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Curing Lights and the science behind them- An Overview

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Abstract: Curing of composites is a complex mechanism. Light is used to activate the photo-initiator system in the light curing units. Ideal requirements for curing light have been mentioned in the article. The article also sums up the various generations focusing on advantages, disadvantages and various advances in the same field. It has been concluded that an appropriately polymerized material has a positive influence on both the physical and biological properties of the restoration and should aid in promoting clinical success.
Keywords : *Light Cure Units, LED, Composites.*

I. INTRODUCTION

Since the birth of dentistry there has been a continuous attempt to formulate a material and technique which fulfills aesthetic requirements, besides having the expected physical, mechanical and biological properties to behave favorably in the oral environment. Clinical efficiency of a light curing unit is crucial for obtaining the optimal polymerization and a successful outcome [1]. With the research in the field of restorative materials, a need for an appropriate curing unit has always been felt.

According to Strassler H. E [2], in the early **1960s**, the first light curing resin composites were introduced, this led to the development of the first curing light.

The first dental curing light was developed in the **1970s**. It was the Nuva Light (developed by Dentsply/Caulk) that used ultra violet light in order to cure the material. This was discontinued because of the use of UV light. Also, these lights were not very effective due to the shorter wavelengths that limited the depth of cure.

According to Frederick A [3], during the early **1980s** advances in the area of visible light curing took place. Only a few years following the introduction of UV radiation for curing dental restoratives, the ability of using visible radiation was introduced: February 24, 1976. On that day, Dr. Mohammed Bassoiuny of the Turner School of Dentistry, Manchester, placed the first visible light-cured composite restoration on Dr. John Yearn, the then head of department. This advancement led to a curing device that now uses blue light. The next type of curing light that developed was the quartz-halogen bulb. This device had longer wavelengths of the visible light spectrum and allowed for greater penetrating curing light and light energy. The halogen curing light replaced the UV curing light.

The **1990s** presented great improvements in light curing devices. It improved previous devices as well as developing new devices. As there were advancements with dental restorative materials, the technology to cure these materials improved as well. The main focus was to improve the intensity in order to be able to cure faster and deeper.

In **1998,** the plasma arc curing light was introduced. It uses a high intensity light source, a fluorescent bulb containing plasma, in order to cure the resin-based composite. It claimed to be able to cure material in 3 seconds. However, on average it took between 3 to 5 seconds.

II. Ideal requirements for curing light

The ideal light-curing unit should have:

- Broad emission spectrum
- Sufficient light intensity
- Minimal drop off of energy with distance
- Multiple curing modes
- Sufficient duration for multiple curing cycles
- Durability
- Large curing footprint
- Easily repairable [4].

III. Generations of Light Curing Unit

The light curing units are classified into the following five generations**:**

1st Generation- Ultra-Violet Light
2nd Generation- Visible Light Curing Units
3rd Generation- Plasma Arc Units
4th Generation- Light Emitting Diodes
5th Generation- Lasers

3.1. Ultra-Violet Light Curing Units

Like many advances in dentistry, the technology for using light to polymerize resin-based materials did not originate within the profession, but instead was an existing technology that was adapted for dental use. The first photo-curing units were designed to emit ultraviolet light (about 365 nm) through a quartz rod from a high pressure mercury source and were introduced in the early 1970s. This development was seen as a revolutionary step in dentistry, for it allowed a “cure on demand” feature, which was previously unattainable using the self-curing products. Typical exposure durations were 20 seconds, but 60 seconds provided enhanced results.

Filled, photo-curable composites as well as sealant materials were available, and were used in very innovative ways to not only restore carious processes, but to also repair tooth fractures and provide easily performed esthetic results. The photo-initiating system relied on benzoin ether-type compounds, which broke down into multiple radicals, without need of an intermediary component. The spectral distribution of light sources of the time with the absorption spectrum of the initiator helps to correlate these two parameters. Although some of the restorations placed using this early technology have proven to be remarkably successful, in general the procedure was fraught with many issues.

3.1.2 Drawbacks

1) Because of the limited ability of light to penetrate deep within the material, incremental build-ups were required instead of bulk placement, and were limited in depth.

2) In addition, concerns were voiced about the potential for harmful effects of the short wavelength energy being exposed to human eyes (corneal burns and cataract formation) as well as possible changes in the oral microflora.

3.2. Visible Light Curing Units

Curing of dental composites with blue light was introduced in the 1970s. The source of this blue light is normally a halogen bulb combined with a filter, so that blue light in the 410 nm-500 nm region of the visible spectrum is produced. Light in this range of wavelengths is the most effectively absorbed by the photo-initiator (camphorquinone) that is present in the resin component of light activated dental composites. This light then causes excitation of the camphorquinone, which in combination with an amine produces free radicals. This results in polymerization of resin monomers at the molecular scale.

The quartz bulb contains a tungsten filament which heats up in the halogen gas. The light from the bulb is collected by reflecting it from a silverized bulb from behind the mirror toward the path down the fiber-optic chain to the tip. The surface of the mirror should be kept clean. When this surface gets heated up, vapors from the mercury, bonding agent solutions or moisture might get condensed over it. The surface should be routinely cleaned using alcohol or methyl ethyl ketone solvents on cotton swabs to renew its effectiveness. Macroscopically, the dental composite hardens, typically after light exposure times ranging from 20 seconds to 60 seconds. The blue light is delivered to the dental treatment area using various types of light guides. These guides may be fused rigid glass fiber bundles or molded polymer guides. Some guides use a flexible pipe containing a transparent liquid to transmit the light [2].

Although halogen bulb based light curing units are most commonly used to cure dental composites, this technology has many drawbacks. Halogen bulbs have a limited effective lifetime of around 50 hours [2]. This implicates a reduction of curing efficiency over time by aging of the components. Many Quartz Tungsten Halogen lamps used in dental offices operate beneath the minimum power output specified by the manufacturers. The insufficient maintenance of the light source and especially the light tip may deteriorate the performance of the light curing unit further over time. The clinical implication of this for the dentist is a negative effect on the physical properties of composites with an increased risk of premature failure of restorations. The lower effective limit of irradiance for halogen technology based Light Curing Units used in dental practice has been suggested to be 300 $mWcm^2$. Some halogen Light Curing Units available presently exceeds an irradiance of 1000 $mWcm^2$. This can be attributed to the insufficient maintenance by the clinicians.

3.2.1. Drawbacks Of Quartz Tungsten Halogen

This type of curing light however has certain drawbacks:

- High temperatures that the filament generates. This makes the unit large in order to house the fan.
- The fan generates a sound that may disturb some patients, and the wattage of the bulb is such (e.g. 80W) that these curing lights must be plugged into a power source, that is, they are not cordless.
- Furthermore, this light requires frequent monitoring and replacement of the actual curing light bulb because of the high temperatures that are reached. (For example, one model uses a bulb with an estimated life of 50 hours which would require annual replacement, assuming 12 minutes' use per day, 250 days per year).
- Also, the time needed to fully cure the material is much more than the Light Emitting Diode curing light. This implicates a reduction of curing efficiency over time by aging of the components.

3.3. Plasma Arc Units

This unit has been developed after the technology used by The United States National Aeronautics and Space Association (NASA) in aeronautical engineering [5]. Plasma arc curing lamps emit light at higher intensities and were primarily designed to save irradiation time as an economic factor. Plasma Arc Curing lamps emit light from glowing plasma, being composed of a gaseous mixture of ionized molecules such as xenon molecules and electrons [6]. Plasma Arc Curing units are characterized by high intensities in a narrow range of wavelengths around 470 nm. Due to the described high energy output of plasma arc systems, the manufacturers of these lamps repeatedly claimed that 3 seconds of Plasma Arc Curing irradiation would achieve similar material properties compared to 40 seconds curing with Quartz Tungsten Halogen lamps. However, this claim has been fully rejected. Today, recommendations for Plasma Arc Curing lights are based on 3 x 3 seconds.

3.4. Light Emitting Diodes

Light Emitting Diodes, such as those encountered as indicators in car dashboards, have lifetimes of over 10,000 hours and undergo little degradation of light output over this duration of time. Also, Light Emitting Diodes require no filters to produce blue light [7]. The spectrum flux of Light Emitting Diode is concentrated over a much narrower bandwidth than that of Quartz Tungsten Halogen or Plasma Arc Curing [4]. Several generations of Light Emitting Diode light-curing units have been introduced over the last few years.

The 1st generation Light Emitting Diode lights generally were low in intensity and did not cure materials completely. The alternative photo-initiators used in bleach shades and the incisal (translucent) shades of composites and in sealants and bonding agents could not be activated by these “blue-light” units. The 2nd generation Light Emitting Diode light-curing units (Bluephase, Elipar Freelight 2, L.E. Demetron 1, Radii, Allegro, SmartLite iQ, Cure) have a single, high-powered diode with multiple emission areas. These units show a large surface area of emission and high-energy output. The 3rd generation Light Emitting Diode light-curing units (UltraLume 5) have two or more diode frequencies and they emit light in different ranges to activate CQ and alternative photo-initiators [8].

The halogen bulbs operate with a hot filament, the Light Emitting Diodes use junctions of doped semiconductors (p-n junctions) for the generation of light. In gallium nitride Light Emitting Diodes under forward biased conditions, electrons and holes recombine at the Light Emitting Diodes p-n junction leading to the generation of blue light. A small polymer lens in front of p-n junction partially collimates the light [4]. In the recent years, the development of high power Light Emitting Diodes is comparable to the advances we have seen with the high tech computer technology. The use of high power Light Emitting Diodes have shown high outputs even with single diodes. However, the heat generation with these has become a major concern in the clinical field.

3.4.1 What’s New

GC has developed the G-Light, a curing light which utilizes the very latest in Light Emitting Diode technology. Many new dental materials do not contain the light initiator camphorquinine and thus cannot be cured by conventional 'blue light' Light Emitting Diodes. The G-Light's blue and violet Light Emitting Diodes give you two different wavelength peaks at the same time, ensuring an optimum curing of all of your Visible Light Curing unit materials. With a high intensity, narrow spectrum of light, it emits the maximum amount of light energy right to the tip of the hand piece. This rechargeable light can be used over 400 times for 10 seconds without any reduction in its intensity. Its constant light energy guarantees efficient and deep curing every time [9].

3.5. Lasers

Dental lasers were introduced and recognized as a tool for better patient care in the early 1990s.The wavelength of the argon laser(between 450 and 500 nm) has been used effectively to polymerize composite resins because it enhances the physical properties of the restorative material compared with conventional visible light curing. Lasers produce little heat, because of limited infrared output. The argon laser is useful in Class II composite restorations, not only because of the decreased curing time needed, but also the small fiber size allows for easy access of the curing light to the interproximal box area and provides a highly satisfactory result for the completed restoration. A major limitation of arc and laser lamps is that they have a narrow light guide (or spot size). This requires the clinician to overlap curing cycles if the restoration is larger than the curing tip.

Laser (Light Amplification by Stimulated Emission of Radiation) light is defined as being coherent, unidirectional, monochromatic, collimated and potentially high-energy yielding. Theodore H. Maiman developed the first lasers. It was a pulsed laser, in 1960. Since then, dental interest in lasers has been of keen interest.

3.5.1. ADVANTAGES

Because of the properties of the argon laser described above, the thoroughness and depth of composite resin polymerization are greater with this laser than they are when Visible Light Curing Unit sources are used. Less un-polymerized monomer is found in resins cured by argon laser compared to those cured with Visible Light Curing Units. This thoroughness results in the enhancement of certain physical properties of the laser cured composite resin, including compressive strength, diametric tensile strength, transverse flexural strength and flexural modulus.

Wear resistance is equivalent when using either method of polymerization, but argon laser polymerization has demonstrated the potential to improve shear bond strength in both enamel and dentin. Another study found no significant difference was reported in bond strengths according to distance between the resin surface and the light source. It has been found that the laser cured bond strengths did not decrease, whereas there was a significant decrease in the halogen cured bond strengths at distances greater than 0.5mm also, laser required less time to achieve equivalent or greater polymerization of restorative material.

3.5.2 DISADVANTAGES

1) Size, weight and portability
2) Heat generation
3) Cost
4) Risk to surrounding tissues
5) Temperature increase
6) Visual damage

3.5.2. ADVANCES

"Pulsed argon laser" may be a solution for the shrinkage problem. Pulsing or periodic interruption of the beam can be precisely control Light Emitting Diode in nanoseconds. The theory is that interruption of the beam allows the target material to cool between laser pulses, thus preventing overheating.

Argon lasers currently available in the market are the HGM dental 200,300 and 400 series (HGM Medical Laser Systems, Salt Lake, UT). Argon lasers are available only in 488nm wavelengths for curing and tooth whitening purposes.

IV. Conclusion

Appropriately polymerized material will have a positive influence on both the physical and biological properties of the restoration and should aid in promoting clinical success. This article focused on various light cure units available today. The never-ending advancements in the field of conservative dentistry encouraged us to investigate and document about this topic. Advancements in the light cure units have continuously followed the advances in the restorative materials.

References

[1]. Malhotra N, Mala K. Light-curing considerations *for* resin-based composite materials*: a* review. *Part* I. Compendium of continuing education in dentistry *2010*;*31*(7):498-505.
[2]. Strassler HE. Cure depths using different light units. Dental Town Magazine 2002, August:22-24.
[3]. Frederick A, Rueggeberg. State of the art: Dental photocuring-A review. Dental materials. 2011; 27: 39-52
[4]. Oyama N, Komori A, Nakahara R. Evaluation of Light Curing Units Used for Polymerization of Orthodontic Bonding Agents. Angle Orthodontist. 2004 Dec;74(6):810-815.
[5]. Knezevic A et al. Degree of conversion and temperature rise during polymerization of composite resin samples with blue diodes. Journal of Oral Rehabilitation. 2005 May;32(5):362-367.

[6]. Kramer N et al. Light curing of resin-based composites in the Light Emitting Diode era. American Journal of Dentistry. 2008 June;21(3):135-142.
[7]. Mills RW, Jandt KD, and Ashworth SH. Dental composite depth of cure with halogen and blue light emitting diode technology. British Dental Journal 1999; 186(8): 388-391.
[8]. Light Emitting Diode Light-Curing Units. *Journal of the Canadian Dental Association*. 2005 Nov;71(10):710-711.
[9]. The latest in Light Emitting Diode technology. British Dental Journal. 2010;209:146-14.