ISSN: 1812–1217

The Effect of Light Curing Tip Distance on Curing Depth of Resin Composite: A Comparative Study.

Ashraf S Qasim
BDS, MSc (Assist Lect)

Department of Conservative Dentistry
College of Dentistry, University of Mosul

ABSTRACT

Aims: To determine the correlation between intensity (I) of light–emitting diode (LED) and tungsten–halogen light sources, and depth of cure of a resin composite at different distances. **Materials and Methods**: LED curing light (Ultra Lite 200E plus) and tungsten halogen light (Astralis 5 Vivadent) were evaluated. Intensity was measured at distances of 0, 2, 4, 6, 8, and 10mm between the light tip and detector. A blackened aluminum plate, 0.5mm thick, with a 4mm–diameter aperture was placed over the detector. The use of this aperture limited the amount of light reaching the detector to a uniform area for both curing lights and also corresponded to the area of the mould for the depth of cure studies. Both light tips were centered on this aperture to reduce any influence of varying I across the light tip. Depth of cure (DOC) of light–curing universal micro hybrid composite shade A2 was also measured. A metallic mould was used to measure the depth of cure at distances of 0, 2, 4, 6, 8, and 10mm between light tip and mould. The degree of divergence of the light of both light curing units was also determined by tracing the illuminated area at a 10mm distance for each of the curing lights. **Results**: For both lights, intensity decreased as distance increased. While, both I and DOC decrease with increasing distance, the relationship between these factors and distance may not be similar for both lights and may depend on the characteristics of individual lights. **Conclusions**: Both I and DOC decreased with increasing distances. DOC usually decreases with decreasing I, the rate of decline varies between various light brands.

Key words: Intensity, Depth of cure, Light emitting diode, Light curing unit.

Qasim AS. The Effect of Light Curing Tip Distance on Curing Depth of Resin Composite: A Comparative Study. *Al–Rafidain Dent J*. 2007; 7(SpIss): 78S-83S.

Received: 25/1/2007 ***Sent to Referees***: 25/1/2006 ***Accepted for Publication:*** 25/2/2007

INTRODUCTION

In recent years, the popularity of esthetic restorations has promoted a rapid increase in use of resins. Methods and devices to prepare and cure resins were developed from chemically cured resins to the modern form of light curing units. Because the polymerization of light–cured resins depends mainly on the characteristics and the type of radiation source used, a way to achieve better properties of the final restoration cured is the improvement of the curing unit[1–4]. In this direction, in the last few years, curing light technology has advanced with the introductions of high intensity (I) halogen lights, LED and plasma arc lights for resin composite polymerization. The main thrust was to develop the curing lights, so that it would result in faster cure of resin composites and generate less heat [5].

Both the light source and the resin composite play an important role in ensuring adequate polymerization. While, the resin composite's composition and shade influence polymerization, light I and wavelength also are contributing factors. A curing light's I depends on the condition of the bulb, filters and light guide; design of the light guide; line voltage and battery power; and the distance of the light from the resin composite surface [4]. In general; total energy, the product of light I and exposure time determines the mechanical properties of the resin composite. Note that the exposure time recommended by the curing light manufacturers may differ from those of the resin composite manufacturers[6,7]. While, most of the above mentioned parameters can be controlled in a clinical situation, the distance of the curing light tip from the resin composite surface is a key variable. If the amount of light reaching the resin composite is reduced, the depth of cure could be decreased [7].

The amount of light reaching the lower layers of the resin composite can be greatly diminished when the distance is increased. While, a number of studies [4,7–12] have shown that light I reduces as distance increases for both tungsten halogen and LED curing light units. It is not clear whether such declines in light I significantly reduce the resin composite's depth of cure (DOC) [8]. To reasonably predict the clinical significance of the light tip–to–composite surface distance, the correlation between I, distance and DOC needs to be established.

The aims of this study is to determine the correlation between I of LED and tungsten–halogen light sources, and depth of cure of a resin composite at different distances.

MATERIALS AND METHODS

LED curing light (Ultra Lite 200E plus) was included in this study. A tungsten halogen light (Astralis 5 Vivadent) was used as a control. Both curing systems were used with a tip diameter of 8mm.

Curing light I was measured using a curing radiometer (MEGA–PHYSIK, Cromatest 7041, Germany) with flat response between 400 and 500nm.

A blackened aluminum plate, 0.5mm thick, with a 4mm–diameter aperture was placed over the radiometer. The use of this aperture limited the amount of light reaching the detector to a uniform area for both of the curing lights and also corresponded to the area of the mould for the depth of cure studies[13]. Both light tips were centered on this aperture to reduce any influence of varying I across the light tip.

The curing light was clamped to a stand and the detector was placed on a movable jack to vary the distance in order to maintain the alignment of the tip to the aperture[14]. The distance of the light tip from the aperture was increased in 2mm increments from 0 to 10mm, and the I at each distance was measured. Five measurements were recorded for each curing light/distance combination.

A light–curing universal micro hybrid composite shade A2 (Voco, Arabesk, Germany, Cuxhaven) was used to measure the DOC at distances from 0 to 10mm. Depth of cure was determined using the method described in the international standard ISO 4049 for polymer–based filling restorative and luting materials, and that has been described in more detail in a previous study [15].

A stainless steel mould (8mm high, 4mm diameter) was placed on a glass slide covered with a polyester film (0.5mm thick). The mold was filled with the resin composite and a second polyester film was placed on top of the filled mold. A glass slide was pressed against the upper polyester film to extrude the excess resin composite and to form a flat surface. The top glass slide was then removed and the entire assembly was placed on white filter paper. Again, the light tip was centered over the mould to ensure similar exposures for I and depth of cure measurements. Five samples were prepared.

Each sample was irradiated with one of the curing lights at the predetermined distance through the top polyester film for 20 seconds. At 3min from the start of irradiation. The sample was removed from the mold, and the uncured material at the bottom of the sample was removed by scraping it away manually with a plastic spatula and alcohol. The remaining length of the cured sample was measured using a digital vernia. Five samples were used to determine the DOC for each curing light/distance combination. The LED curing light was corded to maintain a full charge before use. Curing lights were used at a controlled input voltage of 220±1V using a voltage regulator.

For each light, analysis of variance (ANOVA) and a Student t–test was used to detect statistically significant differences ($P \leq 0.05$) for both I and DOC between the different distances of the light from the resin composite surface. The extent of dispersion of the light at 10mm was recorded by tracing the outline of the illuminated area as the light was shined on a paper.

RESULTS

Table (1) showed the one way analysis of data (ANOVA) for the intensity of LED and Halogen light which demonstrated a significant difference between LED and Halogen. The Duncan's multiple range test and the mean intensity (I) for each light at the different distances from the aperture were shown in Table (2). For each light, statistically significant differences in I of the light were recorded between distances. Figure (1) showed the decline in I values as the curing tip is moved away from the detector. Though the two lights tested exhibit a decrease in I with distance, the rate of intensity loss was not the same for the both lights.

Table (1): Analysis of variance of intensity for LED and Halogen light

Source of variance	Sum of Squares	df	Mean Square	F-Value	*P*-Value
Between Groups	189500.750	11	17227.341	17227.341	.000
Within Groups	24.000	24	1.000		
Total	189524.750	35			

df: degree of freedom.

Table (2): Duncan's Multiple range test of different intensity for LED and Halogen light

	Distance	No.	Mean	Duncan's groups
LED light	0	5	259	A
	2	5	230	B
	4	5	161	E
	6	5	93	H
	8	5	51	I
	10	5	30	J
Halogen light	0	5	201	C
	2	5	185	D
	4	5	157	F
	6	5	114	G
	8	5	78	H
	10	5	50	I

Means with different letters were statically significant

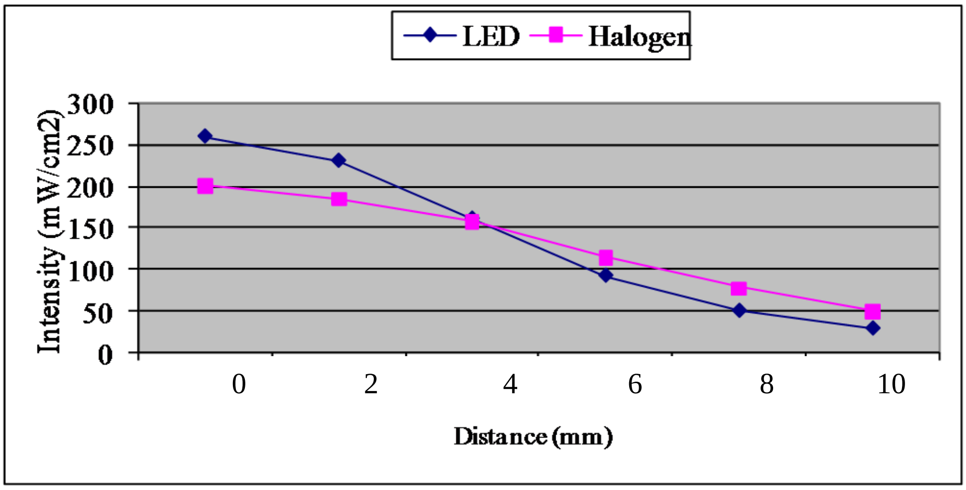

Figure 1: Variation of intensity with distance.

The one way analysis of data (ANOVA) for the DOC was shown in Table (3) which showed a significant difference. Table (4) showed the Duncan's multiple range test and the mean depth of cure (DOC) for each light at different distances. Results showed a significant difference in DOC for the same light at every 2mm increase in distance but between the two lights only some distances showed a significant difference in DOC. The LED light showed the most reduction in DOC at 10mm when compared against the value at 0mm. Figure (2) showed the linear decline in DOC with distance.

Table (3): Analysis of variance for depth of cure of composite cured by LED and Halogen light

Source of variance	Sum of Squares	df	Mean Square	F-Value	*P*-Value
Between Groups	9.535	11	.867	115.186	.000
Within Groups	.181	24	.008		
Total	9.715	35			

df: degree of freedom.

Table (4): Duncan's Multiple range test for depth of cure of composite cured by LED and Halogen light

	Distance	No.	Mean	Duncan's groups
LED light	0	5	5.7	A
	2	5	5.4	B
	4	5	5.05	CD
	6	5	4.9	D
	8	5	4.3	F
	10	5	4.02	G
Halogen light	0	5	5.4	B
	2	5	5.1	C
	4	5	5	CD
	6	5	4.9	D
	8	5	4.5	E
	10	5	4.07	G

Means with different letters were statically significant

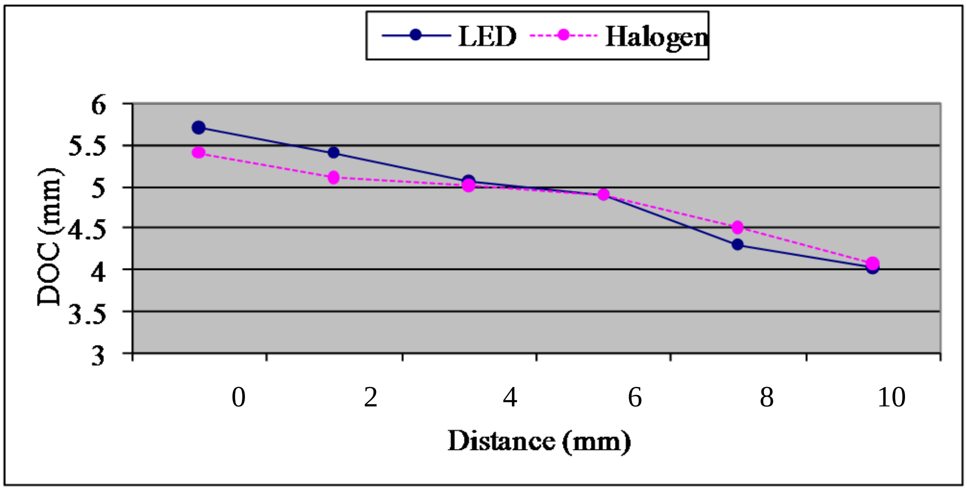

Figure 2: Variation of depth of cure with distance.

Table (5) presented the degree of divergence determined by tracing the illuminated area at a 10mm distance for both of the curing lights. Halogen light had the least divergence of the light beam at 10mm.

Table (5): Diameter of illuminated area (mm) for each light at a distance of 10 mm.

Light	Diameter of illuminated area (mm)
LED	25
Halogen	18

DISCUSSION

This study measured the I of LED light and tungsten halogen light at distances of 0, 2, 4, 6, 8, and 10mm. Using the same series of distances between the lights and the resin composite surface, the DOC of the micro hybrid composite shade A2 for each light was also measured. The loss of I with increasing distance was not the same for the two lights. Although, it is generally accepted that the light I decreases with distance exponentially [8,10]. Theoretically, I of a light source will be proportional to the inverse of the distance squared. However, this popular theory is true only when the light is emitted from a non–coherent point source and when the distance is measured starting at the source of the light. In this study, the I value at 0mm was measured at the light tip as the beam of light emerges from the light guide. Depending on the type of guide and the arrangement of the optic fibers, the beam of light may disperse to different degrees as it leaves the source. Differences in light dispersion vary the amount of light reaching the detector, resulting in various relationships between I and distance for different lights. For both lights tested, our results show that the DOC reduced (Figure 2) with increasing distance from the resin composite surface. In addition, at all distances tested for each light in the study, the DOC of the micro hybrid composite shade A2 was greater than 2mm, the incremental thickness recommended by the manufacturer. However, for both lights that were tested a statistically significant difference existed for the DOC values for every 2–mm distance increase. Previous studies[5,16] have reported similar results for DOC reduction at increased tip–to–composite distances.

The reduction in I was not matched by a similar reduction in the DOC. The same study also showed a high divergent angle for the LED which again coincided with the rapid reduction in I and DOC with distance seen in this study [16].

In part, reduction in DOC and I may result from changes in beam collimation as the curing light is moved away from the resin composite surface. One way to compensate for the reduction in I with distance would be to increase the exposure time, which would help maintain a constant level of total energy supplied to the resin composite. Even at distances as great as 10mm, the total reduction in DOC was less than 2 mm. Hence, though it may be possible to achieve significant resin composite cure at increased light tip–to–composite distances, it may be prudent to stay within the incremental technique recommended by the resin composite manufacturers.

CONCLUSIONS

Both I and DOC decreased with increasing distance while, DOC usually decreases with decreasing I, the rate of decline varies between various light brands. For both of the lights tested in this study. The DOC for the micro hybrid composite shade A2 was above the manufacturer recommended incremental thickness of 2mm, even at a distance of 10mm.

REFERENCES

1. Friedman J. Variability of lamp characteristics in dental curing lights. *J Esthet Dent*. 1989; 1(6):189–190.
2. Dugan WT, Hartleb JH. Influence of a gluteraldehyde disinfecting solution on curing light effectiveness. *Gen Dent*. 1989; 37(1):40–43.

3. Fan PL, Wozniak WT, Reyes WD, Stanford JW. Irradiance of visible light–curing units and voltage variation effects. *J Am Dent Assoc*. 1987; 115:442–445.
4. Felix CA, Price RB. The effect of distance from light source on light I from curing lights. *J Adhes Dent*. 2003; 5(4):283–291.
5. Cristina K, Aparecida MT, Daniel VG, Vanderlei SB. Hardness evaluation of a dental composite polymerized with experimental LED–based devices. *Dent Mater*. 2001; 17:309–315.
6. Miyazaki M, Ohida Y, Moore BK, Onose H. Effect of light exposure on fracture toughness and flexural strength of light–cured composites. *Dent Mater*. 1996; 12(6):328–332.
7. Suh BI, Cripe CA, Cincionne F. Shrinkage stress relaxation using pulsed curing. *J Dent Res*. 1998; 77: 280.
8. Price RB, Derand T, Sedarous M, Andreou P, Loney RW. Effect of distance on the power density from two light guides. *J Esthet Dent*. 2000; 12(6):320–7.
9. Meyer GR, Ernst C, Willershausen B. Decrease in power output of new light–emitting diode (LED) curing devices with increasing distance to filling surface. *J Adhes Dent*. 2002; 4(3):197–204.
10. Prati C, Chersoni S, Montebugnoli L, Montanari G. Effect of air, dentin and resin–based composite thickness on light I reduction. *Am J Dent*. 1999; 12(5): 231–234.
11. Moseley H, Strang R, Stephen KW. An assessment of visible–light polymerizing sources. *J Oral Rehabil*.1986; 13:215–224.
12. Sakaguchi RL, Douglas WH, Peters MC. Curing light performance and polymerization of composite restorative materials. *J Dent*. 1992; 20(3):183–188.
13. Nomoto R, McCabe JF, Hirano S. Effect of aperture size on irradiance of LED curing units. *Dent Mater*.2004; 20: 687–692.
14. Hansen EK, Asmussen E. Reliability of three dental radiometers. Scan *J Dent Res*.1993; 10: 115–119.
15. Fan PL, Schumacher RM, Azzolin K, Geary R, Eichmiller FC. Curing–light I and depth of cure of resin–based composites tested according to international standards. *J Am Dent Assoc*. 2002; 133(4):429–434.
16. Hansen EK, Asmussen E. Visible–light curing units: correlation between depth of cure and distance between exit window and resin surface. *Acta Odont Scand*. 1997; 55(3):162–6.