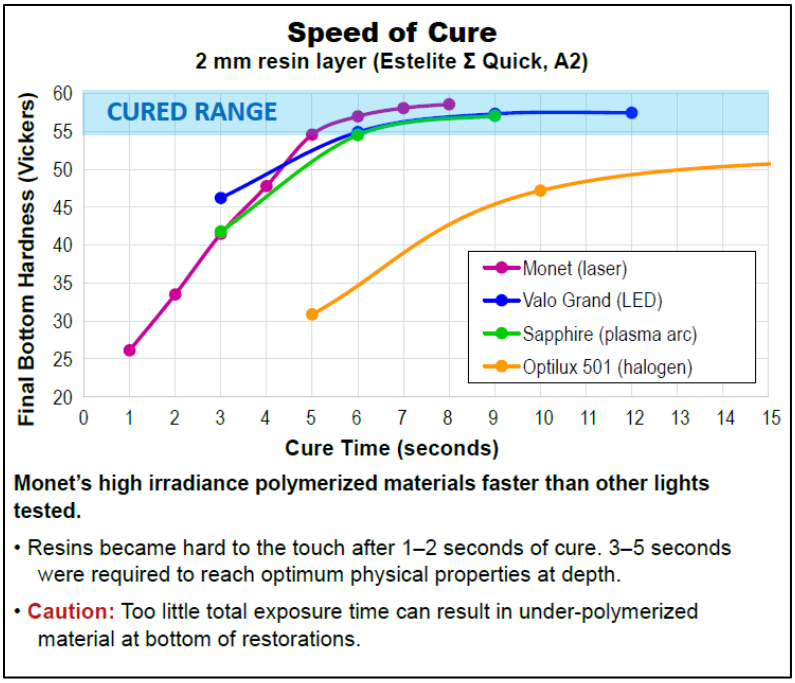
It will take additional time to cure certain brands of sealants with more clear properties due to dominance of 400nm photo initiators in the materials or a lower amount of photo initiator in order to minimize yellow tints in the sealant.

It will also take additional time to cure dual-cured cements and composites due to less quantity of photo initiator compared to fully light cured composites.

There are certain materials that CAO has not tested yet. CAO will continue to test available materials and update our reports accordingly. Please contact CAO if a material in your practice reacts differently for Monet.

C) What is the depth of cure of a laser compared to LEDs?

Gordon J. Christensen's Clinician's Report published the cure depth of Monet in July 2022, (Volume 15 issue 2). Below is the statement from the publication:



Monet's high irradiance polymerized materials faster than other lights tested.

- Resins became hard to the touch after 1–2 seconds of cure. 3–5 seconds were required to reach optimum physical properties at depth.
- **Caution:** Too little total exposure time can result in under-polymerized material at bottom of restorations.

Below is the conclusion from CR about Monet curing:

Monet Laser Curing Light

Advantages

- High irradiance output produced faster and deeper polymerization than other light sources
- Collimated beam had minimal loss of energy over distance
- Slim, ergonomic, cordless design with rotating 90° head

Limitations

- Rapid heating of materials and tissues
- Bright spot required laser safety glasses during operation
- Full polymerization required multiple short exposures

In June, 2023, Clinician Report published another round of testing different LED curing light by using Monet as control and considering Monet is a standard for curing.

				Control: popular model	**Control:** blue diode laser
 **Valo X** Ultradent Products $2,299	 **VAFU** AZDENT $300	 **MedPlus Q7** Mecco $168	 **Swedent Curing Light** Swedent Wholesale $199	 **Valo Grand** Ultradent Products $1,999	 **Monet** Cao Group $2,499

Rocha et al published a test of curing depth using different composites and curing lights (Monet laser and LEDs) in Journal of Dentistry 122 (2022), 104141. The depth of cure results from the publication are shown below:

Table 4
Mean ± SD and Tukey's test for the Depth of Cure (DOC) for the RBCs used in this study.

RBC	Light Curing Modes					
	Monet 1s	Valo Grand 10s	SmartLite Pro 10s	Monet 3s	Valo Grand 20s	SmartLite Pro 20s
Mosaic A2	1.61 ± 0.04 Df	1.89 ± 0.08 Cg	1.98 ± 0.03 BCf	2.01 ± 0.04 BCg	2.15 ± 0.06 Bg	2.39 ± 0.05 Ag
Herculite Ultra A2	1.86 ± 0.04 De	2.21 ± 0.04 Cf	2.27 ± 0.06 BCe	2.30 ± 0.04 BCf	2.44 ± 0.04 Bf	2.70 ± 0.08 Af
Filtek Supreme A2B	2.00 ± 0.06 De	2.80 ± 0.04 Bd	2.97 ± 0.03 ABcd	2.59 ± 0.07 Ce	2.91 ± 0.10 ABe	3.05 ± 0.09 Ae
Tetric Evoceram A2	2.32 ± 0.03 Dd	2.58 ± 0.03 Ce	2.85 ± 0.05 Bd	2.95 ± 0.04 Bd	3.02 ± 0.03 ABe	3.15 ± 0.04 Ae
Admira Fusion A2	2.32 ± 0.17 Dd	2.84 ± 0.04 Cd	3.00 ± 0.06 Ccd	2.92 ± 0.16 Cd	3.21 ± 0.10 Bd	3.42 ± 0.10 Ad
Estelite Quick A2	2.56 ± 0.07 Ec	2.93 ± 0.04 Dd	3.13 ± 0.06 Cc	3.21 ± 0.09 Cc	3.65 ± 0.06 Bc	3.86 ± 0.09 Ac
Mosaic EN	2.98 ± 0.11 Eb	3.51 ± 0.09 Dc	3.80 ± 0.05 Cb	3.73 ± 0.08 Cb	4.15 ± 0.08 Bb	4.45 ± 0.10 Ab
SDR flow+A2	2.95 ± 0.09 Db	3.62 ± 0.03 Cc	3.80 ± 0.04 Cb	3.63 ± 0.12 Cb	4.08 ± 0.12 Bb	4.36 ± 0.08 Ab
Tetric Powerflow IVA	4.16 ± 0.04 Ca	4.54 ± 0.02 Bb	4.90 ± 0.04 Aa	4.91 ± 0.07 Aa	4.93 ± 0.03 Aa	4.99 ± 0.02 Aa
X-tra Fil U	4.29 ± 0.16 Da	4.84 ± 0.05 Ca	4.91 ± 0.04 ABCa	4.85 ± 0.04 BCa	5.03 ± 0.04 ABa	5.04 ± 0.05 Aa

*Capital letters show the difference between light-curing modes; Lower case letters show the difference between RBCs; Blue font letters show DOC values above the 4 mm threshold; Green font letters show DOC values above the 2 mm threshold; Red font letters show DOC values below the 2 mm threshold.

This data shows that Monet can cure the tested composites in 1 second to at least 1.5mm of depth, and in the majority of instances Monet achieved a depth of cure in 3 seconds equal to or better on average than the other curing lights could accomplish in 10 seconds.

Comisi et al published a study using a special model to compare Monet to different LED lights in the European Journal of Dentistry (2022-12-17). The mold used for the test is shown below:

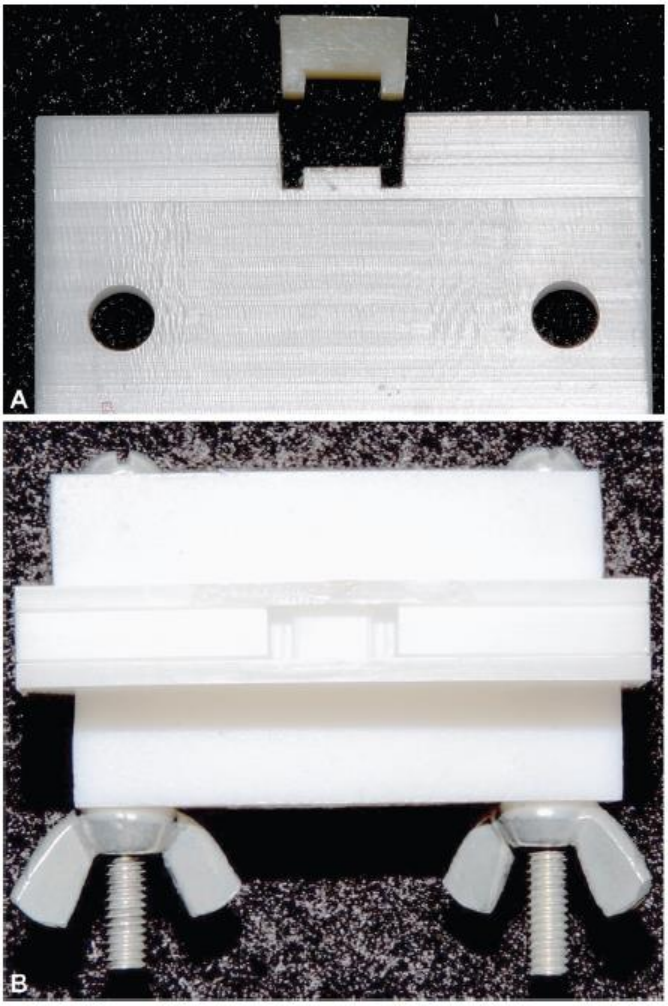


Fig. 1 (A) Side view of the mesial-occlusal-distal (MOD) mold and cured composite sample used for calibration. The "legs" represent the proximal boxes. (B) View of the empty MOD mold from the "occlusal" view.

The deepest location in the mold is about 7mm. The materials were filled in the mold and cured by light. Then the cured samples were soaked in a solvent to remove uncured materials and the samples were statistically analyzed. The test compared a 1 sec cure by Monet to 20 sec cures by other curing lights. The authors stated in the publication that the manufacturer recommended that a 3 sec. cure is needed for depths more than 5mm. It should be noted that some of authors in the Comisi study were also in part of the Rocha study and were aware that a 3 sec cure by Monet approached the depth of cure achieved in a 20 sec cure by LEDs. Based on the depth of mold used in the Comisi test, a 3 sec cure with Monet should have been included in the study. However, the authors only tested a 1 second cure by Monet in that report. It's not surprising that a 1 sec cure by Monet was not as effective as a 20 sec cure by LEDs. It's also not surprising that 1 second is significantly shorter than 20 seconds.

In contrast, Dental Advisor did an independent study for depths of cure using the same mold as Comisi's study, but follow manufacturer's recommendations for curing, it showed

that Monet's 2 spot and 3-second cure per spot is equivalent to 20 second cures by 3M's Elipar and Ultradent Valo X. Below are the results popular composites:

3M Filtek One Bulk Fill:

Monet 2 x 3s | Elipar DeepCure-S 20 s | Valo X 20s

OMNICHROMA Bulk Flow:

Monet 2 x 3s | Elipar DeepCure-S 20 s | Valo X 20s

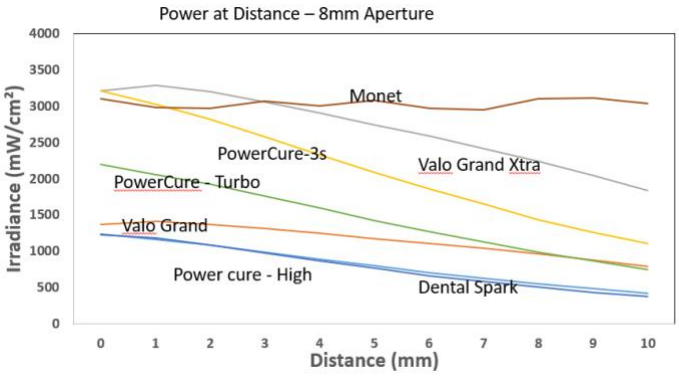
SonicFill 3:

Monet 2 x 3s | Elipar DeepCure-S 20 s | Valo X 20s

D) What are the changes of light intensity with distance

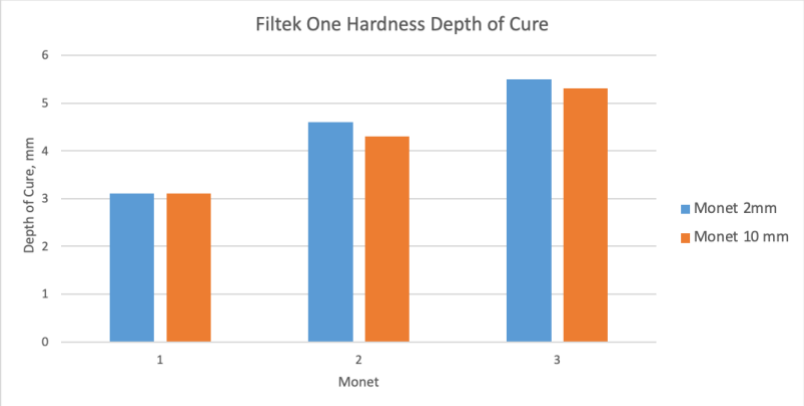
The light intensity of Monet beam does not change with distance due to collimation feature of laser beam. In contrast, light intensity of LED curing light will decrease dramatically with distance.

Below is test results of Monet light intensity vs LED light tested by Dr. Richard Price at Dalhousie University.



The results showed that the light intensity of LED lights decreases more than 30% at 8 mm distance and Monet light intensity does not decreases with distance.

Dental Advisor testing curing of Monet at different distance from surface of restoration, the results showed that there is no difference in curing depth when Monet is 2 and 10 mm away from curing surface under 1, 2, and 3 second cure. Below are the results:



This feature is important for curing, particularly for deep cavities as shown below, the depth of restoration can be more than 8 mm from occlusal surface.

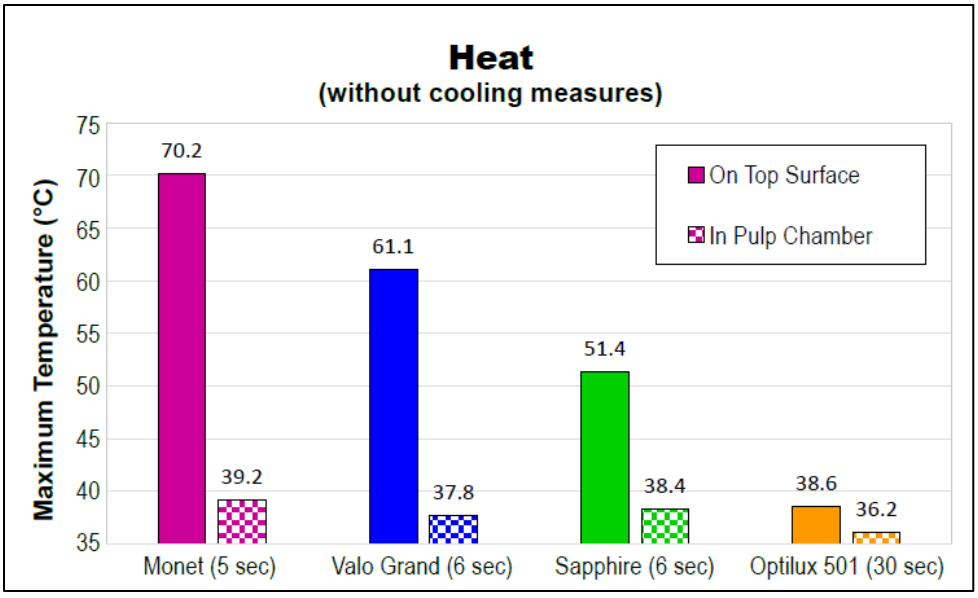
Monet can consistently delivery a good intensity of light to bottom of deep restoration.

E). Does laser curing result in increase of pulp temperature over the biologically allowed limit?

Concerns for pulp temperature rise using the high irradiance Monet laser curing light are valid and warranted.

The following publications showed that the temperature rise by Monet is below the biologically allowed limit of 5.5^{o}C.

Gordon J Christensen's Clinician's Report published pulp temperature data in July 2022 (Volume 15 Issue 7).



The results showed that temperature rise for Monet with 5 sec is still below the biologically allowed limit.

Maucoski et al published results comparing the pulp temperature rise of Monet with other LED lights in Odontology (19 December 2022). The key data for temperature rise in both Class I and Class V restorations are shown below.

Table 3 Temperature rise (ΔT) for the Class I cavity

	Temperature rise (ΔT—°C)					
	0 mm distance			6 mm distance		
	Mean	SD	Significant Groupings	Mean	SD	Significant Groupings
Monet—3 s	2.1	0.2	Aa	2.1	0.1	Aa
PinkWave—10 s	2.1	0.1	Aa	1.8	0.2	Bb
PinkWave—3 s	1.6	0.1	Ba	1.2	0.2	Cb
Valo Grand—10 s	1.6	0.1	Ba	1.2	0.1	Cb
SmartLite Pro—10 s	1.4	0.0	BCa	1.1	0.0	CDb
PowerCure—10 s	1.2	0.0	CDa	0.7	0.1	Eb
PowerCure—3 s	1.1	0.1	Da	0.7	0.1	Eb
Valo Grand—3 s	1.1	0.1	Da	0.9	0.1	DEa
Monet—1 s	1.0	0.2	Da	0.9	0.2	DEb

Means followed by similar letters (lowercase: within the row; uppercase: within the column) are not significantly different (Scheffe's post hoc test, $p \geq 0.05$)

Table 4 Temperature rise (ΔT) for the Class V cavity

	Temperature rise (ΔT—°C)					
	0 mm distance			6 mm distance		
	Mean	SD	Significant Groupings	Mean	SD	Significant Groupings
PowerCure—3 s	4.2	0.3	Aa	2.8	0.2	Ab
PowerCure—10 s	3.6	0.2	ABa	2.5	0.1	Aa
PinkWave—10 s	3.3	0.6	ABCa	2.4	0.4	Aa
SmartLite Pro—10 s	3.1	0.2	ABCa	2.2	0.1	ABa
Valo Grand—3 s	2.6	0.3	BCa	2.5	0.2	Aa
PinkWave—3 s	2.4	0.5	BCa	1.7	0.2	ABCa
Valo Grand—10 s	2.2	0.2	Ca	2.4	0.2	Aa
Monet—3 s	1.0	0.2	Da	1.0	0.3	BCa
Monet—1 s	0.5	0.1	Da	0.6	0.1	Ca

Means followed by similar letters (lowercase: within the row; uppercase: within the column) are not significantly different (Scheffe's post hoc test, $p \geq 0.05$)

The data showed that the temperature rises in both Class I and Class V in both 3 and 1 second exposures were all below the biologically allowed limit of 5.5°C.

Patient will feel the heat if Monet is directly on gingival tissue since soft tissue absorbs more blue light than hard tissue, thus the heat will be felt if blue light is shined on soft tissue.

If the light from Monet needs to be on gingival tissue, use following method will avoid patient reaction to the heat:

1. Use smaller size aperture to block the light on gingival tissue
2. Use code air to blow the tissue site when the light is on

F) Does laser curing improve shrinkage stress?

Shrinking stress at the bottom of a restoration is the main reason for restoration failure and post-op sensitivity. Dr. Sadr at the University of Washington used sophisticated equipment called Optical Coherence Tomography (OCT) to observe the debonding of material from the bottom of a restoration in real time. Below is the published results by Dr. Sadr et al.

TITLE: Laser and LED Light Units Comparison for Bulk Composite Placement

AUTHORS (FIRST NAME INITIAL LAST NAME): S. Haghighi[1], A. Sadr[2], D. C. Chan[3]

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PREFERRED PRESENTATION TYPE: Virtual Interactive Talk

CURRENT SCIENTIFIC GROUPS & NETWORKS: Dental Materials 4: Adhesion

ABSTRACT BODY:

Objectives: The quality of composite restorations partly depends on the performance of light curing units (LCU), as well as the adaptation of the composite and its seal at the cavity floor. The aim of this in vitro study was to calculate and compare the degree of debonding in 7 different single increment composites at the floor of a deep cavity using conventional LED compared with new monochromatic laser LCUs.

Methods: A total of 112 simulated cavities were prepared in shape of cylinder (3mmD, 4mmH) in 7 groups, each restored with a composite: Filtek Bulk Flow, Filtek Bulk One, Filtek Supreme Ultra (3M), SDR flow+, THP spectra (Dentsply), Harmonize (KavoKerr), Omnichroma (Tokuyama Dental). After the bonding step, Monet Curing Laser (3 seconds; AMD Lasers) and Valo Cordless LED (standard mode, 20 seconds; Ultradent) LCUs were used to polymerize each composite. Optical Coherence Tomography (Yoshida Dental OCT) was used to record 3D images of the cavity floor during the polymerization process in real time. Debonding and defect formation was analyzed with digital image processing to calculate total cavity adaptation % in each group. Data was statistically analyzed at 0.05 significance level (n=14).

Results: Cavity adaptation mean values ranged from %49.6 to %88.4 for different groups. Two-way ANOVA showed that the LCU and its interaction with the composite were significant factors in cavity adaptation ($p<0.05$). Post-hoc analysis showed that the adaptation of Filtek Bulk One and Filtek Supreme Ultra significantly improved when laser LCU was used ($p<0.05$), while a significant difference was not detected within other materials ($p>0.05$).

Conclusions: The solid-state laser diode laser light has the advantage of a coherent and collimated light beam with low divergence, which could decrease the time required for curing of composites in deep preparations while reducing the debonding and improving the adaptation depending on the composite.

The test results showed that a 3 sec cure by Monet had significantly lower debonding than 20 sec with Valo.

Through live OCT observations by Dr. Sadr, Monet did not show any stress deboning comparing Valo LED curing light.

G) Is Monet curing ortho brackets faster than LED lights?

Dr. Souza at Sao Paulo State University, Brazil compared Monet 1 (M1) and 3 (M3) second cure with 3 second cure of Valo (V3) and Led-X (L3) at highest power setting for Sheer Bonding Strength, Degree of Polymer Conversion, and Microhardness of bonding brackets to enamel surface. The results are as follows:

Sheer Bonding Strength:

Groups	M	Dp	Min	Max	F	p
M3	25,32[A]	2,62	20,67	27,94		
M1	16,71[B]	3,25	12,01	19,64		
V3	16,73[B]	3,55	12,21	20,68		
L3	20,85[AB]	4,91	16,43	29,42		
					12,4	<0,001

**Different letters represent statistical difference according to Tukey's post test.*

Significance level: p ≤ 0.05.

Degree of Polymer Conversion:

Groups	Degree of Conversion (%)	Dp	Min	Max	F	p
M3	47,4[A]	1,37	45,9	49,6		
M1	44,0[B]	0,94	43,0	45,4		
V3	46,6[AB]	1,17	45,4	48,2		
L3	47,7[A]	0,93	46,4	48,8		
					13,2	0,001

**Different letters represent statistical difference according to Tukey's post test.*

Significance level: p ≤ 0.05.

Microhardness:

Groups	Microhardness (KHN)	Dp	Min	Max	F	p
M3	20,3	1,85	17,5	22,1		
M1	17,8	2,23	16,3	21,7		
V3	19,4	1,23	17,9	21,2		
L3	20,2	1,75	18,6	23,2		
					1,39	0,311

Significance level: p ≤ 0.05.

It can be seen that 1 second cure by Monet for bracket yielded sufficient results for bracket bonding.

H) What are the clinical successes since introduction?

Many units of Monet laser curing light have been used by clinicians since its introduction in 2021. When used correctly, no adverse results were reported. Clinicians like faster and better curing. Below are the quotes from clinicians:

Nassim Missaghian:
"Very fast 1-second cure that makes restoration appointments much quicker, especially for the larger multi-layered restorations that used up a lot of curing time."

Eugene Graff:
"Unbelievably fast curing times. Great curing depth. Reliable curing. Very small and lightweight."

Lisa Elias:
"Great fast cure"

Edward Jackson:
"Best curing light out there. Has approval of Dr Christensen which is important for me. Would recommend to everyone."

Raul Perales:
"Great product and great price."

Chris Kalna:
"Greatest thing to hit dentistry in the last few years. It really aids in the time spent on curing procedures. It's been a godsend."

Arun Nayyar DMD, MS
"The Monet Laser cures composite in 1 second. I find it very expedient for direct composite restorations. Using the small pinhole cover is a unique feature and when cementing Veneers, I can tack the restoration in place with a 1 second burst, this stabilizes the Veneer in place, allowing expedient removal of unset resin cement. My cementation time for 10 veneers is dramatically reduced. "

Erin Elliott, DDS
"My question is, why would you NOT use the Monet curing laser? Gaining an extra 9 seconds each time you cure may not seem like a lot but it is. As providers, we can gain increased efficiency, increased confidence that you're getting a cure and less sensitivity. It's a no-brainer."
……

Since introduced in the market in 2021, there is not a single adverse report for usage of Monet.

6. Return on Investment and Benefits of Laser Curing

Monet can save great amount of chair time by reducing curing time. Below is an example of using 20 sec LED curing vs 1 second Monet curing for standard composite restoration which is about 533 composite restoration per chair per year.

Items	**Curing time by LED light**	**Curing time by Monet**
Curing items per restoration: bonding agent, flowable base, 3 incremental composites	20 second each	1 second each
Total curing time per restoration	100 seconds	5 second
Total curing time per year (533 restorations)	53,300 seconds or 14.8 hours	0.74 hours
Time saved		14 hours
Rate = $600 per hour		
Money saved		$8,400
Monet cost		$2,500
Return on investment in 2 years		572%

Real clinical situations may vary depending on procedures. However, Monet is sure to provide great ROI by reducing curing time from 20 or 10 of LED curing to 1 to 3 seconds.

Below are the key benefits of Monet laser curing:

- Fast curing – save time for clinical procedures, particularly for tough isolation cases.
- Easy of use – one-button operation to provide the most convenience for clinical procedures.
- Better curing – The parallel beam provides better curing for all restoration shapes, particularly for deep preps. Monet laser curing provide better curing, less debonding in bottom of restoration and no post sensitivity. Monet provides better patient care and longevity of restoration.

7. Summary

The Monet laser curing light offers improved light properties over LEDs for dental curing. Independent research results showed that the Monet laser curing light has better and faster curing than any other lights in the market while not introducing a temperature risk for pulp chamber. No clinical adverse results have been reported since its introduction when used according to instructions and the provided guidance. It is believed that laser curing is the future for dentistry while AMD continues to improve the light properties of Monet to be the optimal light source for dental curing.

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