Blue Laser Curing of Composites

Laserska polimerizacija kompozitnih materijala

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Summary

There are two drawbacks of standard photopolymerization units: relative inability of a complete cure of darker composite shades in premolar and molar regions, and a hazardous effect of curing light on the eyes of the dentist. An argon-ion laser was used as a source for photopolymerization of several light shade composite resins. The depth of cure was measured at three different wavelengths (457.9 nm, 476.5 nm and 488.0 nm) and in the laser multiline mode. The depth of cure measurements was determined with a micrometer. The best results were obtained with a 476.5 nm laser line for Silux composite: more than 3.8 mm in 2 seconds at 155 mW. This arrangement is not suitable for clinical use in the present form, but a low-power compact laser device has been proposed to meet practical requirements.

Key words: *composite resins, photopolymerization, laser*

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Introduction

Currently used photopolymerization units have two major drawbacks. The first is a relatively shallow depth of cure, particularly of darker composite shades in undercuts, and the other is a hazardous effect of ultraviolet and near-ultraviolet light on the eyes of the dentist (1). There is a growing concern about the potential for retinal photochemical injury from chronic exposure to the activating blue light (2). Spectral distribution of some commercial light sources show the need for protective eye-glasses while working whith photopolymerizable composite resin materials (3).

In search for optimal activating light, we have already tried several high pressure lamps whose emission lines correspond to the peak of the camphorquinone absorption curve (4,5). In this study, the curing ability of coherent light produced by an argon-ion laser was analyzed.

Material and Methods

An ILA 120-1 argon-ion laser in a multiline mode is producing a blue-green light which can be divided in six emission lines using an internal prism system. These lines have the wavelengths of 457.9 nm, 476.5 nm, 488.0 nm, 496.5 nm, 501.7 nm and 514.5 nm. The first three emission lines lie within a broad maximum of the photochemical reaction initiated by camphorquinone (Figure 1). In the multiline regime, the output of the laser is adjusted to 1.1 Watt. In a single line regime, the 457.9, 476.5 and 488.0 nm lines had a power of 60 mW, 155 mW and 400 mW, respectively. Figure 2 shows the laser, the power meter device and two mirrors dispersing the laser beam to a diameter of 4.0 mm. The molds for composite samples were made of a dark plastic material with holes of 3.0 mm in diameter and 3.8 mm deep, placed on a specially designed carrier.

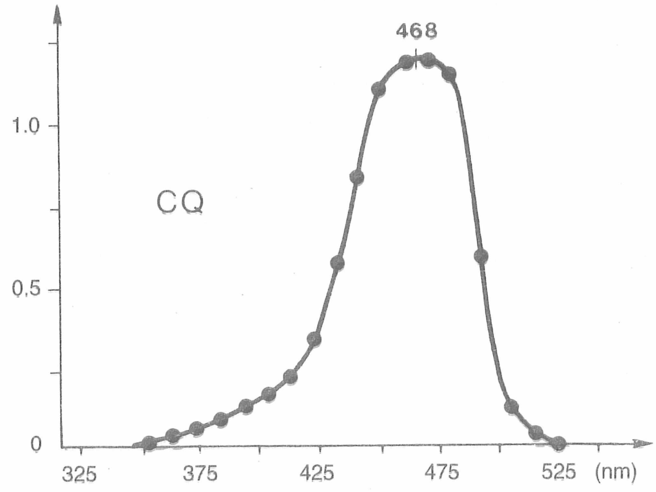

Figure 1. *Camphorquinone absorption coefficient curve*
Slika 1. *Krivulja apsorpcijskog koeficijenta kamforkinona*

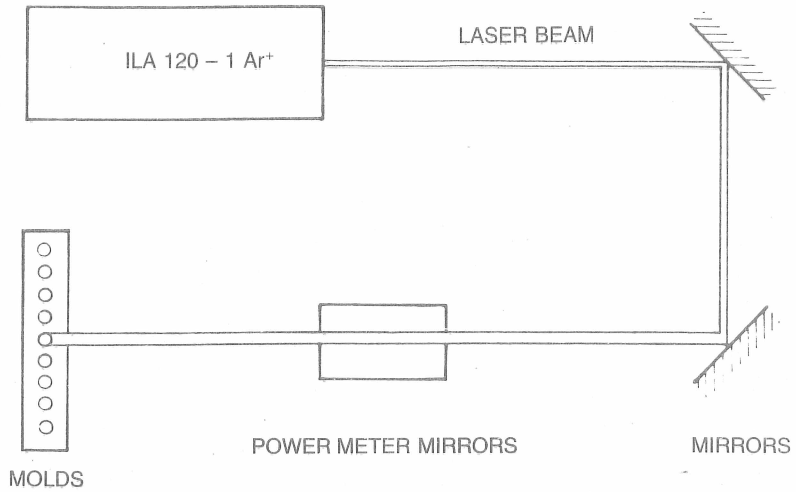

Figure 2. *Laser photopolimerization experimental arrangement*
Slika 2. *Postava za lasersku polimerizaciju kompozitnih uzoraka*

Different composite resins of the light shade were filled into the molds with a plastic instrument. The exposition times were 2, 4, 6, 8 and 10 seconds, controlled by a shutter and a stopwatch. Each illumination was performed three times. Evaluation of the depth of cure was made by scraping away the soft part of the sample and measuring the cured resin with a micrometer.

Results

Figure 3 shows polymerization measurements of two composite resins using full spectral range illumination as a control. The values in the graphs represent the mean of three measurements, with standard deviations. Figures 4, 5 and 6 show the results obtained with three laser lines: 457.9 nm, 476.5 nm and 488.0 nm. Gene-

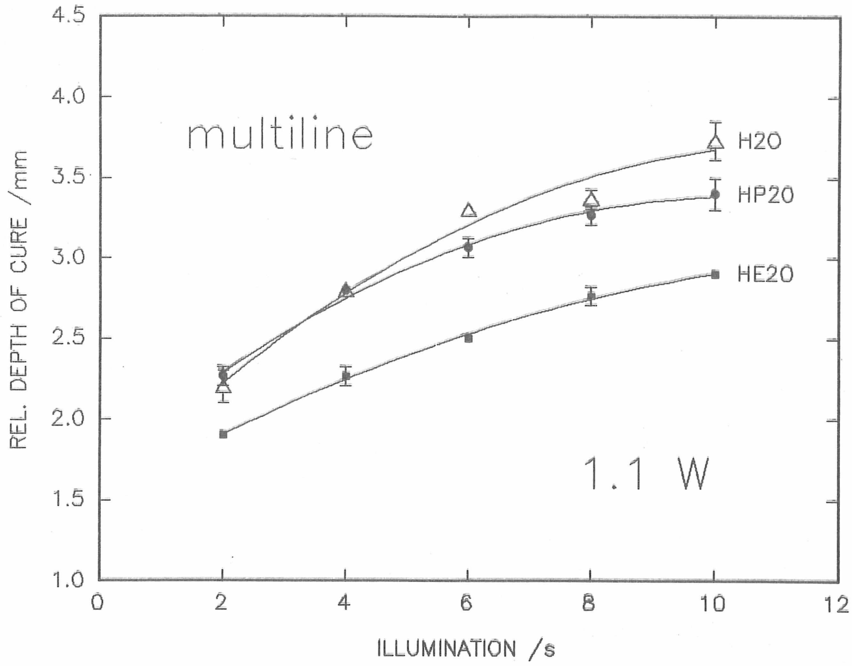

Figure 3. *Depths of cure for Heliomolar (H20), Helioprogress (HP20) and Heliosit (HE20) composite samples with full spectral range of argon laser*

Slika 3. *Dubine stvrdnjavanja triju kompozitnih materijala (Vivadent, Liechtenstein) s čitavim spektrom argonskog lasera*

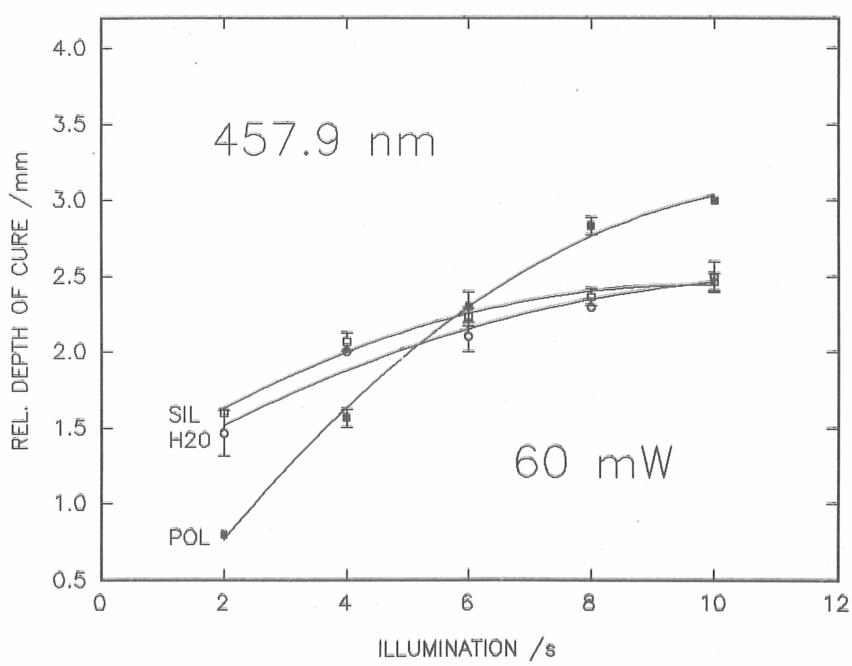

Figure 4. *Mean values and standard deviations for Silux (SIL), Polofil (POL) and Heliomolar samples illuminated by 457.9 nm argon laser beam*

Slika 4. *Srednje vrijednosti i standardne devijacije kompozitnih uzoraka osvijetljenih laserskom zrakom 457,9 nm.*

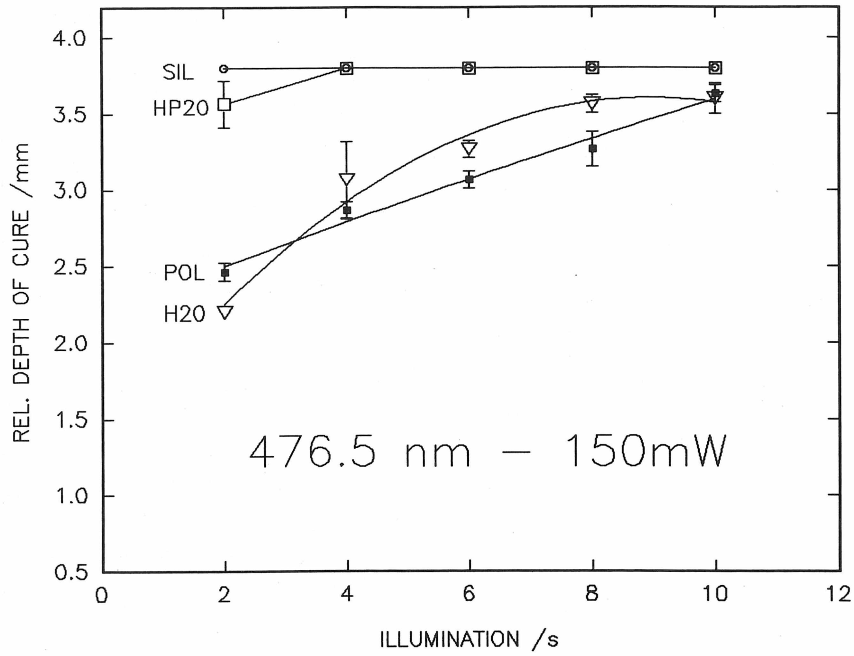

Figure 5. *Photopolymerization results of composite samples illuminated by 476.5 nm argon laser beam*

Slika 5. *Rezultati polimerizacije kompozitnih uzoraka osvijetljenih laserskom zrakom valne dužine 476,5 nm*

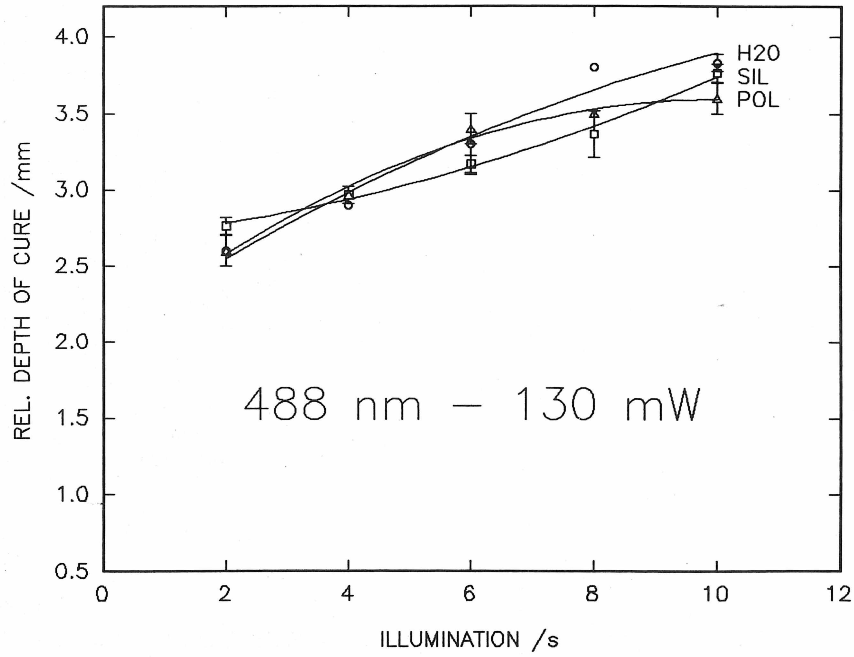

Figure 6. *Depth of cure measurements for three different composite brands exposed to 488.0 nm argon laser beam*

Slika 6. *Mjerenja dubine stvrdnjavanja triju različitih vrsta kompozita osvijetljenih laserskom zrakom valne dužine 488,0 nm* rally, all values, even those obtained with the shortest exposition, were surprisingly high.

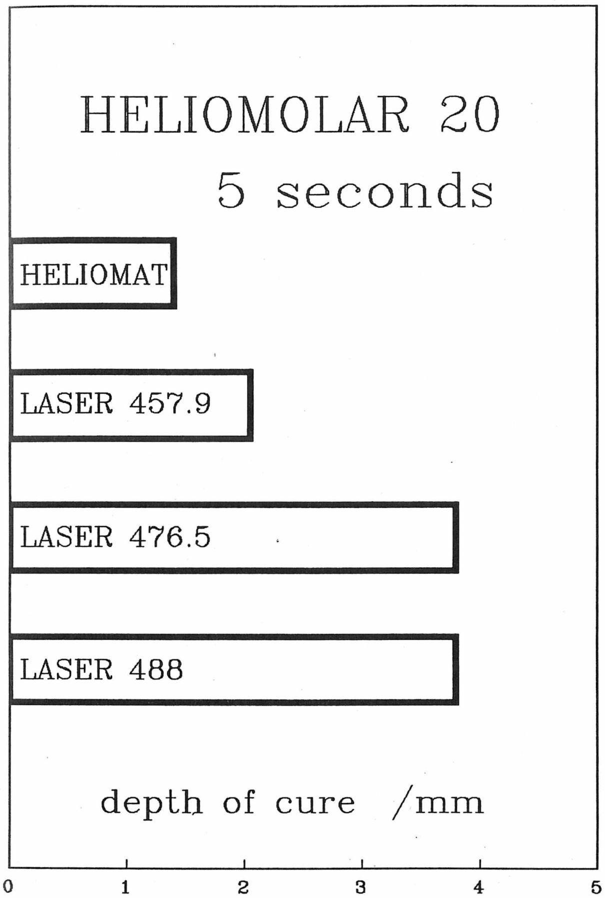

Figure 7. *Comparison between conventional and laser polymerization*

Slika 7. *Usporedba uobičajenog i laserskog načina polimerizacije*

Figure 7 summarizes the depths of cure for Heliomolar Radiopaque (H20) illuminated for 5 seconds with a standard polymerization unit (Heliomat) and the laser. The depth of cure measurements were clearly higher for laser cured samples, especially for wavelengths of 476.5 and 488.0 nm. It must be pointed out that these results are not final, because the depth of the molds was 3.8 mm!

Discussion

Theoretically, the peak photochemical reaction for visible light polymerized composite resins is achieved at a wavelength of 468 nm (6). Standard units produce a blue-violet light ranging from 380 to 600 nm. The aim of this study was to tackle the question of a potential optical hazard and a need of complete double-bond conversion (7). The solution might be in cure with a coherent light source.

The results showed outstanding capabilities of high-powered laser light in comparison with a standard device, especially at wavelengths of 476.5 and 488.0 nm. A similar depth of cure was attained in the multiline mode, but with a considerably higher power output. However, such an arrangement is unsuitable for clinical use, because it is very complex and expensive.

In recent literature, Burtscher (8) has pointed to a potential temperature rise and high contraction values of composites cured with laser light. At the moment, we could not perform a complete physical and chemical analysis of the samples, but low-power laser polymerization studies are currently under way. This is actually a basis for future work on a clinically compact all-solid-state laser curing device.

LASERSKA POLIMERIZACIJA KOMPOZITNIH MATERIJALA

Sažetak

Nedostaci standardnih uređaja za fotopolimerizaciju su relativna nepotpunost stvrdnjavanja kompozitnih ispuna tamnijih nijansi u potkopanim dijelovima ispuna i opasnost za oči stomatologa zbog kroničnog djelovanja bliskog ultraljubičastog svjetla. Za polimerizaciju u laboratorijskim uvjetima po prvi put je korišten argonski laser. Dubine stvrdnjavanja različitih uzoraka kompozitnih materijala određivane su pomoću »scraping« tehnike i pomičnog mjerila. Korišten je cjelokupni spektar lasera i valne dužine 457.9 nm, 476.5 nm i 488.0 nm. Najbolji su rezultati dosegnuti s laserskim linijama koje se poklapaju s vrhuncem apsorpcijske krivulje kamforkinona. Ovakav način polimerizacije nije prikladan za kliničku uporabu, ali bi se laserom male snage i optimalne valne dužine u budućnosti mogla postići potpunija polimerizacija kompozitnih ispuna.

Ključne riječi: *kompozitni materijali, polimerizacija, laser*

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