

**3M** Science.  
Applied to Life.™

# Scientific Presentation

## Elipar™ DeepCure-S Paradigm™ DeepCure LED Curing Lights

July, 2017

Dr. Karsten Schwarz



# Overview

- Product Description
- 2 Devices – 1 Performance
- Ease of Light Curing and Complication of Incomplete Curing
- Scientific Data
- Clinical Evaluation
- BlueLight Analytics and MARC<sup>®</sup> Patient Simulator
- Clinical Procedure Case



# Elipar™ DeepCure-S and Paradigm™ DeepCure LED Curing Lights:

## The Next Generation of Light Curing

No matter how many improvements we see in bonding and composite technology, one piece of equipment is essential to making it all happen...

...the dental curing light.

We have improved our curing light technology to ensure a reliable performance.



# The Next Generation of Light Curing

3M presents the latest in LED curing light technology:

Two curing lights with identical technical performance:



**Elipar™ DeepCure-S**  
LED Curing Light  
(Stainless Steel)



**Paradigm™ DeepCure**  
LED Curing Light  
(Lightweight Plastic)

# Product Description

- **Intensity** — 1,470 mW/cm<sup>2</sup>
- **Utilizable wavelength range** — 430–480 nm
- **Black coated light guide**  
optimized geometry provides access to all tooth surfaces without extreme opening of the mouth
- **Easy and intuitive operation**  
with two-button and single-mode operation — no toggle between settings for optimal performance
- **120 minutes of consecutive curing time**  
720 10-second cures with constant light output regardless of battery charge
- **Comfortable, ergonomic, efficient operation**  
V-shaped handpiece and the 360° rotating light guide provide a comfortable grip.  
10-mm tip diameter provides a complete one shot cure of MOD fillings.
- **Easy to clean**  
due to the vent free and sealed housing

## 2 Devices – 1 Performance

### Elipar™ DeepCure-S LED Curing Light

- **One-piece, high-quality, stainless steel housing** virtually unbreakable (weight 250 g)
- **Glass ceramic coating** offers protection against fingerprints and staining
- **Unique magnetic light guide** for quick and easy removal of the light guide for disinfection
- **Charging base with built-in light meter** indicating operating status and light intensity



## 2 Devices – 1 Performance

### Paradigm™ DeepCure LED Curing Light

- Durable, lightweight construction (weight 180 g) made of shatterproof, high-performance plastic
- Battery charging with Charging Plug





# 2 Devices – 1 Performance

## Elipar™ DeepCure-S and Paradigm™ DeepCure LED Curing Lights

The Elipar™ DeepCure-S and Paradigm™ DeepCure LED Curing Lights are identical in technical performance. All data presented here is applicable for both curing lights.

Throughout the remainder of this presentation the curing lights will be referred to generically in text as 3M™ Curing Lights.



# Complications resulting from incomplete light curing:

**Inadequate polymerization** will result in less than optimal properties and poor clinical performance of composite restorations. Mechanical and thermal properties are degraded when the composite fails to reach a **minimum of 80% of ideal cure hardness**:

- Deterioration of margins
- Decreased bond strength
- Reduced hardness
- Greater cytotoxicity

This might lead to **replacement** of the restoration due to:

- Secondary caries
- Restoration and tooth fracture
- Staining/discoloration
- Wear
- Pulpal irritation/post-op sensitivities or even pulpal death

# Light = Light: Or how to know the right light?

Current estimates suggest there are more than 40 manufacturers and **150 different models** of light curing units available on the market today. New ones are introduced every year.

As one may expect, there is a lot of variation amongst the units:

- Price range: \$9 – \$4,900
- Irradiance range: 400 – 5,000 mW/cm<sup>2</sup> (as stated by the manufacturer)
- Incremental cure time: 1 – 60 seconds
- Cooling: air vs. water vs. no cooling system
- As many as 6 different curing modes

=> **Outcome is varying degrees of performance!**

# Scientific Data

# Light Transmission



Light transmission in SiO<sub>2</sub> brine  
Source: 3M internal data

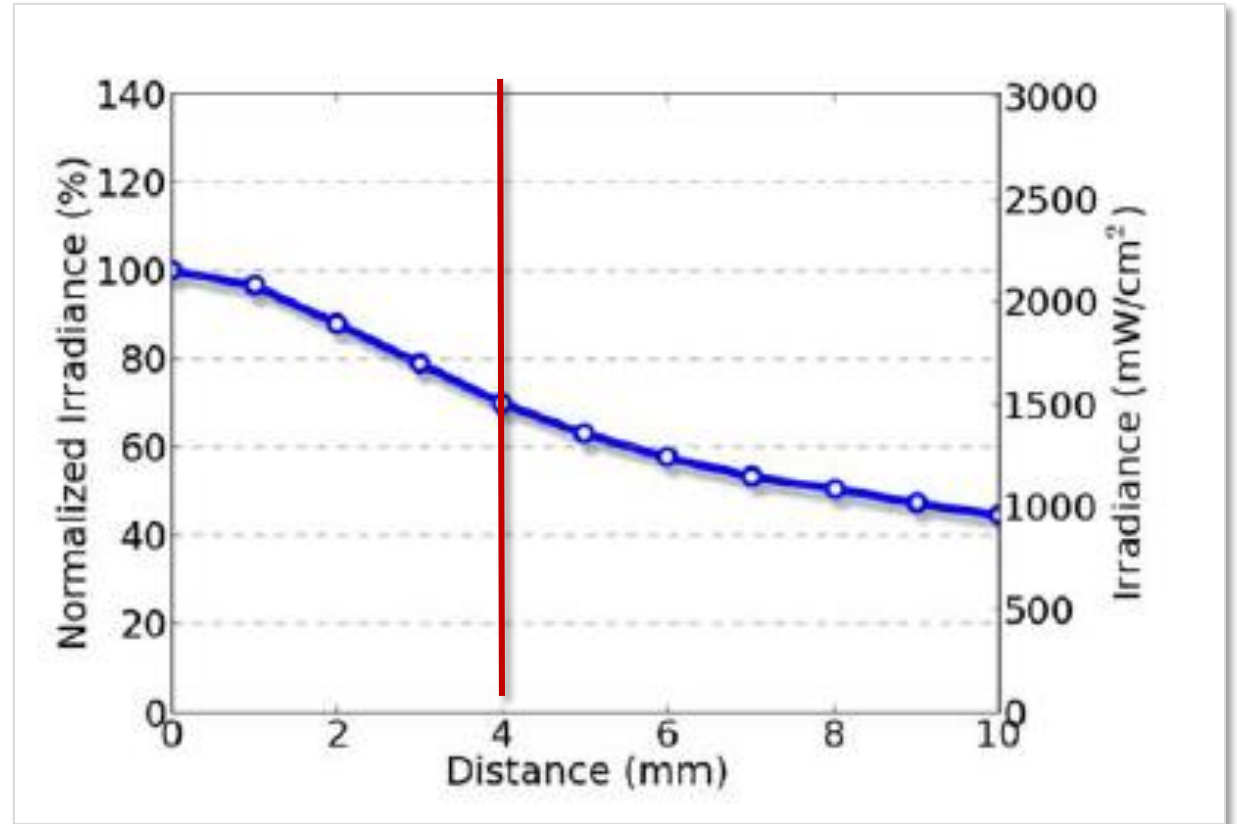
Light penetration shows a **more uniform beam profile and deeper transmission** of light for 3M™ Curing Lights compared to competitive curing lights. The decrease in irradiance over distance **might not deliver enough energy** to cure composite restorations especially in deep cavities which may result in **inadequate light curing of restorations and eventual failures.**

# Irradiance Over Clinically Relevant Distances

Irradiance measurements taken at **clinically relevant distances** between surface of the resin composite and the light tip provide more **significance to dentists** than tip irradiance measurements.

The 3M™ Curing Light still delivers 70% of its maximum irradiance at 4mm. This allows for a reliable light curing of composite restorations even in deep cavities.

The irradiance produced by some curing lights drops quickly and significantly at clinically relevant distances!

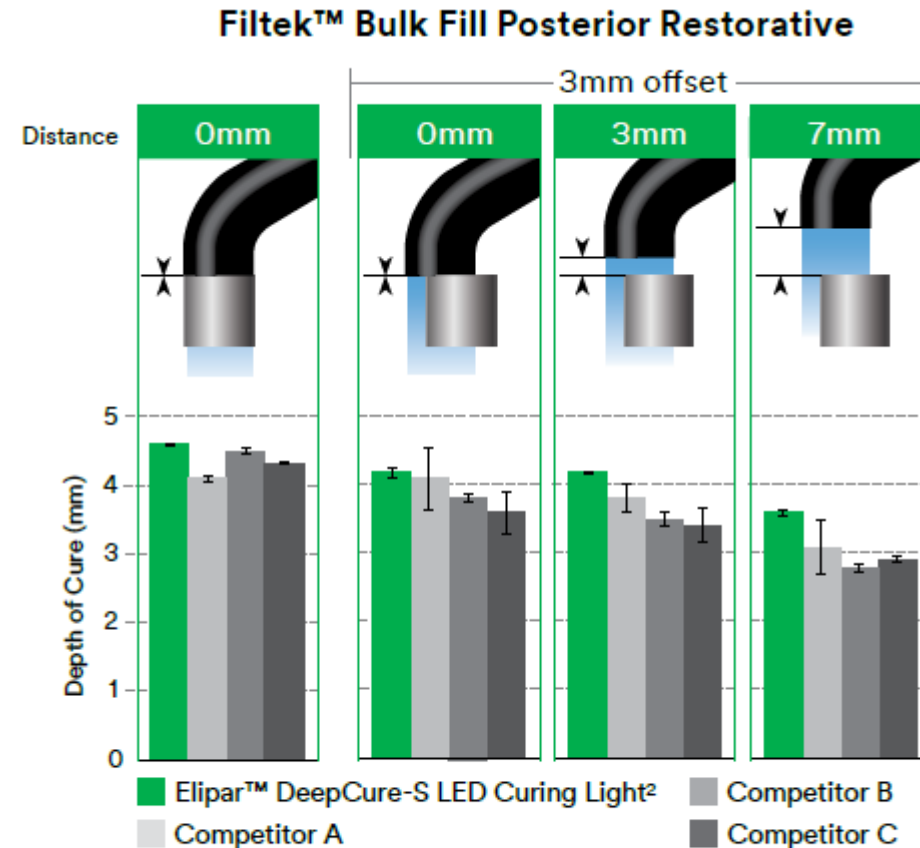


Changes in irradiance over clinically relevant distances of Elipar™ DeepCure-S LED Curing Light.  
Source: BlueLight Analytics Inc.

# 3M™ Curing Lights – Equal or Higher Depth of Cure

Depth of cure of Filtek™ Bulk Fill Posterior Restorative cured with the 3M™ Curing Light and three competitive curing lights at 0, 3 and 7mm clinically relevant distance and light tip placed 3mm off centered. Data show **highest depth of cure** for the 3M curing light.

Movements of the light tip during the light curing procedure negatively affect the curing performance resulting in lower depth of cure. The more uniform beam profile of the 3M curing light proves to be **less sensitive to these movements**.



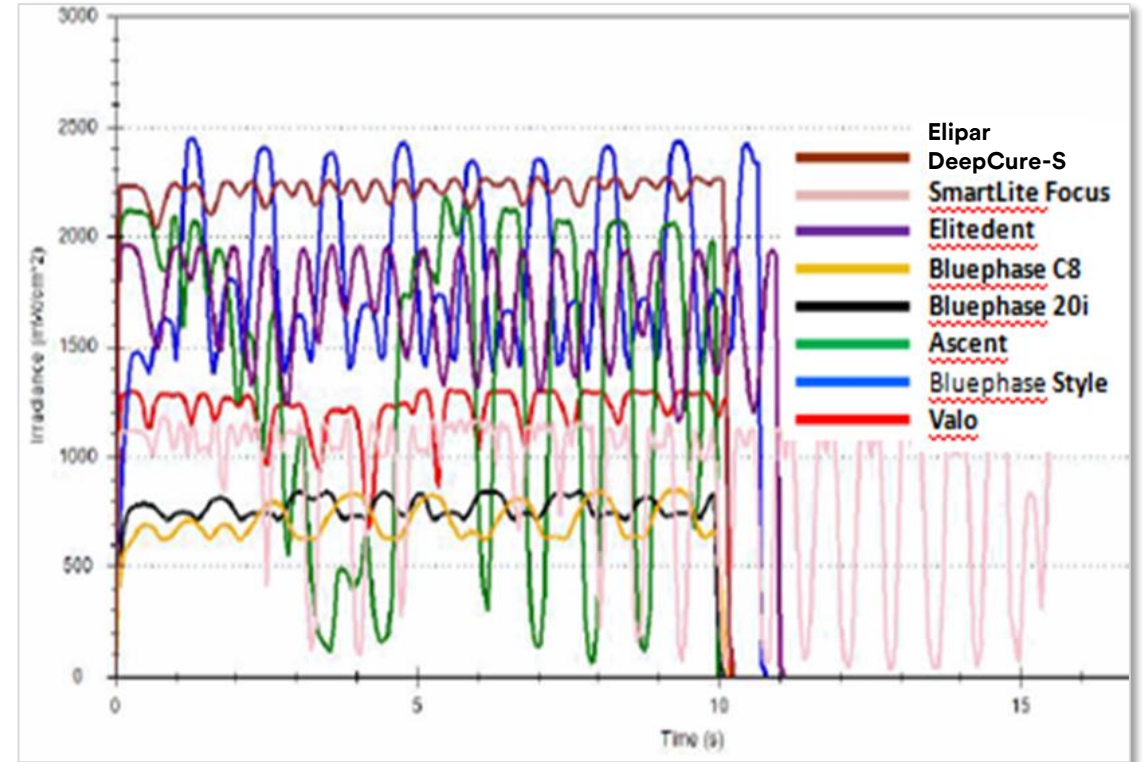
**Figure 2: Filtek™ Bulk Fill Posterior Restorative Shade A3, curing time 20 sec. (according to Instructions for Use).**  
Source: 3M internal data

# Impact of Tip Movements On Irradiance Distribution

Moving the curing light tip a few millimeters off the optimal curing position can greatly reduce the curing efficacy. e.g.:

- light is not centered over the restoration
- variation in tip distance to restoration from 0 to 10mm.

The optimized beam uniformity of 3M™ Curing Lights **maintains intensity over a greater range of distances** — horizontal, vertical and angular movements — allowing the clinician consistent, high quality results at all clinically relevant distances.

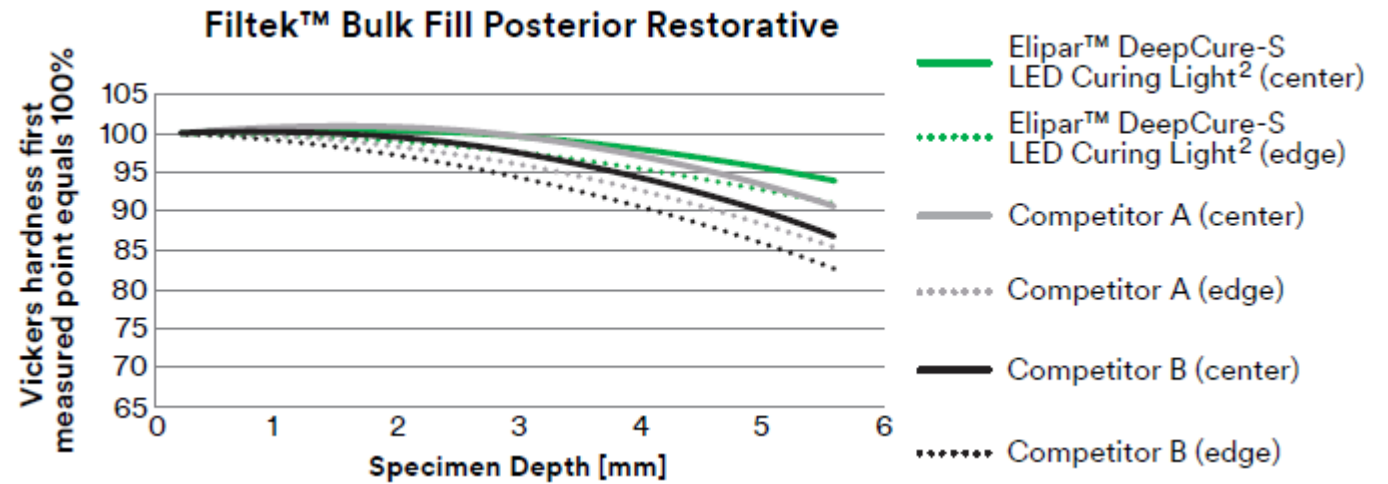
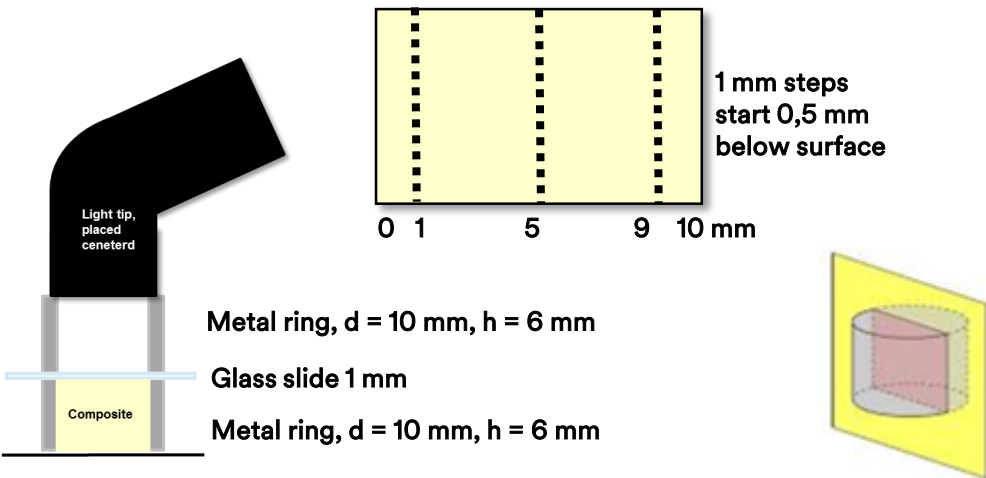


Comparison of the intensity by moving the curing lights  $\pm 4$ mm horizontally measured with the Marc Resin Calibrator. Source: 3M internal data



# Vickers Hardness

Comparison of the **hardness profile** of Filtek™ Bulk Fill Posterior Restorative light cured with three different curing lights. To analyze the **polymerization quality** within 6 mm high and 10 mm diameter disc shaped specimens, hardness profiles through the middle as well as at 4 mm left and right from the middle of the specimens were measured with a automatic micro hardness indenter.



Filtek™ Bulk Fill Posterior Composite A3, 20 sec. light curing, 24h water storage at 36 °C  
Source: 3M internal data

# Correlation Between Beam Profile and Resin Microhardness

## Objective:

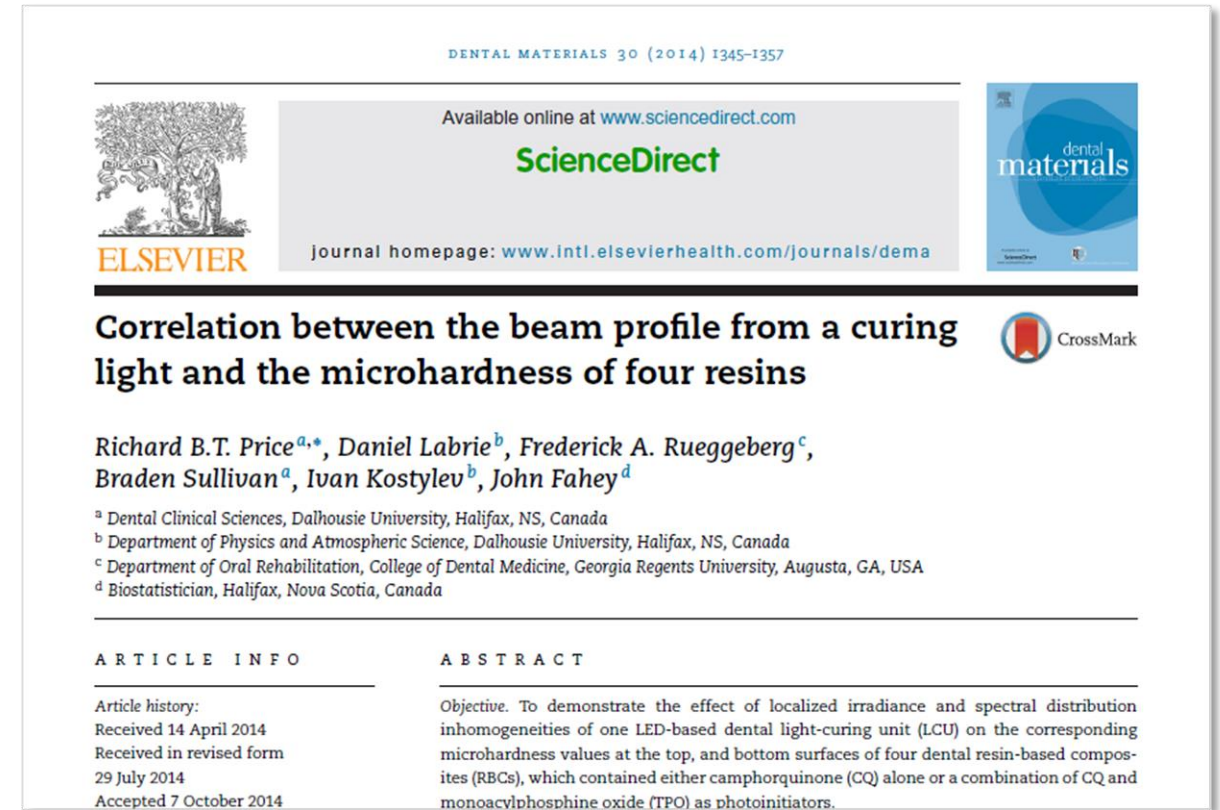
To demonstrate the effect of localized irradiance and spectral distribution inhomogeneities of a curing light on the corresponding microhardness values at the top, and bottom surfaces of four dental resin-based composites.

## Results:

Local irradiance and spectral emission values **were not uniformly distributed** across the light tip. There was a **strong significant positive correlation** with the irradiance beam profile values taken through bandpass filters and the microhardness maps.

## Conclusion:

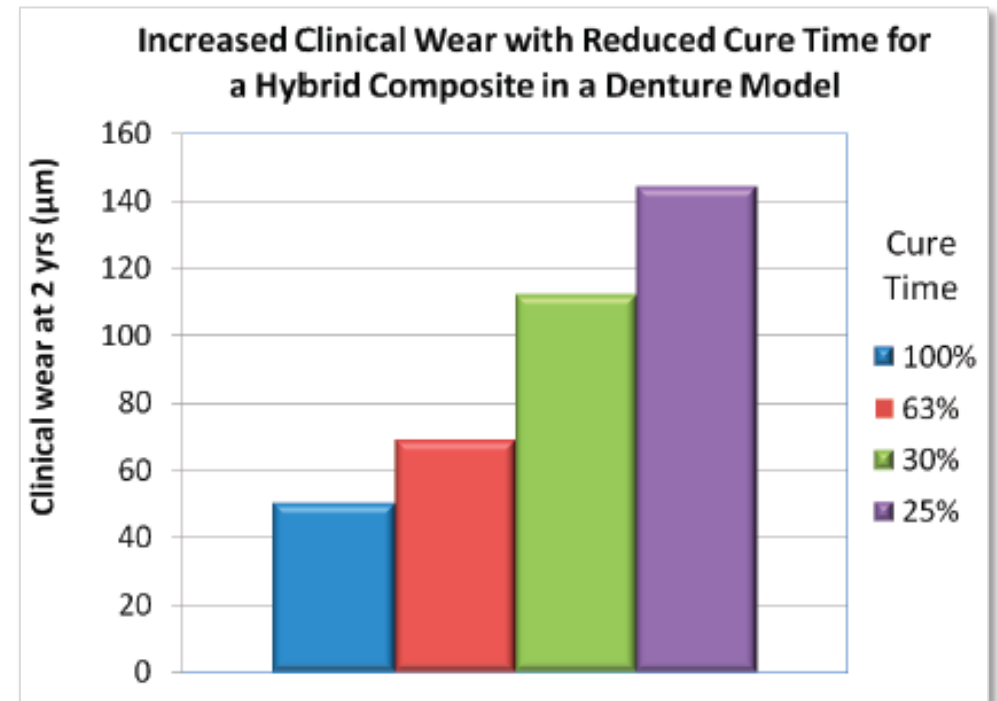
Localized beam and spectral distributions across the tip end of the light guide **strongly correlated with corresponding areas of microhardness** in both the top and bottom surfaces among four resin-based composites with different photoinitiator contents.



# Relationship Between Light Energy Delivered and Resin-Based Composite Properties

Based on many scientific publications, light-cured composites must receive adequate light energy to achieve their intended physical, chemical, and optical properties.

It is well established that reduced levels of resin polymerization caused by delivering an inadequate amount of light, or light at the wrong wavelengths, will adversely affect many resin-based composite properties.



Increased clinical wear with a reduced cure time for a hybrid resin-based composite in a denture model. Source: ADA Professional Product Review 2013;8,2

# Pulpal and tissue temperature increase during polymerization – anything to be concerned about?

## Pulp response to externally applied heat

Leo Zach, D.D.S.,\* and Gerson Cohen, D.D.S.,\*\* New York, N. Y.

NEW YORK UNIVERSITY COLLEGE OF DENTISTRY

The ascending severity of pulpal lesions induced by heat as an isolated stressor is described and illustrated in this study, which is part of a continuing investigation into the biology of pulpal response. Previous work has described the reactions of pulp tissue to the complex physical variables of cavity preparation under many modes of operative procedure.<sup>1-5</sup> In this portion of the study, an attempt was made to single out the role of heat as the most significant variable,<sup>6</sup> without the superimposed effect of cavity preparation, preparations, or fillings on the pulp.

Every stress that is borne by, or transmitted to, viable dentine induces a concomitant response within the dental pulp. Not the least of these stresses is the heat generated during operative procedures, especially when the amount of coolant is inadequate to prevent dissipation of frictional heat. Pulpal changes thus far studied in experimental teeth represent the combined effect of several dental tubules and heating the pulp. Thermogenesis associated with several operative techniques at high and low speeds, with and without coolants, has been graphed, and the total pulpal response has been described.<sup>7, 9</sup> Pulpal response to increased temperatures induced by the application of measured heat sources to the tooth surface have also been reported.<sup>8</sup> Thus far, actual intrapulpal temperatures correlated with the external heat source have not been reported in vivo. This study, by applying a known heat source and measuring its effect intrapulpally in a variety of tooth sizes and shapes, defines the histological and the heat parameter of pulpal stressors.

## RESEARCH AND EDUCATION

SECTION EDITOR  
LOUIS J. BOUCHER

### Temperature threshold levels for heat-induced bone tissue injury: A vital-microscopic study in the rabbit

A. R. Eriksson, D.D.S.,\* and T. Albrektsson, M.D., Ph.D.\*\*

University of Göteborg, and Institute for Applied Biotechnology, Göteborg, Sweden

Healing following bone surgery may be delayed or even prevented if the bone cells are severely injured by the frictional heat generated during the surgical preparation.<sup>1,4</sup> However, little is known about the critical temperature that causes a reversible or irreversible bone injury. This critical temperature is popularly believed to be around 56° C because alkaline phosphatase is denatured at this temperature level.<sup>2,4</sup> Studies in which bone reactions to temperatures lower than 56° C have been investigated indicate that bone necrosis may result even if the denaturation point of alkaline phosphatase is not exceeded. Rouiller and Majno<sup>3</sup> described hard tissue injury after heating the rabbit metatarsal or radial bone to 55° C for 3 minutes. In a rabbit experimental model, Lundskog<sup>10</sup> found some histological evidence of bone death adjacent to an implanted scald that was heated to 50° C for 30 seconds. In both these investigations and others, indirect methods (histology and histochemistry) have been used for evaluating hard tissue viability. Other studies have shown that conventional histologic evaluations tend to underestimate the true extension of tissue death.<sup>11-13</sup> One reason for the lack of knowledge of the critical temperature of bone tissue is the methodological shortcoming of defining bone necrosis. Furthermore, the important question is not whether the bone will die, but whether it will survive as a differentiated tissue.

hard tissue changes after heating in the range of 40-50° C.

#### MATERIAL AND METHODS

##### Animals and anesthesia

Fifteen adult male and female Belgian hare long-eared rabbits weighing 5 to 7 kg were used in the experiments. During chamber installation and vital-microscopic sessions, the animals were anesthetized with intramuscular injections of Hypnorm (U.V.A. Laboratories, Paris, France) at a dose of 0.5 ml/kg body weight and intraperitoneal injections of Valium (Hoffman LaRoche Ltd., Quebec, Canada) at a dose of 0.5 ml/kg body weight. Where required, supplemental anesthesia with 0.5 ml Hypnorm was provided at intervals of 30 minutes.

##### The thermal chamber

The chamber is a hollow, threaded titanium implant (Fig. 1). Two glass rods are glued inside the chamber and separated by a space 100 µm wide. A narrow canal runs from the top end of the chamber to the vicinity of the glass space. After insertion of the chamber into the proximal metaphysis, bone from the surroundings will grow through the space. It is later possible to transilluminate the ingrown tissue, which remains in continuity with the adjacent tibial bone, so as to obtain a microscopic

Journal of Oral Rehabilitation 1997 24; 791-801

### Clinical and histological evaluation of thermal injury thresholds in human teeth: a preliminary study

P. BALDISSARA, S. CATAPANO & R. SCOTTI University of Ferrara, School of Dentistry, Department of Prosthodontics, Ferrara, Italy

**SUMMARY** The effect on healthy dental pulp of thermal increases ranging from 8.9 to 14.7°C was evaluated. These temperature increases correspond approximately to those caused by certain restorative procedures, such as tooth preparation with high-speed instruments and the fabrication of direct provisional crowns. Two criteria of evaluation have been used in conjunction, a clinical (symptomatic

and a histological one, to assert with greater precision potential damage to the pulp. The results suggest a low susceptibility of cells to heat, which does not appear to be a major factor of injury, at least in the short term. The main cause of postoperative inflammation or necrosis of the pulp is probably the injury of the dentine, a tissue in direct functional and physiological connection with the pulp.

#### Introduction

It is commonly believed that temperature increases associated with certain dental procedures pose a serious threat to the vitality of the pulp.

Pulp temperature increases of 5.5 and 11.1°C in Macaca Rhesus monkeys caused 15% and 60% irreversible pulpitis, respectively (Zach & Cohen, 1965). Schubert (1957) regarded 41.5°C as the threshold beyond which pulp inflammation occurs. In certain restorative procedures, temperatures can easily exceed these values, especially if the procedures are carried out incorrectly.

The preparation of full crowns with air-cooled high-

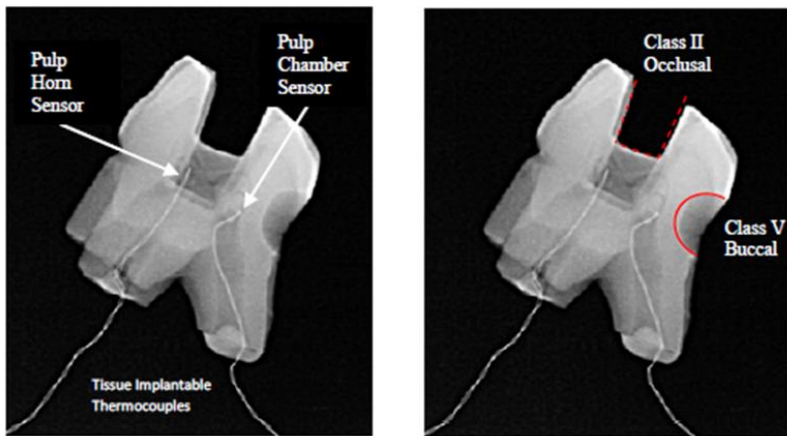
temperature values beyond which the pulp is injured, using thermal stimuli that closely resemble those actually occurring in practice. The determination of threshold values is very important because these are of use in all studies dealing with any of the numerous procedures that cause a temperature increase, in so far as they indicate the values beyond which heat turns from a possible co-factor into a major factor of biological damage. Furthermore, threshold values serve to determine the safety range for instruments or methodologies that cause a temperature increase of dental tissues, and thus avoid negative side-effects.

#### Materials and methods

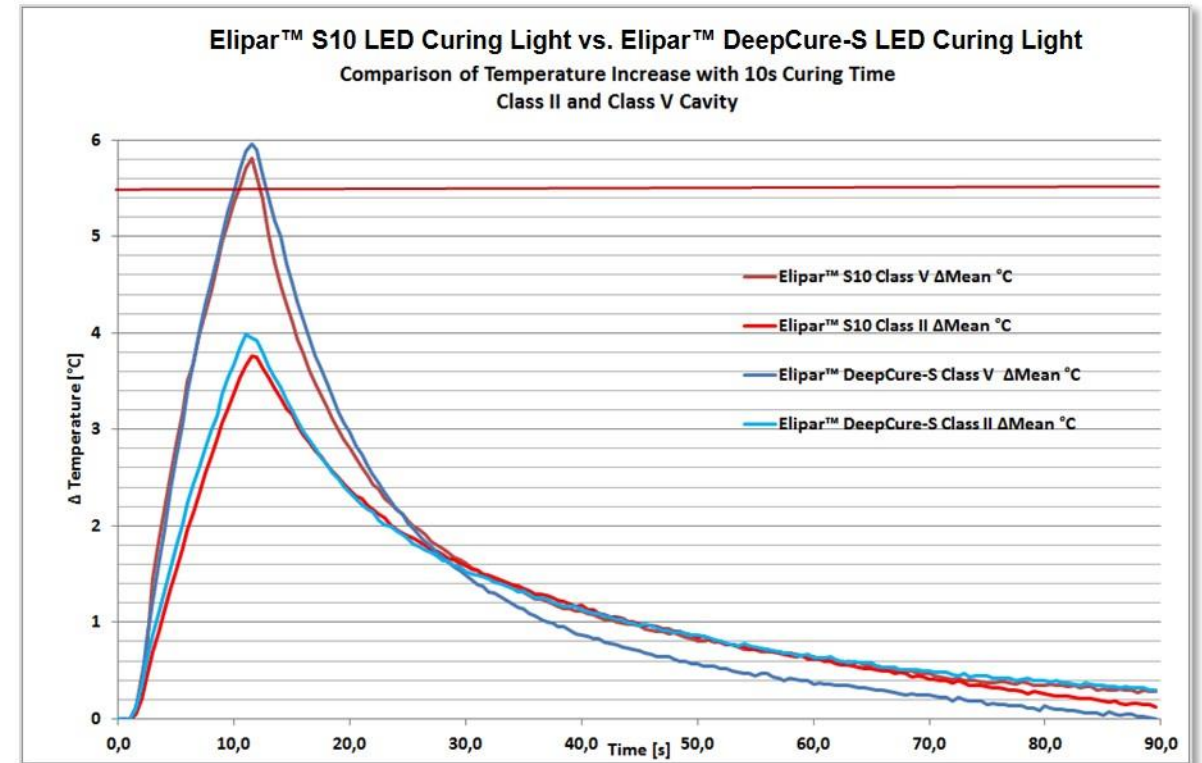


# Maximum Pulp Temperature Increase

Human molars were prepared by removing the pulpal material, cutting the roots and inserting thermocouples as shown in the radiographs below. Class II and V preparations were made with 1.5 and 0.5mm of dentin remaining respectively. The tooth was submerged up to the cement-enamel junction in a 35°C water bath.



Statistics showed that this difference is not significant!



Pulp temperature increase: Changes in temperature within the pulp chamber and the pulp horn of a human tooth placed in a simulated intraoral environment and light cured for 10 sec.

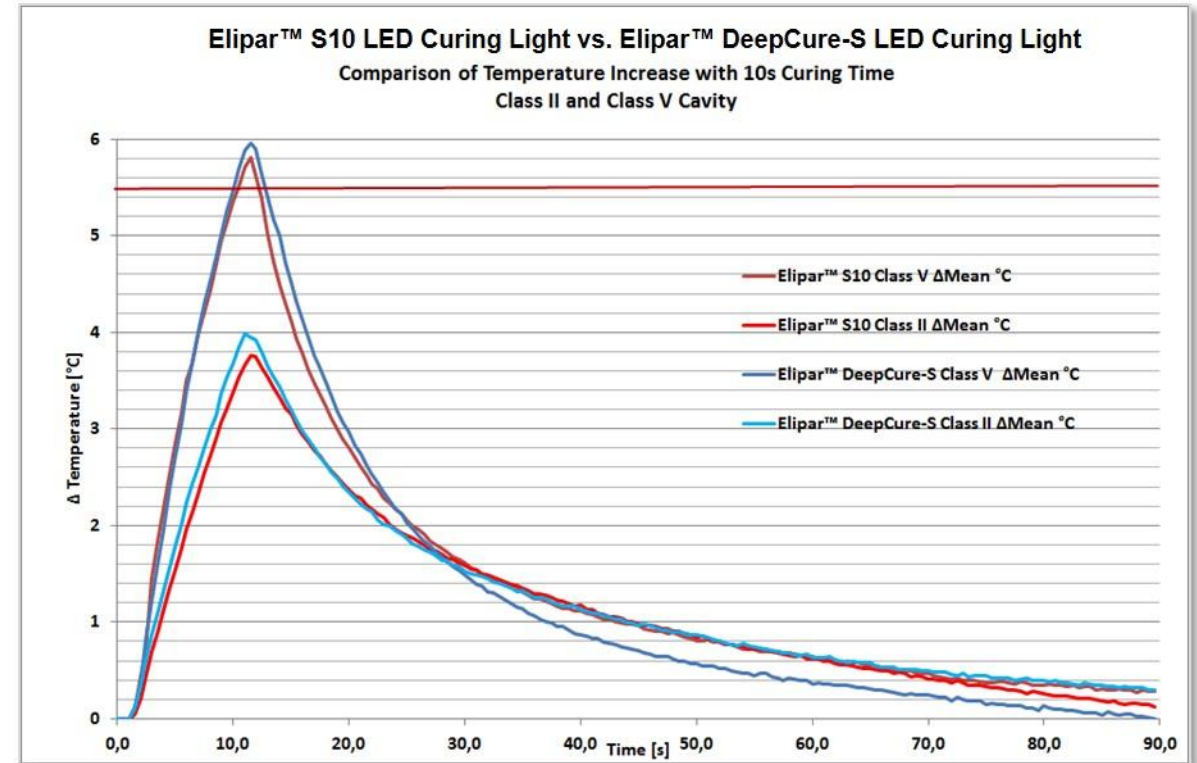
Source: 3M internal data

# Maximum Pulp Temperature Increase

Based on current medical complaint history on Elipar S10/Elipar/Paradigm LED Curing Lights from 2010 to 2014, 65 medical complaints affecting 69+ patients were reported to 3M.

None of the medical complaints presented a reportable adverse event for this product.

Estimation of number of applications is very difficult since a majority of dental material/dental treatments require light curing. It can be easily assumed that in period of time from 2010-2014 the number of light curing intervals exceeds one billion. Resulting in a very low number of complaints per million.



Pulp temperature increase: Changes in temperature within the pulp chamber and the pulp horn of a human tooth placed in a simulated intraoral environment and light cured for 10 seconds.

Source: 3M internal data

# Clinical Guidelines to Minimize Thermal Pulp and Tissue Damage

In clinical situations it is very difficult to evaluate the cause of pulpal irritation because the removal of tooth structure is accompanied by physical damage as well as thermal irritation.

To minimize this damage the following 2 steps can help to prevent overheating during polymerization:

1. **Air-cool** restoration during light curing
2. Break up recommended curing time into **2 curing cycles** with a **short pause in between** the 2 curing cycles of 2–3 sec. (e.g. if the recommended curing time for one increment is 20 seconds, light cure twice for 10 seconds with a 2–3 second break between the two curing cycles).



# Clinical Evaluation

Field Evaluation conducted with 40 general dentists by 3M in Germany, USA, Turkey and Denmark.

# Overall Satisfaction

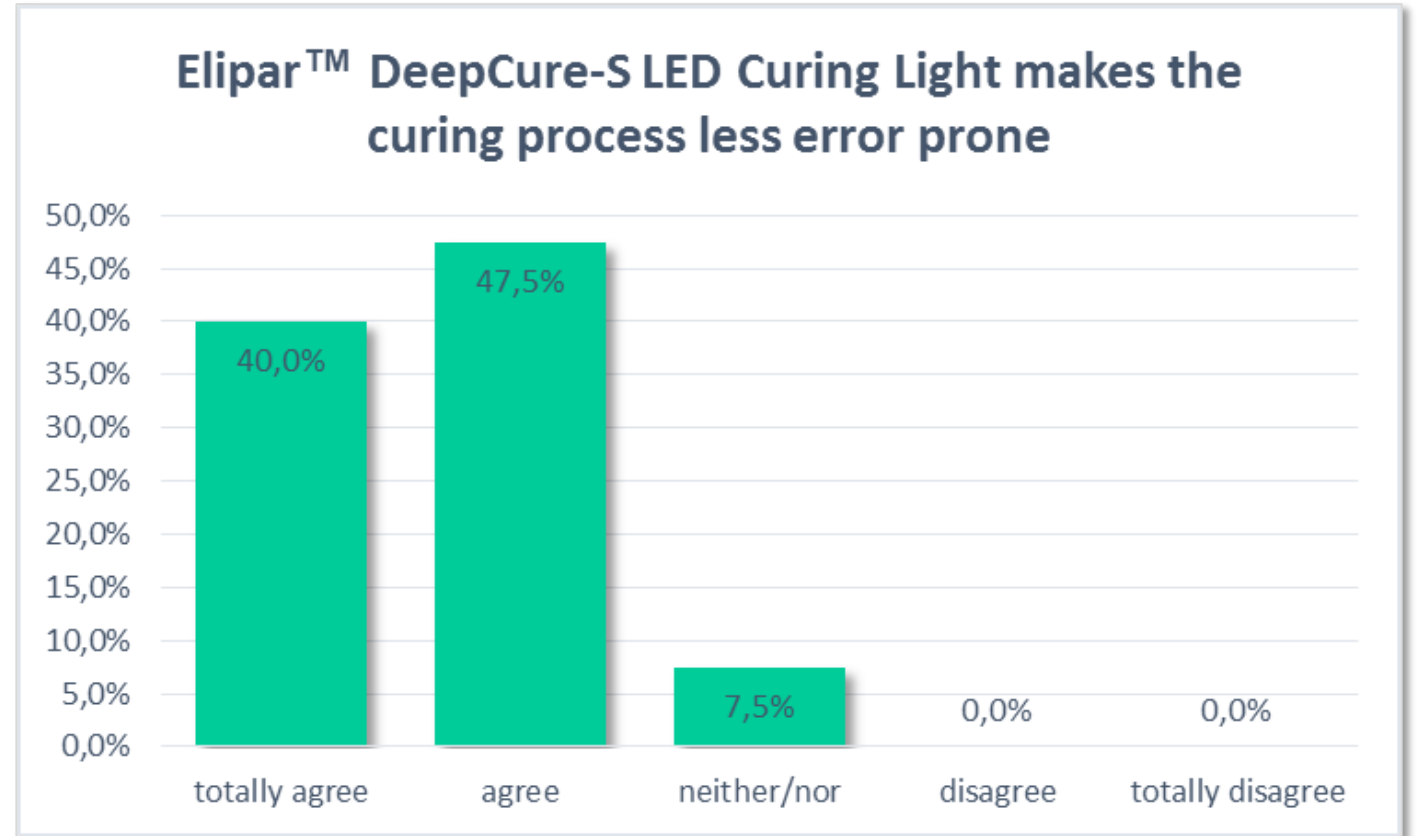
98% of participating dentists were either **satisfied** or **very satisfied** with the 3M™ Curing Lights.



Source: Field Evaluation conducted by 3M in USA and Europe

# Curing Less Error Prone

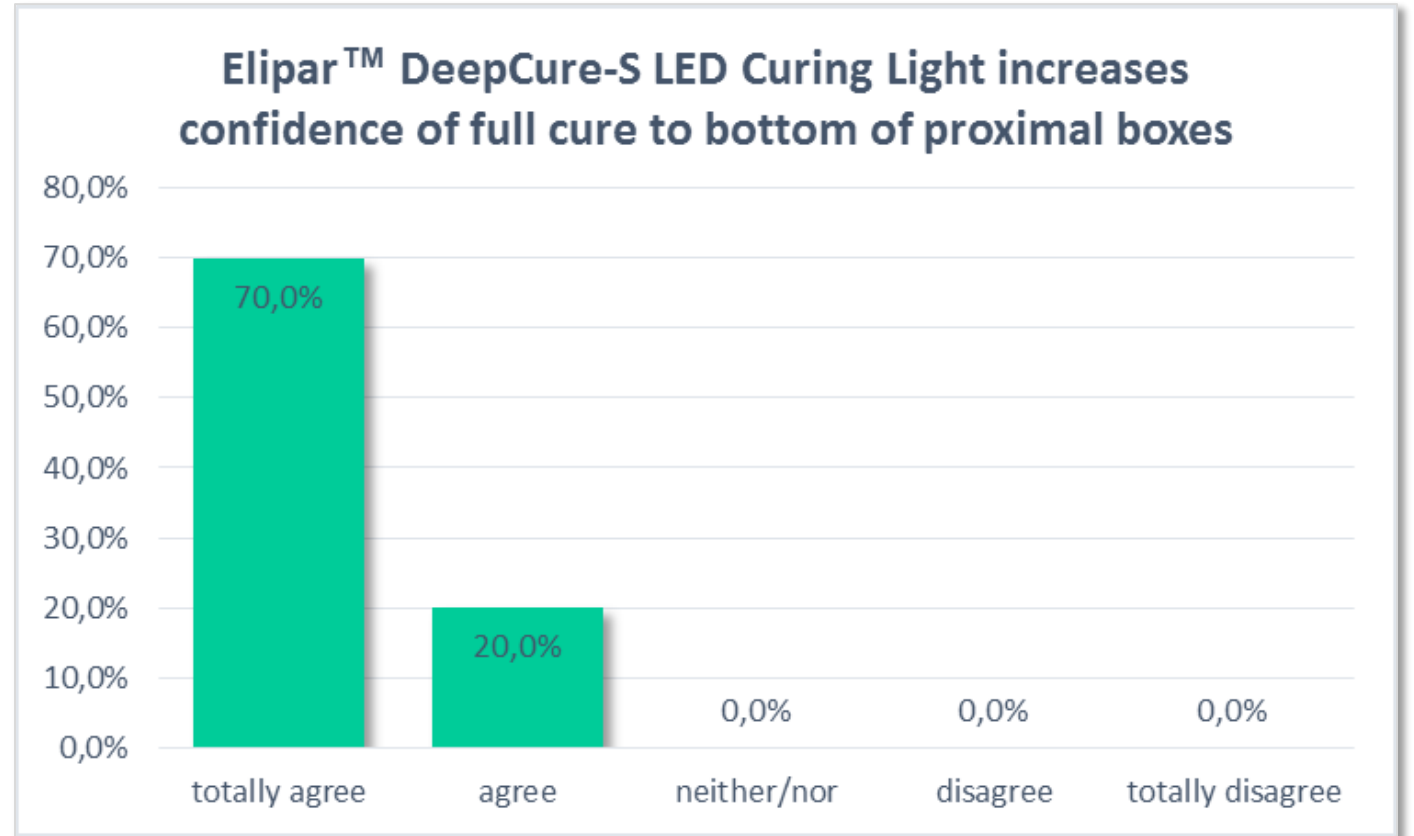
88% of the dentists felt that using 3M™ Curing Lights made the curing process **less error prone** (less sensitive to user variability).



Source: Field Evaluation conducted by 3M in USA and Europe

# Confidence of Full Cure

80% of the evaluators felt an increased confidence of a full cure to the bottom of the proximal box when curing with the 3M™ Curing Lights.



Source: Field Evaluation conducted by 3M in USA and Europe

# Opening Angle with Different Curing Lights

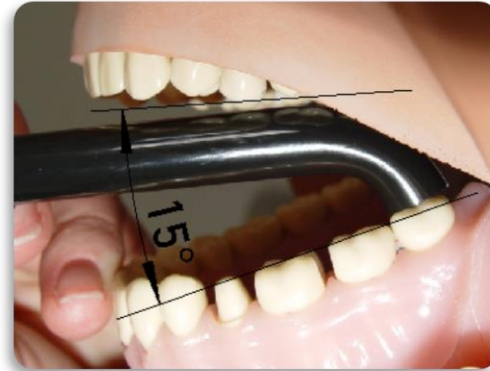
With the new light guide we are now playing in the same class as devices with the LED located in the light guide tip (Valo) and deliver **better patient comfort/ better handling**.

New design of light guide:

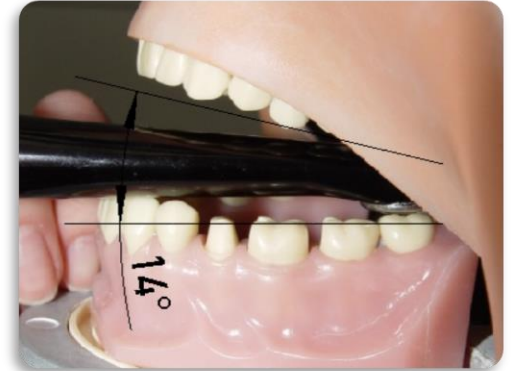
- **black coating** to prevent glare
- **optimized light guide geometry**



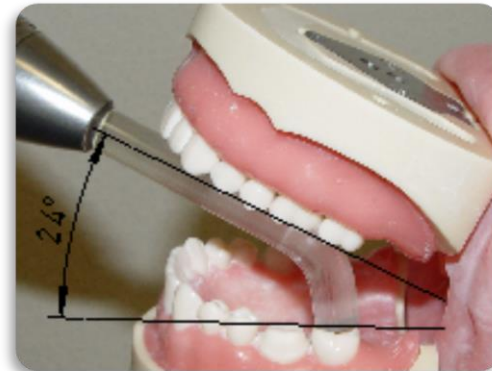
DeepCure Curing Lights, 3M



Bluephase Style, Ivoclar



Valo, Ultradent



Elipar™ S10 LED Curing Light, 3M

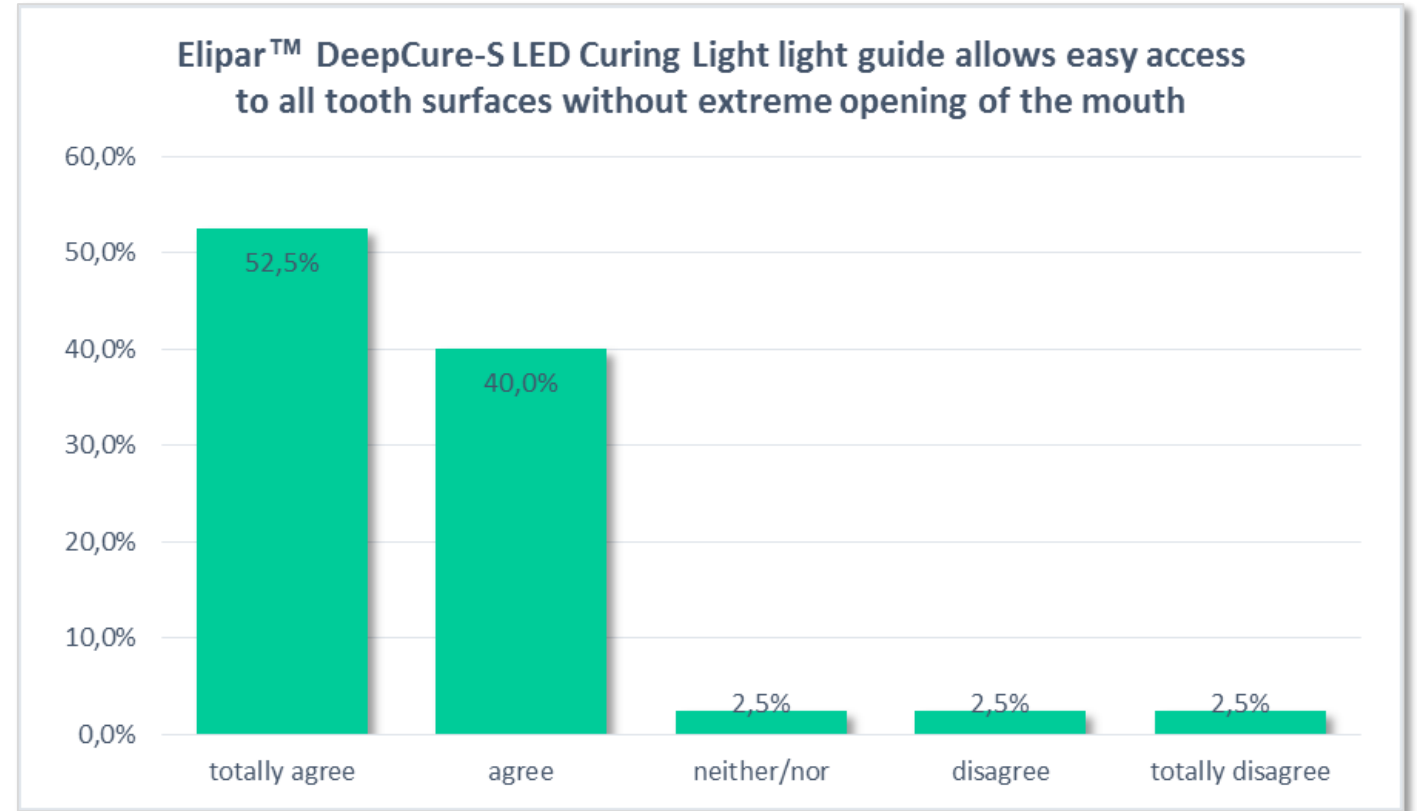


Demi Ultra, Kerr



# Easy Access to all Tooth Surfaces

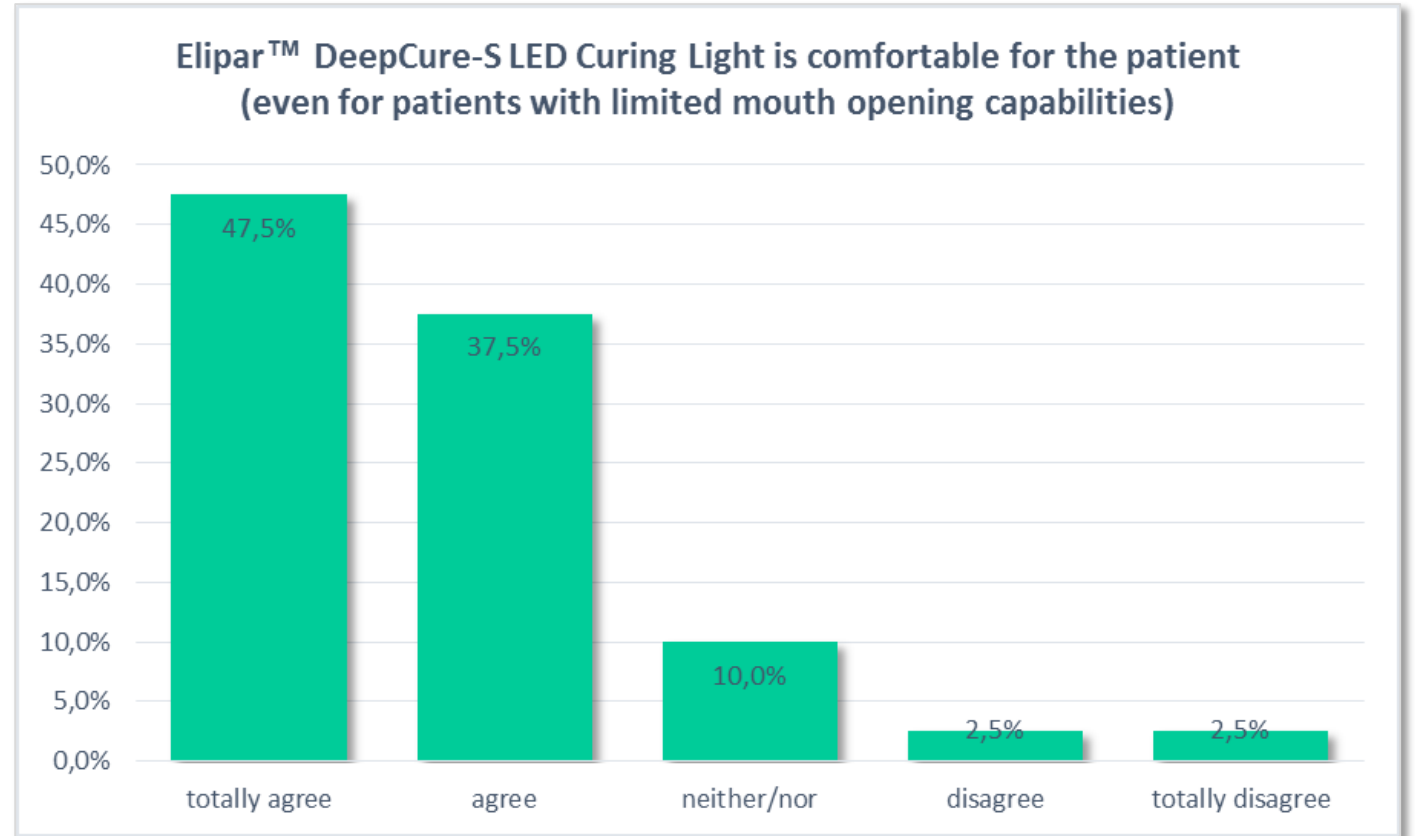
More than 92% of the dentists confirmed that the new light guide design allows easy access to all tooth surfaces without extreme opening of the mouth.



Source: Field Evaluation conducted by 3M in USA and Europe

# Comfortable for Patient

85% of the dentists participating in this clinical evaluation agreed or totally agreed the curing light is **comfortable for the patient** (even for patients with limited mouth opening capabilities).

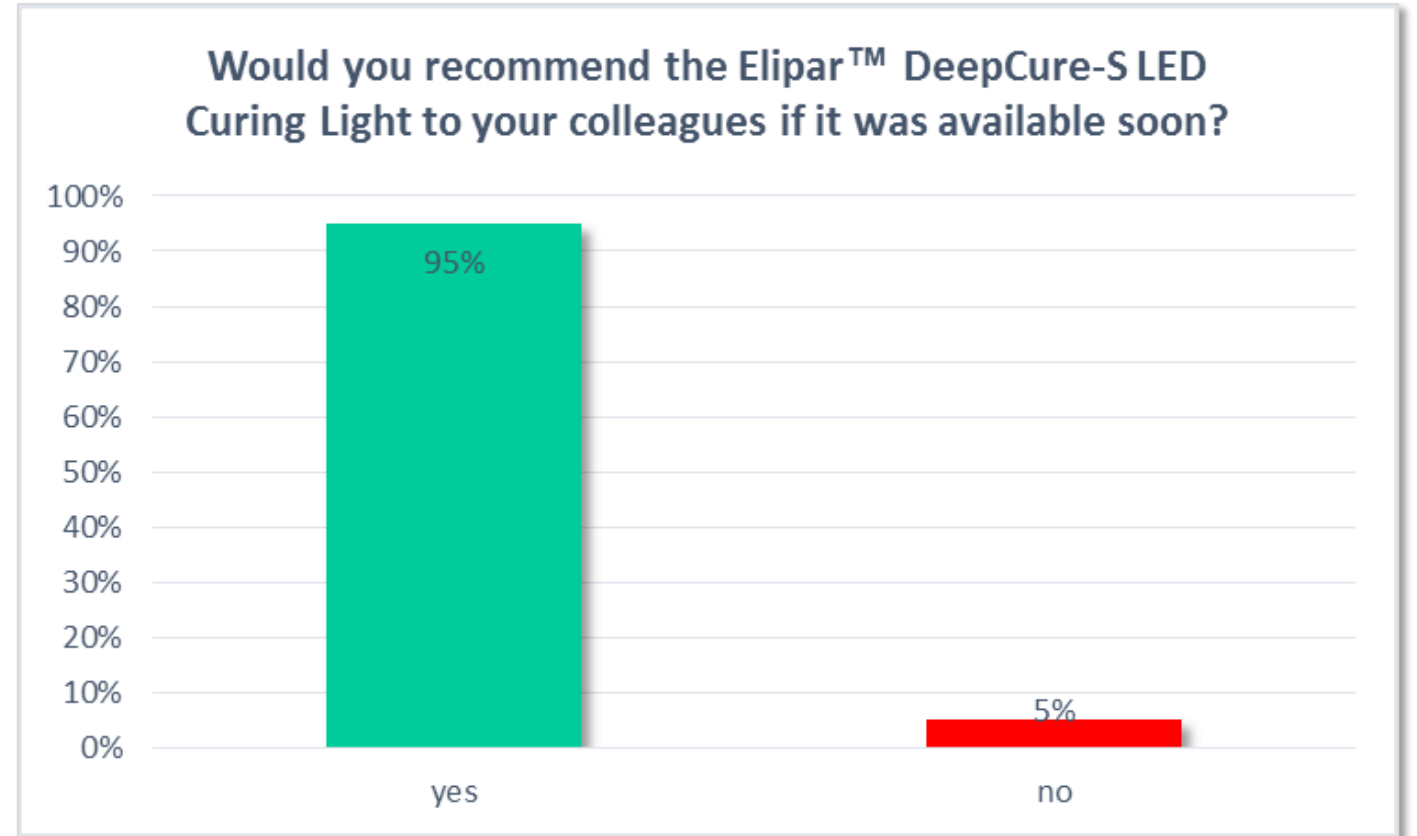


Source: Field Evaluation conducted by 3M in USA and Europe



# Recommendation to Colleagues

95% of the evaluating dentists would **recommended** the new 3M™ Curing Light to **their colleagues** if it was available.



Source: Field Evaluation conducted by 3M in USA and Europe

# Light Curing Matters

BlueLight Analytics Inc.

# Managing Accurate Resin Curing

**MARC® patient simulator** the only training system for perfect light curing technique.

**Sensors measure the irradiance and wavelength** of light energy received by simulated restorations in a typodont head.

The MARC patient simulator provides both the **physiologically accurate challenges of a restoration procedure** and **real-time analytical feedback of curing light operator performance.**

Students and dentists who have the advantage of simulation-based training are equipped to deliver optimal care.



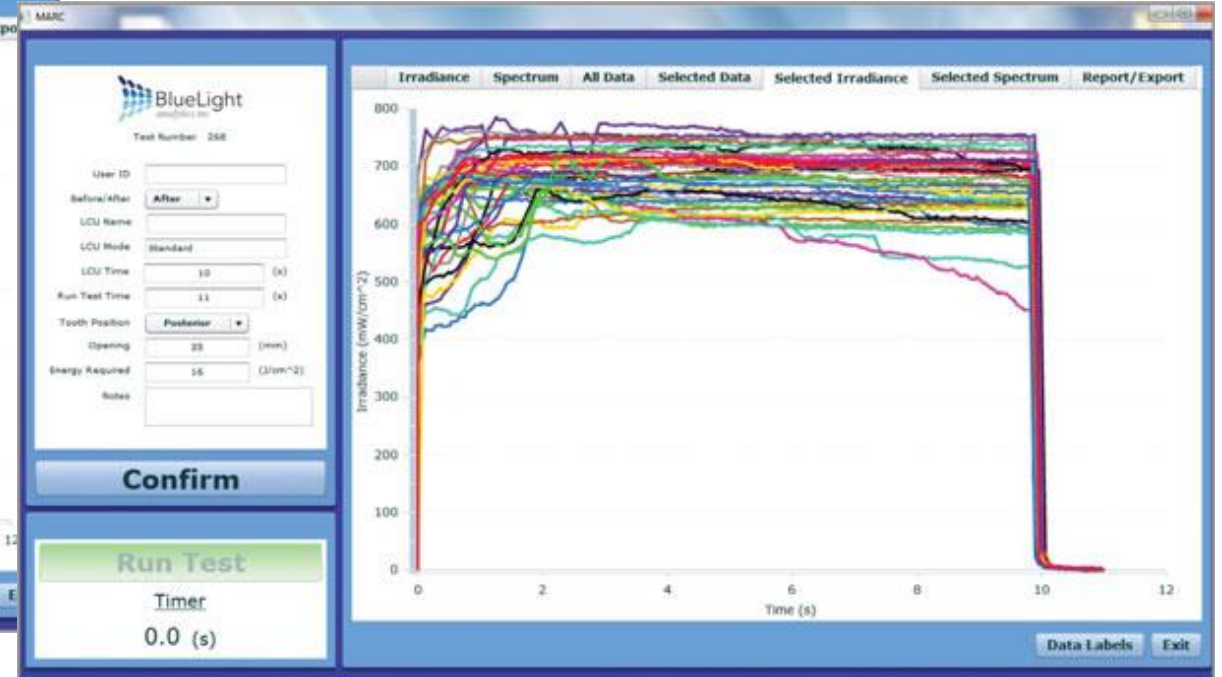
**MARC® patient simulator**  
Source: BlueLight Analytics Inc.

# MARC<sup>®</sup> Patient Simulator Training



Established performance in real-time before curing technique simulator training.

Source: BlueLight Analytics Inc.



Measured performance improved in real-time after curing light technique simulator training

Source: BlueLight Analytics Inc.

Using the same curing light on the same tooth for 10 seconds, students demonstrate an improvement in light curing technique after simulator training.

# The Effectiveness of Using a Patient Simulator

## Objective:

To evaluate the effectiveness of using a patient simulator on how to deliver energy optimally to a restoration from a curing light.

## Results:

The abilities of dentists and dental students to light cure a simulated restoration were not significantly different. Hands-on teaching using a patient simulator enhanced the ability of dental students to use a curing light. This skill was retained for at least five months.



## The effectiveness of using a patient simulator to teach light-curing skills

Richard B. Price, BDS, DDS, MS, PhD;  
Howard E. Strassler, DMD; Hannah L. Price;  
Sachin Seth, BSc, DDS, MEd; Chris J. Lee, DDS, MSc

**T**he teaching and placement of posterior resin-based composite (RBC) restorations have become increasingly popular in the last 10 years.<sup>1</sup> A survey published in 2011 reported that of 46 dental schools, 63 percent no longer taught that amalgam was the preferred posterior restorative material.<sup>2</sup> According to the American Dental Association Survey Center's 2005-06 Survey of Dental Services Rendered,<sup>3</sup> an estimated 146

## ABSTRACT

**Background.** The authors evaluated the effectiveness of using a patient simulator (MARC Patient Simulator [MARC PS], BlueLight analytics, Halifax, Nova Scotia, Canada), to instruct dental students (DS) on how to deliver energy optimally to a restoration from a curing light. Five months later, the authors evaluated the retention of the instruction provided to the DS.

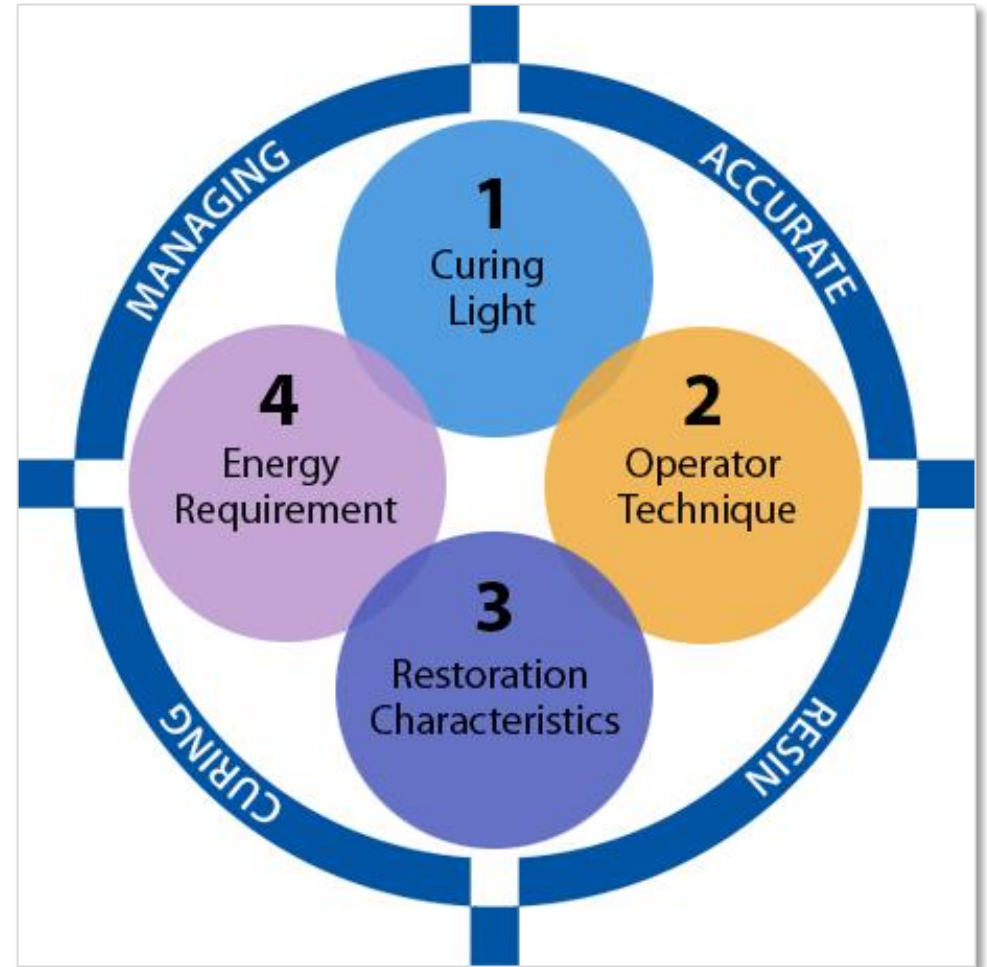
**Methods.** Toward the end of the DS' first year of dental education, the authors evaluated the light-curing techniques of one-half of the class of first-year DS (Group 1) before and after receiving instruction by means of the patient simulator. Five months later, they retested DS in Group 1 and tested the remaining first-year DS who were then second-year DS and who had received no instruction by means of the patient simulator (Group 2). They gave DS in Group 1 and Group 2 MARC PS instruction and retested them. The authors also tested fourth-year DS (Group 3) and dentists (Group 4) by using the MARC PS before giving any instruction by means of the MARC PS.



# Four CORE™ Variables

The following four sets of variables must be managed by dentists when they light cure intraorally:

1. **Curing lights**, curing modes and light tips can each significantly affect the light's output.
2. **Operator technique** has a direct impact on the amount of energy that reaches the restoration. Proper eye protection, light tip control and proper curing light positioning increases the operator's ability to optimally light cure.
3. The **size, type and location of the restoration** and the patient's mouth opening all affect energy delivery.
4. The **amount, rate, and type of light energy delivered** to light-cured dental material determines the properties of restorations.



Source: BlueLight Analytics Inc.

# 7 Steps to Successful Light Curing

Providing adequate energy from the curing light is a key factor to the success of resin-based composite restorations. There are important steps to ensure better light curing:

1. Position the patient for optimal view of restoration and easy positioning of light guide.
2. Wear blue-blocking orange glasses or use orange shields for safety and to be able to watch light curing procedure.
3. Position yourself so the curing light can be stabilized in an optimal position over the restoration.
4. Adjust the light guide to provide the optimal access to the restoration. Inspect the tip for any damage or debris.
5. Stabilize the curing light during curing with the beam perpendicular to the surface of the composite.
6. Start curing no closer than 1 mm from the composite and then move as close as possible after the first second of curing.
7. Air-cool the tooth during the curing cycle to avoid overheating the oral tissues. If necessary, break down curing cycle into 2 shorter curing cycles, (e.g. instead of 20 second cure, cure twice for 10 seconds with a 2–3 second break in between).

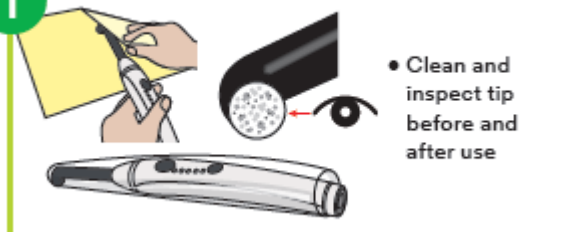
Source: BlueLight Analytics Inc.






# Curing guidelines, according to the Halifax Consensus Statement,\* help to assure a safe and proper cure

**1**



- Clean and inspect tip before and after use

**2**



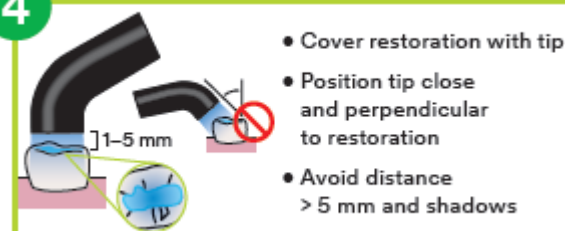
- Set curing time according to manufacturer's instructions

**3**



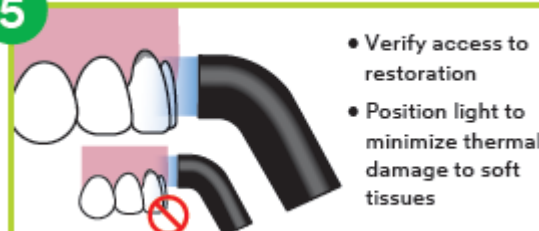
- Wear eye protection
- Stabilize tip
- Monitor position of light while curing

**4**



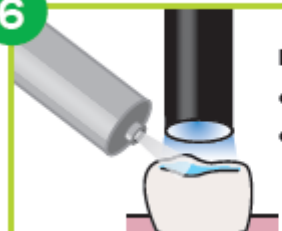
- Cover restoration with tip
- Position tip close and perpendicular to restoration
- Avoid distance > 5 mm and shadows

**5**



- Verify access to restoration
- Position light to minimize thermal damage to soft tissues

**6**



Manage heat development:

- Air cool: light on, air on
- Cure in intervals (e.g. 2 x 10 sec. instead of 1 x 20 sec.)

**7**



- Regularly check light output

Steps 1 through 7 are general guidelines from the Halifax Consensus Statement and may not be applicable to every curing light. For Elipar DeepCure-S and Paradigm DeepCure LED Curing Lights, please refer to Instructions for Use.

\*Source: Halifax Consensus Statement from the 2014 Symposium on Light Curing in Dentistry, Dalhousie University, Halifax, Canada

# Clinical Procedure Case

# One Simple Procedure, Four Innovative Products

Scotchbond™  
Universal Adhesive



Filtek™ Bulk Fill  
Posterior Restorative  
Elipar™ DeepCure-S  
LED Curing Light



Sof-Lex™ Spiral  
Finishing/Polishing  
System



Case by Dr. Gunnar Reich, Germany



# One Simple Procedure, Four Innovative Products



Scotchbond™ Universal Adhesive



Filtek™ Bulk Fill Posterior Restorative



Elipar™ DeepCure-S or Paradigm™ DeepCure LED Curing Lights



Sof-Lex™ Spiral Finishing/Polishing System

**Thank you.**