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Shedding Light on a New Risk: High Intensity Dental Curing Lights

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Disclosures

- I have no financial interest in any specific product or service covered today, but I am the inventor and developer of a new form of curing light eye protection that will not be discussed in this presentation.

Objectives

- To become familiar with the mechanisms and forms of ocular damage that can occur as a result of exposure to high intensity blue light
- To become familiar with the types of eye protection available for use with dental curing lights and understand their advantages and disadvantages
- To understand the risks to patients and operators if curing light users use no eye protection and opt to look away to avoid blue light exposure
- List 3 workplace practices to help ensure the use of eye protection when using dental curing lights

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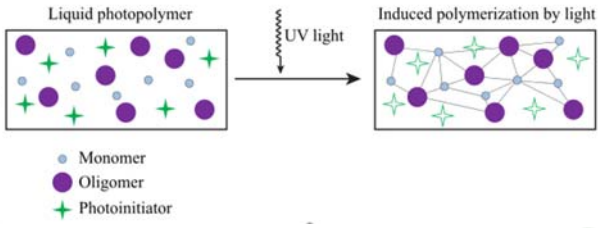
My Story

History of Curing Lights in Dentistry

- Composite resins capable of being light-cured were developed in the 1960's.
- Early light curing units (LCU's) utilized shorter UV wavelengths and had a limited depth of cure.
- Source: Strassler 2011

UV Light Radiation-induced polymerization reaction



Visible Light Curing

- Shorter wavelength/higher energy/limited depth of cure
- In the 70's quartz-halogen curing lights emitted blue light over a broad spectrum with intensities around 400 mw/cm2.
- The most common photoinitiator has been camphorquinone (CQ), which responds to wavelengths between 460 and 480 nm.
- When CQ is subjected to light radiation in this range, a free radical is formed from an amine that in turn attacks the monomer and creates growing chains of polymers.

Source: Strassler, 2011

Increased Speed=>Increased Profit

In the 90's, light manufacturers offered new technologies to reduce cure times

Emitted wavelengths remained consistent, yet intensities increased from 600 mw/cm2 to 1300 mw/cm2

Heating of pulp an issue

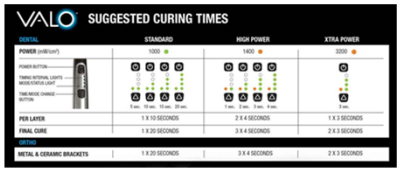
Source: Strassler, 2011

The Dawn of the LED Lights

- Light-emitting diode (LED) lights introduced in the late 1990's offered the following advantages:
  - Less heat generation
  - Reduced power demands
  - Higher light output
  - Consistent output over entire lifespan
  - Cordless options
  - Broader light spectrum for photoinitiators other than CQ

Source: Strassler, 2011

The Increase in Curing Light Intensities



- 1970-1990:
  - 400-600 mw/cm2
- 1990's:
  - 1000 mw/cm2
- Early LED's:
  - 1500 mw/cm2
- The highest output LED's today:
  - Nearly 6000 mw/cm2

Source: Ultradent website, Valo Cordless, Technical Details

The Dental Curing Light—Essential for Many Procedures

- Within the average dental practice, roughly 1000 composite resin fillings are placed annually
  - Most require multiple cures
- Additional curing light uses:
  - Sealants, veneers, cementing crowns, some whitening systems, orthodontic brackets, temporary crowns and their cements, etc.

Source: Strassler, 2014

So, how often are curing lights used?

- 1000 composite fillings per year, with an estimated average of 3 cures per filling=3000 cures annually for fillings
- 10 additional uses per day for other services x 200 days/year=2000 cures annually for other services
- 5000 cures per year / 200 days worked = 25 cures per day

Education level/Awareness of Dentists

- In one study 84% did not know the intensity of their curing light(s), and 67% did not know the wavelengths of their lights
  - 99% took no additional precautions for patients taking photosensitizing medications
  - 7% utilized no forms of protective eyeware
- Another study found that practicing dentists were no better at delivering light energy than first year dental students
  - All groups studied were able to deliver significantly more light energy after proper instruction
- A 2006 study found only 84% of dental schools provided blue light eye protection to their students

Sources: McCusker, 2012; Price, 2014; Hill, 2006

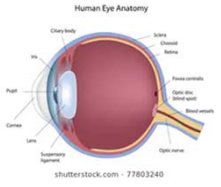
Education level/Awareness of Dentists (cont.)

- In one study, 100% of dentists satisfied with lights, yet less than ½ of the lights worked properly
- Multiple studies have shown that dentists don't consider increased light sensitivity of individuals with hx of cataract surgery or photosensitizing
- Another study found nearly 1/3 of the dentists surveyed used inadequate eye protection against the blue light emitted by dental curing lights.
- The same study found nearly 80% did not know the irradiance value of their LCU's, and therefore could not have known appropriate cure times for their lights.

Sources: Price, 2014; Kopperud, 2017

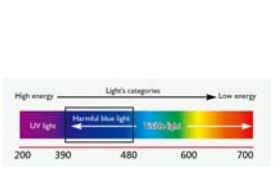
The Blue Light Hazard: Mechanisms and Forms of Ocular Damage

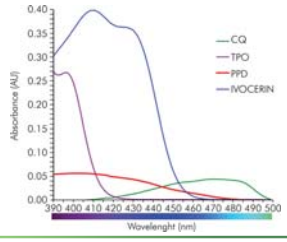
- Eye anatomy
- Wavelengths/penetration depths of ocular tissues
- UV-A radiation exposure:
  - Damage to cornea, cataractogenisis
  - Opacification of the lens
- Blue Light exposure:
  - The most damaging wavelength of blue light is 440nm
  - The narrow band of light may not evoke protective aversion response



Source: Price, 2014

Harmful blue light vs. photoinitiators





How Blue Light Damages the Retina

- A study on LED curing lights found that curing without appropriate filtration can bleach retinal rhodopsin within 20 to 40s
- Blue light transmits through the ocular media and is absorbed by the retina
- High levels cause retinal burning
  - Immediate, irreversible, yet not noticeable in mild cases
- Chronic exposure can cause retinal aging and degeneration
- Chronic photochemical injury from blue light will accelerate age-related macular degeneration

Source: Price, 2014

Effects of Retinal Burning and Macular Degeneration

- The visual cycle explained
- Photoreversal and the capacity of the eye to absorb blue light
- Repeated exposure to blue light causes cells to heat up and die
- The macula is the central portion of the retina able to communicate the most detailed visual information to the brain
- Macular degeneration is incurable causes a blind spot in the central portion of affected individual's visual field

Source: Inglis-Arkell, 2014

Age-related Macular Degeneration

Early AMD – Usually no vision loss, therefore eye exams are critical. Early AMD is diagnosed when drusen are found beneath the retina.

Intermediate AMD – May be some vision loss, but may be no symptoms. Larger drusen and/or pigment changes are found on the retina.

Late AMD – At this stage, vision loss has become noticeable.

Source: American Macular Degeneration Foundation website

For some people with macular degeneration there is a sudden blurring or loss of sight in the center of vision while the rest is in focus.

Forms of Eye Protection Available

- **Paddles** are held in place by an extra worker, and are positioned to protect the eyes of the curing light operator
- This requires two people
- The eyes of the person holding the paddle usually aren't protected
- The person holding the paddle has a difficult time positioning it

Forms of Eye Protection Available

Loupes with built-in filter

- Effective and convenient
- Other than dentists, few wear loupes
- Possible to still catch glimpses

Forms of Eye Protection Available

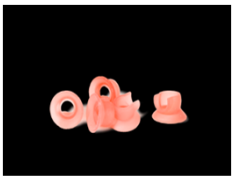
Oval Filters

- Most common forms of eye protection supplied by curing light manufacturers
- As the curing light is turned to cure different aspects of teeth, it needs to be continually repositioned into view
- Limited coverage, usually have a short lifespan before acrylic fractures

Forms of Eye Protection Available

Nose Cones

- Woefully inadequate due to poor filtration and significant light scatter
- Make access to certain teeth and/or aspects of teeth difficult



Forms of Eye Protection Available

Glasses/Goggles

- Offer the best protection
- Require operators to remove other forms of eye protection before using them, and need to be removed after curing light use

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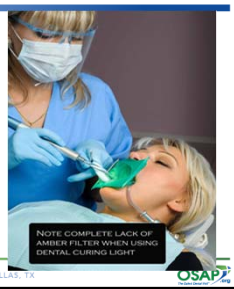
Examples of Improper Use and Inadequacies



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Examples of Improper Use and Inadequacies

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Looking Away—A Common Practice

- Many opt to look away while curing for protection
- I assume this practice is rooted in efficiency
- A prominent product evaluator mentioned that over 50% of offices practice this "technique"

Source: Kopperud, 2017

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The Hazards of Looking Away for the Operator

- Studies have shown that operators get occasional glimpses of blue light
- The narrow band of blue light does not provoke the typical response of closing eyes in bright light
- As few as 7 light exposures in a workday are enough to cause permanent damage to the retina
- This damage is irreversible and cumulative in nature, and can take years to cause noticeable visual impairment

Sources: Rassaei, 2013; Price 2014

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The Hazards of Looking Away for the Patient

- Multiple sources indicate that looking away severely impairs ability to properly cure
- The curing light tip either tends to drift off target, or is not placed in the correct position from the beginning
- Light drift or early/delayed activation can shine light in patient's eyes
- Undercured restorations more likely to exhibit post-operative sensitivity, bulk fracture, premature failure, microleakage, staining, etc. and require replacement

Sources: Strassler 2012; Price 2014; Price 2016;

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Speaking of the Patient….

- There is limited to no data on use patterns for patients wearing curing light protective filtering glasses
- Protective filtering glasses for the patient are the only available option
- Also, unable to find specific regulatory guidance on patients wearing amber glasses during the curing process
- Many feel the light is inside the mouth and causes no risk, but scatter and/or light drift can expose patients

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The Megremis Study

- Dr. Spiro Megremis, Director, Research and Evaluations, Science Institute of the ADA presented research at the AADR in 2016 entitled "The Ability of Protective Filtering Devices and Shields to Block Transmission of 'Blue Light' from Curing Units"
- His research showed that 6 of 15 brands of protective filtering devices (oval filters and goggles) and 3 of 7 brands of protective shields did not adequately block blue light emitted from quartz-halogen lights, single-peak LED curing lights, or both
- Thus, a high percentage of curing light users are using eye protection and unknowingly being exposed to harmful blue light and suffering eye damage

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Let's Take Inventory…

- A known hazard, the dental curing light, has undergone dramatic increases in intensity in the past decade
- Regulatory guidance and enforcement has been virtually non-existent
- Dental personnel are untrained, unaware, or not concerned with this risk
- The dental workplace is drifting away from the solo-practitioner model and towards a higher-volume, hurried environment

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3 Work Practices that can Make a Difference

1. Stock rooms with a number of options for eye protection
2. Keep eye protection stored immediately next to the LCU
3. The hazards of using dental curing lights should be included in annual OSHA training, OSHA should mandate the use of eye protection when using curing lights,

Potential Steps to Improve Safety

- Education in dental programs to include the ocular risks from LCU's and require the use of eye protection
- Safety training for dental personnel to include discussion of ocular risks posed by LCU's
- Regulations for mandated use of eye protection during light curing procedures.
  - Not at discretion of dental personnel
  - Regulation and standardization of approved eyewear

Resources

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