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Effect of light guide tip diameter of LED-light curing unit on polymerization of light-cured composites

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KEYWORDS
Light emitting diode; Light-cured composite resin; Light guide tip; Light illuminance; Depth of cure; Knoop hardness

Summary *Objective*: The aim of this study was to investigate the influence of the diameter of the light guide tip on the polymerization of light cured composites when light guide tips of different diameters were used with an light-emitting diode (LED)-unit.

Methods: An LED-unit was used with three light guide tips of 4, 8 and 10 mm diameter. Variations of light illuminance with irradiation time of each light guide tip were measured with a lux meter. Two Composites were exposed for 10, 20, 30 or 40 s. Thereafter, the depths of cure of the specimens were measured by the scraping method, and Knoop hardness was measured at 0.5 mm intervals.

Results: The relative light illuminances from the 8 mm tip and 10 mm tip were 45 and 32% of that of the 4 mm tip. The depth of cure for the 4 mm tip was significantly greater than the others. At a depth of 2.0 mm, the 4 mm tip produced significantly greater hardness than the others. The depth of cure of composite irradiated for 10 s using the 4 mm tip corresponded to those of composites irradiated for 20 s using the 8 mm tip and for 30 s using the 10 mm tip. Thus, when the irradiation time was extended, Knoop hardness of the 4 mm tip was not significantly different from the others.

Significance: This study showed that the polymerization of light cured composite was affected by the diameter of the light guide tip of the LED-unit.

Introduction

Halogen bulb based light curing units (halogen light-curing units) have become the most popular method of curing dental composites in the clinical setting, but these light curing units have some defects. The light intensity of the halogen light-curing units decreases over time due to bulb and filter aging [1–3]. Recently, many different types of units have been developed, with newer types of light curing units using other curing methods such as laser, xenon arc and light-emitting diode (LED)-based technologies. Laser and xenon arc curing units have the advantage of a reduced curing time, however, these light-curing units have a larger and more complicated construction, and are more costly than halogen light-curing units and LED-units.

LEDs have a working lifetime of over 10,000 h, while halogen bulbs have a limited effective lifetime of about 40–100 h [4]. The irradiance of

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an individual LED is quite low, when compared with that of a halogen lamp. The photoinitiator of most composites is activated by light in the 450–470 nm wavelength, with 470 nm being the wavelength of peak absorption for the most commonly used photo initiator camphorquinone (CQ) [5]. LEDs can have wavelength peaks of around 470 nm [6–9], so negating the need for filters. In addition, the thermal emission of the LED light-curing units is significantly lower than that of halogen light curing units [10].

The LED-unit can deliver light to the restorative area in the same way as other light-curing units, using various diameters of light guide tip. Although there have been some reports on the influence of the diameter of light guide tip when using other light-curing units [11–13], LED-units have not been investigated in this way. The aim of this study was to investigate the influence of the diameter of the light guide tip on the polymerization of light curing composites when using an LED-unit.

Materials and methods

The light-curing apparatus used was the LUX O MAX (Akeda Dental, Lystrup, Denmark, Lot No. 20.020.369). It uses blue light-emitting diodes as the light source and is a cordless, pencil type. This curing unit with three light guide tips of 4, 8 and 10 mm in diameter as shown in Fig. 1 was used in this study.

Two light cured composite resins as shown in Table 1 were used in this study. The shade of the test material was A2 for each composite resin.

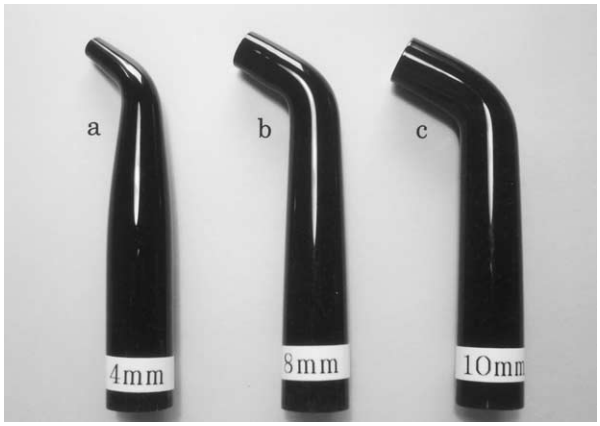

Figure 1 The light guide tips of LED-curing unit used in this study (a) 4 mm in diameter (b) 8 mm in diameter (c) 10 mm in diameter.

Table 1 The light-cured composites used in this study.

Material	Manufacture	Shade	Lot no.
Clearfil AP-X	Kuraray Medical Okayama, Japan	A2	0639AA
Tetric Ceram	Ivoclar Vivadent Schaan, Liechtenstein	A2	D62228

Light illuminance measurement

Variations in light illuminance at the center and margin of each light guide tip were measured using a lux meter (T-1H, Minolta Camera Co. Ltd, Tokyo, Japan) with time. A light-tight black-painted stainless cap with an aperture of 4.0 mm in diameter at its center was placed on the detector of the lux meter. The light guide tip and the lux meter were set so that the detector of the lux meter was parallel to and under the center of the light guide tip. The light illuminance was recorded for 120 s.

Variations of light illuminance with irradiation time at the margin of the 8 and 10 mm diameter light guide tips were measured in a manner identical to that for the light illuminance at the center of the light guide tip, in order to evaluate the difference in light illuminance between the center and the margin of broad diameter light guide tips. The margin of the light guide tip was matched with the margin of the stainless cap with an aperture. The light illuminance was measured at two points on the light guide tip in opposition to each other, and the value was averaged.

Depth of cure measurement

A stainless steel split mold with a cylindrical cavity 4 mm in diameter and 10 mm in depth was used. Composite was filled into this mold, covered with polyester strip (50 μm thickness, 3M ESPE, St Paul, MN, USA), and evened with a glass plate. After removing the glass plate, the light guide tip was adjusted to the center of the resin sample surface through the polyester strip. Thereafter, each composite resin was irradiated for 10, 20, 30 or 40 s with each light guide tip. After 3 min, the scrap test was used to determine depth of cure. The uncured material was carefully removed with a plastic spatula and the depths of cure of the specimens were measured using a micrometer. Three specimens were made for each condition, and the average value was the depth of cure. The data were analyzed using Fisher,s test ($P < 0.05$).