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Dental Curing Light and Your Eyesight

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Abstract

Light-activated materials are used in orthodontics for many purposes such as bonding of orthodontic brackets etc. However, these materials require high-irradiance blue light LED that is used are capable of polymerizing dental light-activated materials in less than 10 seconds. Despite the advantage over light activation time, high irradiance blue light is able to cause serious ocular damage. Thus, this short commentary will place the issues within dental curing lights and it health risks. Lastly, it will be present thoughts for future considerations in the field.

Keywords: Polymerization, Curing Light, photoinitiators

Introduction

One of the great advances in the profession of orthodontics has been the introduction of light-cured adhesives.[1] Mills was the first to suggest the use of led in orthodontics.[2] bonding of orthodontic brackets started being employed in orthodontics in the 1960's by using the enamel acid etching technique. At that time, only auto-polymerizing materials were available. With the introduction of light-activated adhesive systems, orthodontists had sufficient time to position the bracket on enamel surface and remove the excess material. This evolution has allowed the emergence of several other bonding methods using different composites and light-curing devices.

During the early 1980s, advances in the area of visible light curing took place, which ultimately led to the creation of a curing device that uses blue light. The next form of curing light developed was the quartz-halogen bulb; this device had longer wavelengths and allowed for larger penetration of the activity light for resin composites.[3]

The nineties had given nice enhancements in light curing devices. As, dental restorative materials advanced, so did the technology to cure these materials; the main focus was to boost the intensity so as to cure faster and deeper. In 1998 the plasma arc was introduced. It uses a high intensity source of illumination, a fluorescent bulb containing plasma, in order to cure the resin-based composite, and claimed to cure resin composite material within 3 seconds. However, whereas the plasma arc activity established to be standard, negative aspects (including, but not limited to, an expensive initial price, curing times longer than the claimed three seconds, and expensive maintenance) of these lights resulted in the development of other curing light technologies.

As the technology advanced newer curing light developed which had high intensity and reduced the curing time, which became more efficient for the orthodontist. We know that every material has its own beneficial and negative sides. These lights were introduced to replace the older ultraviolet polymerizing curing units which, could cause ocular damage. A study was carried out on blue light polymerizing sources which concluded that none presented a UV hazard to the operator in normal use but this blue light from new units may give rise to retinal damage.[4] Blue light is the most hazardous component of the visible spectrum because of high-energy, short-wavelength radiation that can lead to the production of free radicals that react freely with lipids, proteins, carbohydrates, and nucleic, acids. [5]

Intense light can cause retinal damage either by thermal injury or at certain wavelengths, by inducing damaging photochemical processes in the retina. For example, if higher intensity of radiation is applied than usual while keeping the curing light constant, thermal injury may be induced in the patient's oral tissue. Conversely, applying too low radiation or too short curing can cause inadequate bonding of brackets or failure of restoration.

The depth of cure of visible light composites is dependent on material factors (resin chemistry, filler fraction, particle size), optical properties (shade, translucency, refractory index) and on the intensity and duration of exposure of the visible light source. The light intensity of visible light-curing units is not constant but diminishes in use with deterioration of the light bulb, filter and reflector, and wear of the light guide. The main purpose of present article was to give physical and biological interaction of dental curing light its side effects and challenges of achieving ocular protection. Special attention is paid to operator's eyesight.

Physical characteristics of curing light source

The light curing source was first described by Tavas and Watts. The light used falls under the visible blue light spectrum. This light is delivered over a range of wavelengths and varies for every type of device. There are four basic types of dental curing lights; tungsten halogen, light-emitting diode (LED), plasma arc curing (PAC), and laser. The two main dental curing lights are the halogen and led. Different curing lamps have completely different emission spectra within the electromagnetic 350–550 nm spectrum and have different intensity. The polymerization effect is obtained, in most cases, by way of the photo initiator camphorquinone, in itself an allergen. The emission range of halogen lamps is 350–550 nm with peaks between 470–490 nm within the blue and blue-green light region, and a light intensity of at least 0.4–1.1 w/cm2. The intensity of halogen lamps may be as high as 10,000 times that of sun radiation within certain wavelength ranges in the visible light region. Most plasma arc light lamps and light-emitting diode (led) lamps have a narrower wavelength interval. Many of them have no UV component, although a new led lamp is now on the market with a 400-nm peak in addition to a 450-nm peak. There are plasma arc lamps presently out there with spectral ranges from 380 nm. These plasma arc lamps have a better intensity and older led lamps have a lower intensity as compared with lamps. Previously, the majority of curing lamps in the dental clinic were of halogen type, with some radiation in the UVA range. Presently, newer led lamps have the same or even higher intensity compared with halogen lamps. It is subjective experience of the authors that the trend for newly developed curing lamps leans toward led lamps.

Potential oral tissue and dermal effect

The radiation exposure depends upon angle of light beam, the distance of light source and the lamp spectrum, 10-

30% of curing light is reflected towards the operator. The possibility of enhanced reflection resides in the use of oral mirror or strips during the curing process, while the dark colored rubber dam represent a reduced reflection.

The studies did not prove, exposure from curing lamps during normal use and a normal day would reach threshold limit values for blue light on skin. However, the UV fraction of the lamp with highest intensity applied getting ready to the operator's skin would reach the TLV in eleven min. These limits are set for activity exposure for staff not at risk of photosensitivity. If workers suffer from photosensitivity diseases or are taking photosensitizing drugs, these limits do not apply. A study on UV absorption potency of gloves shows that latex gloves absorb 76% of UVA whereas vinyl gloves absorb solely 33% of the radiation.[6]

The oral tissues are not uniform structures in the sense that the thickness of the epithelial layer, the keratinization, the vascularization and the hydration differ from site to site. These factors might represent variations compared to skin with reference to light absorption, scattering and reflection.

It is accepted that allergic sensitization by way of mucosal exposure is more difficult to accomplish than by dermal exposure, presumably because of the difference in the concentration of langerhans cells. In addition, a delayed reaction is not as easily provoked on the mucosal surface as on skin. Epidermal tests are therefore used also for intraoral reactions. However, it is not thoroughly investigated whether photosensitized reactions may be induced differently in the mucosa than in skin. The oral mucosa has experienced less evolutionary tolerance to reactions evoked by radiation and, hence, repair mechanisms may not have been developed to the same extent as in skin.

Experimental data indicate that oral exposure to curing light is accompanied by a t-cell induced inflammation. An adhesive also increased the t-cell number, but the combination adhesive/light exposure did not increase this response[2], probably due to a shielding effect by the polymerized adhesive. Although more scarce than in skin, the fact remains that melanocytes and immune presenting cells are present in the oral tissues and that exogenous irradiation-absorbing molecules originating from food, various oral hygiene products or medications and corresponding endogenous molecules (haemoglobin, riboflavin, dna) are accessible to the curing light. Some of the suspected allergic reactions where the allergen is not found might therefore be attributed to photoallergic reactions.

Normally, thermal effects are not expected in either tissue because the temperature of the curing process does not reach a level leading to tissue coagulation. However, heat transfer from the irradiated area is a factor of major importance in influencing the temperature rise caused by irradiation. Heat transfer is dependent on the vascularization, which varies with age and the quality of tissues, such as in the tooth pulp. Depending on the vascularization, 100 mw/cm^2 is typical thermal threshold irradiance for long-time irradiation, which will take several minutes to cause a thermal increase.

Potential effect on retina

Conjunctiva

The mucous membrane of conjunctiva can be easily damaged by UV, that activates a complex series of oxidative reactions and distinct pathways of cell death. Squamous cell carcinomas of the conjunctiva are possible and frequently begin at the limbus. A study showed ocular melanomas, such as choroidal melanoma, to be eight to 10 times more common in caucasians than blacks.[7] UV radiation is thought to be a risk factor in both of the above findings. There is evidence to support an association between chronic UV exposure and the formation of a conjunctiva. This thickening of the mucous membrane and membrane is especially seen in people who live in sunny climates and people who work outdoors. The prevalence of pterygia occurring on the nasal conjunctiva has been explained by peripheral light focusing onto the medial anterior chamber beneath the limbal corneal stem cells. Actively dividing stem cells are likely to have a lower damage threshold than non-mitotic corneal epithelial cells.A weaker link has been found between UV radiation and the formation of pinguecula with a high prevalence found in populations that live in both sunny and snow-covered environments.

Cornea

Both the corneal epithelium and endothelium (which cannot regenerate) are vulnerable to UV radiation. Increased UVB exposure causes damage to the antioxidant protective mechanism, resulting in injury to the cornea and other parts of the eye. A significant amount of UVB is absorbed by corneal stroma, so thinning with keratoconus or refractive surgery allows more UVB to reach the lens. It is not yet known whether surgical stromal thinning increases the risk of cataract. Whilst many of the pathologies associated with UV exposure are chronic, taking years to develop, photokeratitis is an obvious example of an acute response to UV radiation. Also known as snow-blindness, this reversible condition is characterised by severe pain, lacrimation, blepharospasm and photophobia. The corneal epithelium and bowman's layer absorbs about twice as much UVB radiation than the posterior layers of the cornea. It is the superficial epithelium that becomes irritated in photokeratitis. A one hour exposure to UV reflected off snow or a six to eight hour exposure reflected off light sand around midday is enough to cause a threshold photokeratitis. At levels below this there may still be mild symptoms of ocular discomfort. Climactic droplet keratopathy, or spheroidal degeneration, is a permanent pathological change characterised by an accumulation of droplet-shaped lesions in the superficial corneal stroma. Chronic exposure to environmental UV radiation has been suggested as a significant factor in its development.[6]

Effect on eye

Adverse effects on the eyesight are the most important aspect of biological injury from curing radiation, either as direct, accidental eye exposure or as cumulative effects of scattered radiation following unprotected use of curing lamps. The phenomena is explained by anatomy and function. Visible light reaches specified photoreceptors in the retina that may be subjected to photochemical injury if the intensity of the radiation is high enough. The blue-light retinal injury is comparable to the injury following direct exposure to sunlight (solar retinitis). Harmful effects of this kind are seen by short radiation exposure with high intensity, or by moderate exposure throughout prolonged time. The harmful result could appear once many days and should continue for weeks. In severe cases permanent retinal injury is perceived as a blind spot within the centre of the field of vision.

Besides, it is assumed that blue-light exposure amplifies aging and chronic processes within the eye. It has been seen that LED light cause dark spot in vision leading to cataract. Thermal damage isn't thought about to contribute to such injuries.

Discussion

Various LED's have been introduced in market with different intensity claiming short exposure durations and low process. Other, development of lithium polymer battery technology has provided lighter and durable power supplies. However, with the introduction of battery less dental curing light has greatly expanded the lifetime dental curing lights. Manufacturer have also produced curing lights to design beam divergence to well optimize beam heterogenicity A study was carried out in which it proved, that 30% reflection from curing light radiation and 30cm distance should be maintained between dental operation site and operator. The above calculations were performed according to the exposure limit guidelines set by the American Conference of Governmental and Industrial Hygienists (ACGIH) and the International Commission on Non-Ionising Radiation Protection (ICNIRP). The maximum estimated reflected light for eye was about 1min/day and for a direct (accidental) blue-light exposure with zero distance from the eye should not exceed 1sec. This was additionally true for the ultraviolet part of halogen lamps. The reflected ultraviolet light from halogen lamps failed to exceed the exposure limits for eye or skin exposure.[12]

Information from operating instructions

The instructions illustrate the potential adverse effects from curing light exposure.[12] Extracts of the instructions for the light-emitting diode lamp are cited here:

1. Irradiation must not be directed towards the eyes, illumination must be restricted to the area of the oral cavity in which the clinical treatment is intended.
2. Irradiation of soft tissue should be avoided as excessive exposure to high-intensity light may cause damage or irritation. If applicable, cover such areas.
3. Do not use in patients with a history of photobiological reactions—or who are currently on photosensitizing medication (including 8-methoxypsoralen or dimethylchlorotetracycline).
4. Individuals with a history of cataract surgery may be particularly sensitive to the exposure to light and should be discouraged from ELIPAR TRILIGHT treatment. Treatment is acceptable if special safety measures like the utilization of protecting specs to get rid of blue violet and ultraviolet illumination square measure undertaken.
5. Individuals with a history of retinal disease should seek advice from their ophthalmologist before operating the unit. This cluster of people should take extreme care and go with any and every one safety precautions (including the utilization of appropriate lightweight filtering safety goggles).
6. The low maximum time for direct (accidental) UV/ blue-light eye exposure strongly suggests that any curing lamp should be shut off at all times when not actively used.

Prevention of adverse radiation

The maximum blue-light exposure of 1 min/day avoid adverse reactions using halogen lamps, and is not valid for all curing lamps. On the other hand, the more intense blue light radiation of plasma lamps as well as newer LED lamps may lead to even shorter maximum exposure time. PACL is 5 times more intense than that form HCL. Although curing units with higher intensities, operating for a minimal time, are recommended to produce sufficient curing depth and good mechanical properties, the radiometer manufacturer claims that an intensity of, 200 mw cm^2 is inadequate, even with an increased curing time. A predictive model for depth of cure by Rueggeberg et al. suggests that increased duration of exposure can compensate for decreased intensity in some situations. Miyazaki et al. Report that the fracture toughness and flexural strength of composites were identical when irradiations with the same amount of energy (light intensity 3 curing time) are used, even with a low light intensity of 100 mw cm^2. However, at some lower point, longer exposure times did not compensate for reduced light intensity moreover, at low light intensities, the flexural strength of composites decreases significantly during storage in water and the potential for leaching increased. Therefore, although the lower limit of intensity that can be compensated for is not fully determined, an adequate degree of light intensity is always desired.

Eye protection in the form of UV- and blue-light filtering goggles, not sun glasses, is therefore necessary for dental personnel. Ordinary prescription glasses don't stop ultraviolet illumination or blue-light penetration. Artificial contact lenses do not offer sufficient protection because they may lose their filtering characteristics over time or may allow penetration of some radiation in the blue and UV range though they're declared to own ultraviolet illumination filters. It is essential for dental personnel to make sure that the cut-off range of protective glasses as declared by the manufacturer is adequate for the intended function.[7]

References

1. Justin d. Ward; bethany j. Wolf; luis p. Leitec; Jing zhou. Clinical effect of reducing curing times with high-intensity led lights. Angle orthodontist, vol 85, no 6, 2015
2. Corina maia de souza pinto, josé tarcísio lima ferreira, mírian aiko nakane matsumoto, maria cristina borsatto, raquel assed bezerra da silva fábio lourenço romano2. Evaluation of different led light-curing devices for bonding metallic orthodontic brackets. Braz dent j 22(3) 2011
3. Dunn wj, taloumis lj. Polymerization of orthodontic resin cement with light-emitting diode curing units. Am j orthod dentofacial orthop. 2002;122:236–241.
4. Neil mccusker,a clare bailey,b stephen robinson,c naresh patel,d jonathan r. Sandy,e and anthony j. Ireland. Dental light curing and its effects on color perception. American journal of orthodontics and dentofacial orthopedics. September 2012 vol 142(3)
5. Moseley h., strang r. And stephen k. W. (1986) An assessment of visible light polymerising sources. J. Oral rehabil. 13, 2 15-224.
6. Lehtinen R, Kuusilehto A (1990) Absorption of UVA light by latex and vinyl gloves. Scand J Dent Res 98:186–188
7. Roberts JE (2002) Screening for ocular phototoxicity. Int J Toxicol 21:491–500
8. Davis l. G., baker w. T., cox e. A. Et al. (1985) optical hazards of blue light curing units: preliminary results. Br. Dent. J. 159, 259-262.
9. Ellingson 0. L., landry r. J. And bostrom r. G. (1986) An evaluation of optical radiation emissions from dental visible polymerisation devices. J. Am. Dent. Assoc. 112, 67-70.
10. Mosley h, strang r, macdonald i (1987) evaluation of the risk associated with the use of blue light polymerizing sources. J dent res 15:12–15
11. ACGIH (american conference on governmental and industrial hygienists) (1999) tlvs and beis. Based on the documentation for threshold limit values for chemical substances and physical agents and biological exposure indices.
12. Health hazards associated with curing light in the dental clinic. Clin oral investig. 2004 sep;8(3):113-7.