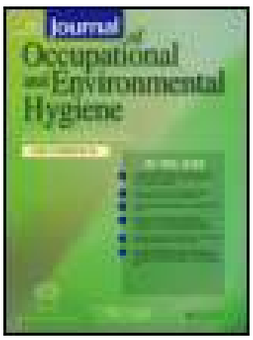

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The Dental Curing Light: A Potential Health Risk

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The Dental Curing Light: A Potential Health Risk

ABSTRACT

Powerful blue-light emitting dental curing lights are used in dental offices to photocure resins in the mouth. In addition many dental personnel use magnification loupes. This study measured the effect of magnification loupes on the 'blue light hazard' when the light from a dental curing light was reflected off a human tooth. Loupes with 3.5x magnification (Design for Vision, Carl Zeiss, and Quality Aspirator) and 2.5x magnification (Design for Vision and Quality Aspirator) were placed at the entrance of an integrating sphere connected to a spectrometer (USB 4000, Ocean Optics). A model with human teeth was placed 40 cm away and in line with this sphere. The light guide tip of a broad-spectrum Sapphire Plus (Den-Mat) curing light was positioned at a 45-degree angle from the facial surface of the central incisor. The spectral radiant power reflected from the teeth was recorded 5 times with the loupes over the entrance into the sphere. The maximum permissible cumulative exposure times in an eight-hour day were calculated using guidelines set by the ACGIH. It was concluded that at a 40 cm distance, the maximum cumulative daily exposure time to light reflected from the tooth was approximately 10 minutes without loupes. The weighted blue irradiance values were significantly different for each brand of loupe (Fisher's PLSD p5,000 mW/cm^2, and LED light curing units that deliver a spectrally narrow radiant power in the 430 to 480 nm range on the maximum permissible daily exposure times.

The current ISO 10650 standards for LCUs[25, 26] limit the radiant exitance in the 190 nm to 385 nm region to no more than 200 mW/cm^2. Figure 6 shows that this LCU has negligible output in the

UVA range at the distances used in this study. Thus dental personnel do not appear to be at risk for UV-mediated ocular damage from this LCU.

This study found that all the loupes increased the radiant flux entering the integrating sphere. Although the radiant flux received by the sphere, or equivalently by the eye, was greater when loupes were used, the magnified image on the retina caused the maximum cumulative daily exposure time from the Sapphire PAC light to increase between 16 and 28 minutes. The larger image size on the retina may increase the retinal hazard as a consequence of the spot-size dependence of retinal thermal injury.[43] Furthermore, the beneficial effect of eye movements to reduce the time-averaged retinal irradiance for a small source may be reduced due to the fact that when loupes are used, the eyes are more fixed looking at one spot on a tooth. Thus, these maximum exposure times may need to be less.[52] Further studies are required on the ocular hazards of using loupes and the overall cumulative effects of other high output light sources in the dental office. Loupe manufacturers could effectively eliminate the blue-light hazard by incorporating a bandpass filter in the loupes that cuts out light below 500 nm, and that can be flipped up when not needed.

CONCLUSIONS

The light radiated by the broad spectrum dental LCU used in this study may be potentially hazardous to the operator's eyes.

1. When looking at the reflected light from human teeth without magnification loupes, at 40 cm distance, the maximum cumulative daily exposure time to light reflected from the tooth was approximately 11 minutes.

2. All the loupes increased the weighted blue light irradiance received by the eye.

3. Although the radiant flux received by the eye was greater when magnification loupes were used, the surface area of the image was increased by the square of the magnification. Thus the hazard was less and the maximum cumulative daily exposure time using the plasma arc light curing unit increased to 16 - 28 minutes.

4. Lack of eye movement when using loupes and potential thermal injury associated with a larger image on the retina may increase the damaging effects of the higher radiant exposure to the retina.

RECOMMENDATIONS

Anyone who uses a dental light-curing unit should be cognizant of the cumulative ocular 'blue light' hazard from the light. When photocuring resins, they should wear protective eyeglasses that have been designed to filter out the harmful wavelengths.

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1.Lee JG, Ramos EN, Price RB, Perry RD, Labrie D, Sullivan B. Effect Of Loupes On Ocular Blue Light Hazard: Direct Viewing Paper IADR 2013 #674

https://iadr.confex.com/iadr/13iags/webprogram/Paper170245.html

2.Ramos, EN, Lee JG, Price RB, Perry RD, Labrie D, Sullivan B. Effect Of Loupes On Ocular Blue Light Hazard: Indirect Viewing Paper IADR 2013 #675

https://iadr.confex.com/iadr/13iags/webprogram/Paper170392.html

Figures and Tables

Figure 1: Blue-light hazard function representing the potential harmful radiation by visible light to the retina.

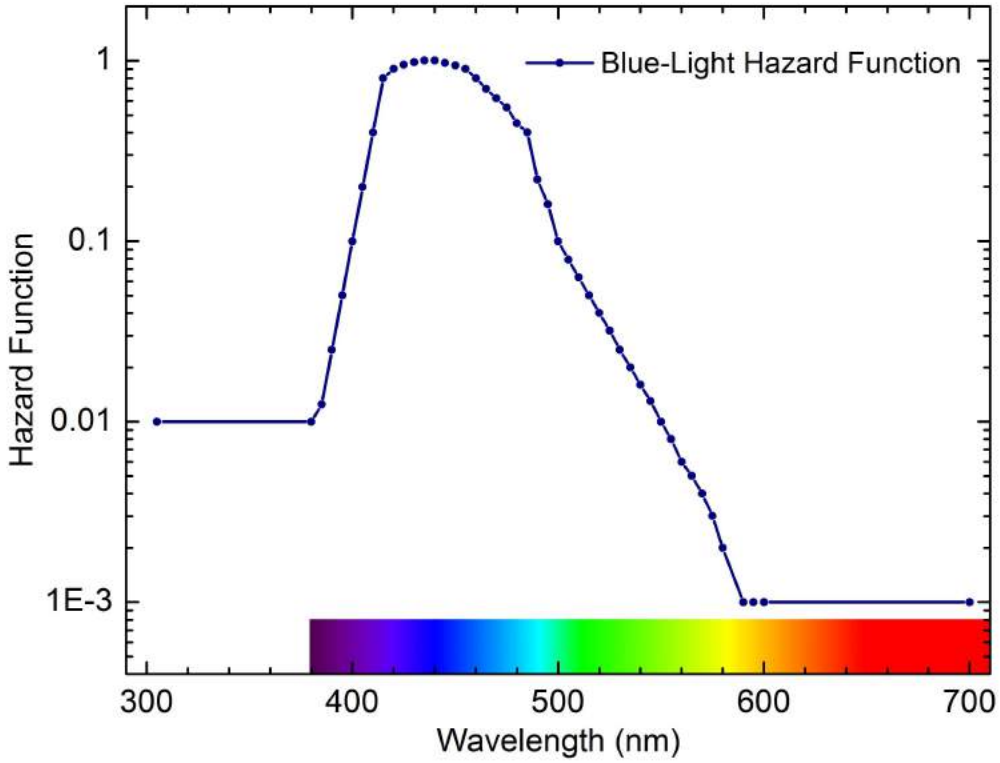

Figure 2. Direct (a) and indirect viewing (b) from a light-curing unit (LCU) at a distance of 40 cm. The subtense angle, α, and projected solid angle, Ω_p, as seen by the eye are defined in (b) where h and w are the height and width of the LCU tip image on the tooth, respectively. In (c), the spectral radiant power, P_λ, is measured as a function of wavelength, λ, using an integrated sphere –

spectrometer system. The spectral irradiance at the entrance aperture, E_λ, and radiance, L_λ, are given by the equations below.

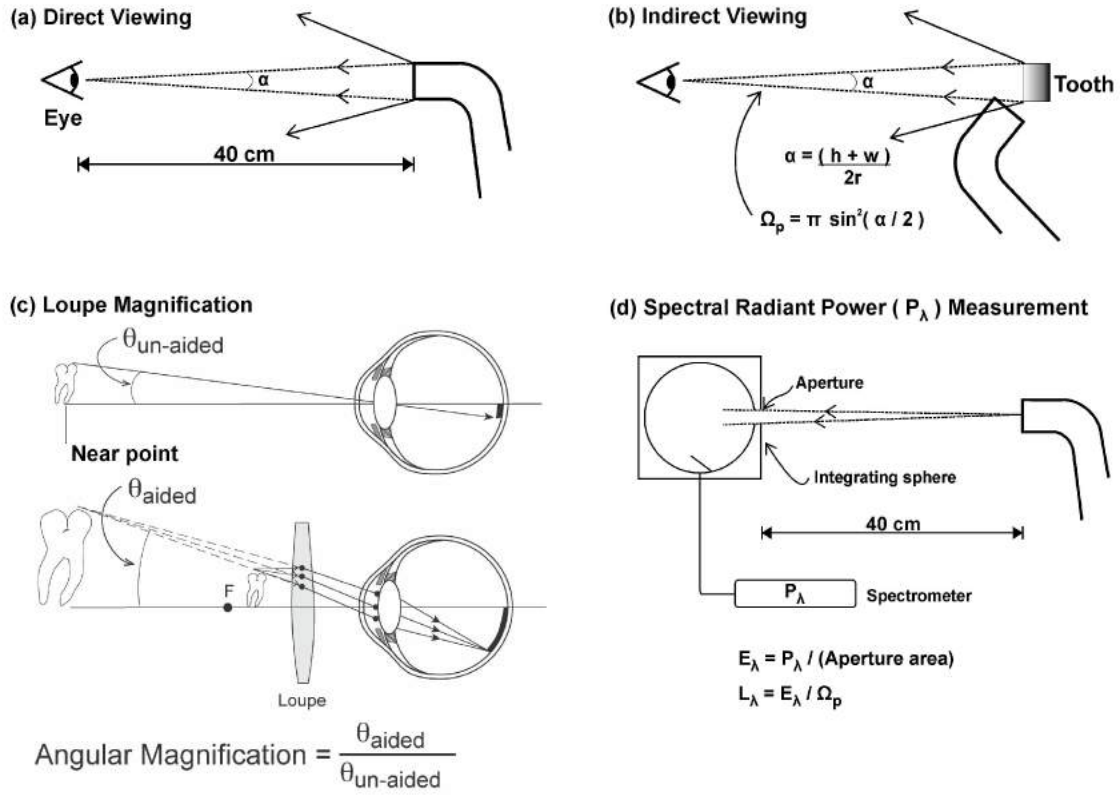

Figure 3: The five magnification loupes evaluated in this study. Design for Vision 2.5 x [A], Design for Vision 3.5 x [B], Quality Aspirator 2.5x and 3.5x [C]), Carl Zeiss 3.5x [D].

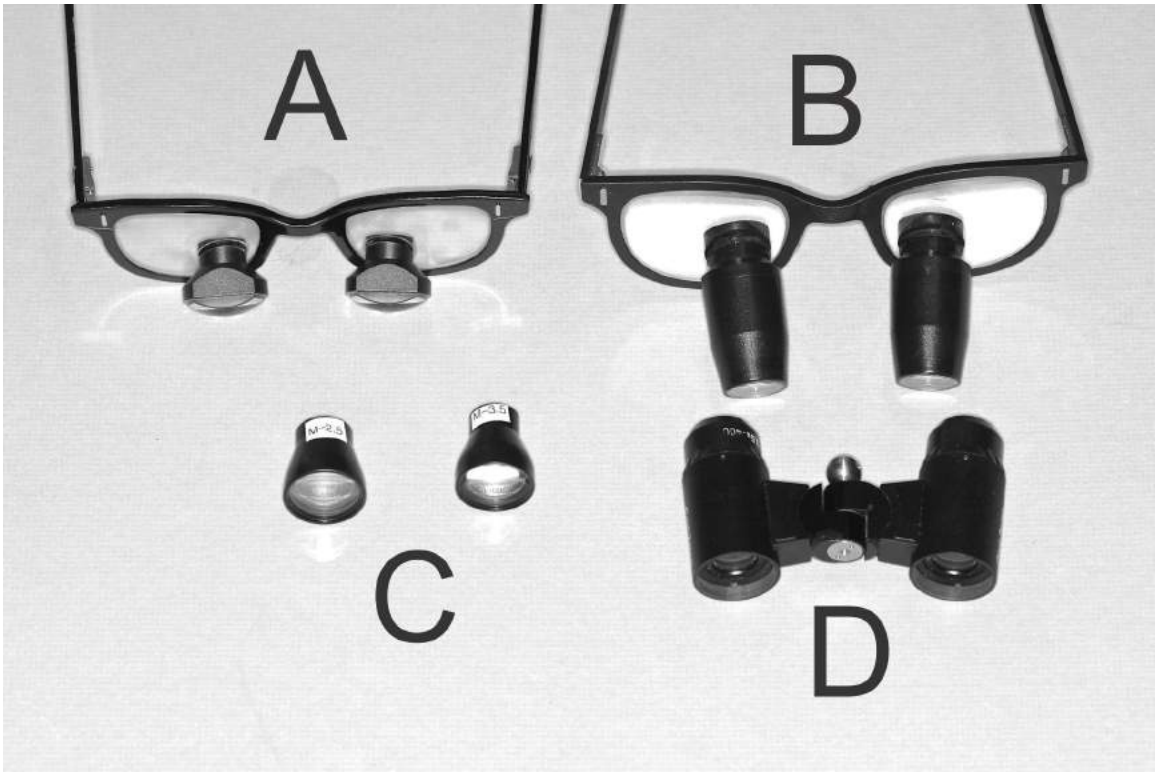

Figure 4: Light passing through the magnification loupes and entering the integrating sphere through a 4 mm diameter aperture mimicking light entering the eye.

Figure 5 Light output from the light curing unit reflected off the facial surface of a maxillary central incisor when photocuring a dental restoration on the side of the tooth.

Figure 6: Spectral radiant power (μW/nm) from the Sapphire LCU viewed indirectly at a distance of 40 cm after the light was reflected from the facial surface of a maxillary central incisor. Note the absence of light radiated by the LCU below 400 nm, or above 510 nm.

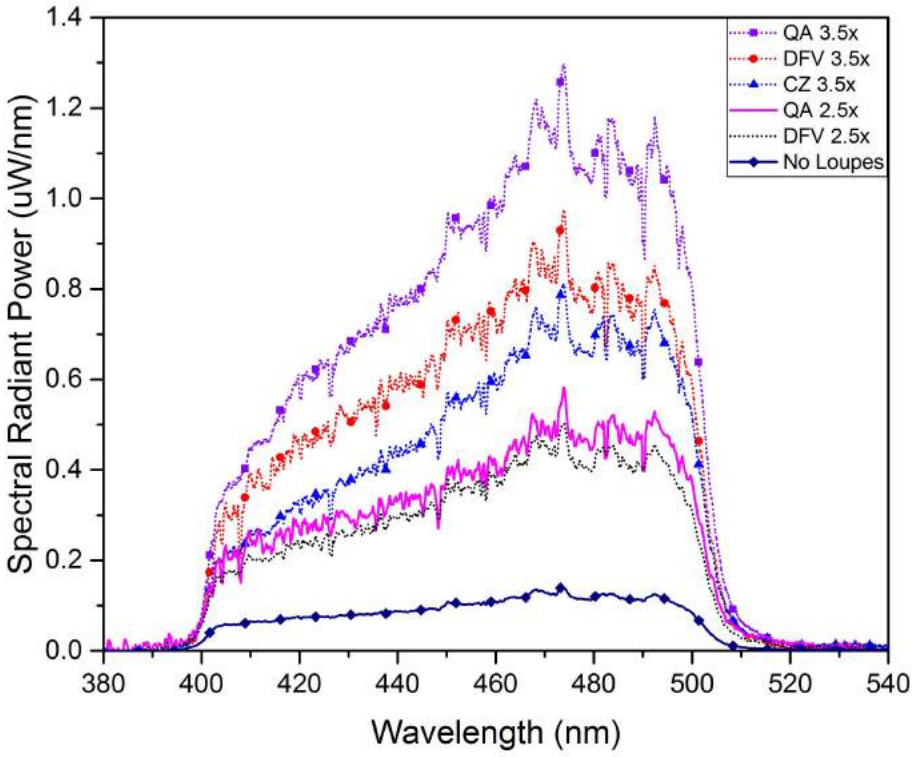

Table I: Maximum daily exposure time, t_{max}, when directly viewing the Sapphire LCU at a distance of 40 cm both with and without 3.5x magnification loupes (Design for Vision [DFV], Carl Zeiss [CZ], Quality Aspirator [QA]), and 2.5x magnification loupes (DFV and QA).

DIRECT VIEWING	**No Loupes**	**CZ 3.5x**	**No Loupes**	**QA 2.5x**	**DFV 3.5x**	**QA 3.5x**
	Day 1		Day 2			
LCU Radius (cm)	0.415	0.415	0.415	0.415	0.415	0.415
Distance (cm)	40	40	40	40	40	40
Weighted blue light irradiance (mW/cm^2)	4.98	25.82	4.29	14.11	30.46	34.27
Alpha (mrad)	20.7	20.7	20.7	20.7	20.7	20.7
Magnification	1.0	3.5	1.0	2.5	3.5	3.5
Projected Solid angle (msr)	0.338	4.14	0.338	2.11	4.14	4.14
Radiance ($W/cm^2/sr$)	14.73	6.24	12.69	6.68	7.36	8.28
t_{max} (s) in an 8 hour day	7	16	8	15	14	12

Table II: Maximum daily exposure time, t_{max}, when viewing the light from a Sapphire LCU reflected off a maxillary central incisor at a distance of 40 cm both with and without 3.5x magnification loupes (Design for Vision [DFV], Carl Zeiss [CZ], Quality Aspirator [QA]), and 2.5x magnification loupes (DFV and QA).

Indirect Viewing	No Loupes	QA 2.5x	DFV 3.5x	No Loupes	DFV 2.5x	QA 3.5x	No Loupes	CZ 3.5x
	Day 1			Day 2			Day 3	
LCU Radius (cm)	0.415	0.415	0.415	0.415	0.415	0.415	0.415	0.415
Distance (cm)	40	40	40	40	40	40	40	40
Weighted blue light irradiance ($\mu W/cm^2$)	53	130	330	54	170	430	49	250
Alpha (mrad)	20.7	20.7	20.7	20.7	20.7	20.7	20.7	20.7
Projected	0.338	2.11	4.14	0.338	2.11	4.14	0.338	4.14

Solid angle (msr)								
Radiance ($mW/cm^2/sr$)	157	62	80	160	80	104	145	60
t_{max} (s) in 8 hour Day	640	1600	1300	630	1200	960	690	1700

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