ISSN: 2582-9904

ORIGINAL RESEARCH

In Vitro Testing of Protective Eye Wear in Blocking Blue Light from Dental Light Curing Unit: A Pilot Study

Meghna Das[a], Vidyashree Nandini V[b], Shiney Boruah[c]

ABSTRACT

Aim: To evaluate the efficacy of wearing protective eyewear in preventing harmful Dental light-curing units (LCUs).

Background: Dental light-curing units generate blue light, capable of inducing soft-tissue burns and ocular harm like retinal damage. The intensity of blue light emitted by dental Light Curing Units is substantially higher, thereby potentially constituting a significant "blue light hazard."

Material and Methods: Circular composite disc samples were grouped into two, one of which was polymerized directly while the other had protective glass in between, Fourier transform infrared spectroscopy (FTIR) analysis was done and the degree of conversion was calculated. The degree of conversion aided in measuring the blue light blockage effect of the protective glasses.

Results: Data obtained were analysed using One Way ANOVA. The mean values for "Degree of Conversion" in Group I (Without Protective Glass) is 1.334 + 1.512 and for Group II (with protective glass) is -2.623 + 1.544 .One Way ANOVA revealed statistically significant difference between Group I and Group II (p=0.000)

Conclusion: Within the limitations of this in vitro study, it can be concluded that the protective glasses are successful in filtering the harmful blue light emitted by LCU and should be used in day-to-day practice to improve the amount of light they deliver to the restoration from the LCU and prevent any harm to the ocular tissues.

Clinical implications: Blue light filtering glasses in a dental operatory provide optimal protection, and the operator can safely watch and improve the amount of light delivered to the restoration from the LCU.

Key words: Blue light hazard, ocular damage, Degree of Conversion, composite resin

How to cite this article: *Meghna Das, Vidyashree Nandini V, Shiney Boruah. In Vitro Testing of Protective Eye Wear in Blocking Blue Light from Dental Light Curing Unit: A Pilot Study. J Clin Prosth Impl 2024;6(2):72-76.* ***https://doi.org/10.55995/j-cpi.2024014***

INTRODUCTION

Dental light-curing units (LCUs) play a crucial role in contemporary dentistry, the majority of commercially available dental composites rely on photo-polymerization reactions triggered by blue visible light. Various types of light curing units (LCUs) operate based on distinct physical principles, including quartz-tungsten-halogen (QTH) bulbs, lasers, plasma arc lights, and light-emitting diodes (LEDs). Despite the array of options, LED-based LCUs have emerged as the prevailing choice in modern dental practices.[1,2] These units are employed for the light-induced polymerization of direct and indirect dental restorations, sealants, and bonding orthodontic brackets.The concentrated light emitted by modern LCUs has the potential to induce burns on soft tissues and harm the eyes, with prolonged exposure to elevated levels of blue light constituting what is known as the "blue light hazard".[3,4,5] Notably, this hazard is most pronounced at a wavelength of 440 nm, which falls within the wavelength range produced by dental LCUs.Recent investigations into the effects of blue light emitted by various digital devices have demonstrated significant harm to ocular health, including genetic mutations and disruptions to sleep patterns. Dental Light Curing Units (LCUs), operating within the 400 nm to 500 nm range, possess a notably higher potential for causing substantial harm to both dental practitioners' and patients' eyes.[5,6] While a significant portion of ocular research addressing the perils of blue light primarily focuses on minimal levels originating from computer screens, personal electronic gadgets, and light-emitting diode light emitters, it is important to note that the emission of blue light from

[a] Dental Surgeon, Alumnus, [b] Professor & Head, [c] Assistant Professor, SRM Kattankulathur Dental College and Hospital, , SRM Institute of Science and Technology, Chengalpattu District, Tamil Nadu, India

dental LCUs surpasses these levels considerably and could give rise to a notable "blue light hazard." This risk can be mitigated through the utilization of eyewear designed to prevent the transmission of blue light. [4,7] The purpose of this study is to analyse the filtering of the blue light provided by protective glasses.

METHODOLOGY

The current study is designed with the purpose of demonstrating the blocking effect of protective eyewear. The study utilized an indirect technique to evaluate eye protection to check whether the "blue light filtering glass" disallows the passage of harmful blue light emitted by the LCU. If the blue light was allowed/ disallowed it would, in turn, prevent polymerization of composite resin. To evaluate blockage, the degree of conversion of composite was measured and analysed (IEC No SRMIEC-ST0723-751 dated 14.9.23).Sixty Composite Resin Discs (Spectrum composite, Dentsply, USA) (N=60) of diameter 4mm and thickness 2mm (figure 1) were prepared and grouped as, Group I (n=30) cured without orange blue filter glass protective wear (Cotisen, China) (figure 2) and Group II (n=30) cured with the protective glasses as a barrier (with thickness 1.5 mm) between light (LED Curing Light with intensity of 1000-1200 W/Cm2 and 20s duration) and composite resin.

Fig 1. Composite disc preparation before FTIR analysis

Fig 1. Composite disc preparation before FTIR analysis

The samples were prepared using circular mold of 4 mm diameter and 2mm thickness. A circular wax disc (pyrax, Laboz Inc, India) with similar dimensions was used to produce the mould, which was then formed by taking an impression of the disc with putty impression material.(Aquasil, Dentsply,USA)All the samples were prepared, stored for 24 hours and initially analyzed by Fourier transform infrared spectroscopy. For Group I curing was performed directly with the light-curing unit (figure 3) and for Group II curing was performed for 60 seconds by placing blue light protective glasses i.e. orange-red blue light filter glasses in between the composite containing mold and light-curing unit (figure 4).

Fig 3. Group I samples polymerised directly

Fig 4. Group II samples polymerized with protective glass as a barrier between light and composite

Fig 5. Disc placed in Hydraulic press

It was observed that Group I samples were polymerized after curing into hard discs whereas

Group II maintained the soft dough consistency of the composite as it had before curing it. Hence Group I discs were crushed into powder using a hydraulic press (figure 5). All the samples thus prepared were wrapped individually in black paper and stored in a dark container (figure 6, 7)The residual double bonds (RDB) and degree of conversion (DC) for samples were ascertained by using Fourier transform infrared spectroscopy in total reduced reflectance (FTIR-ATR) measurements. The samples were analysed with FTIR spectrometer in an ATR mode, with a scanning range from 4000 to 550 cm−1 at a speed of 4 cm−1 s −1. The degree of conversion was analysed by estimating the change in absorbance intensities of their peak heights ratio aliphatic C=C recorded at a strong peak of 1638 cm-1 and at a weak peak of 1608cm-1 during polymerization. The following equation was used to calculate the residual double bonds (RDB) of monomer to polymer in the samples: 8

$$RDB\% = 100 \times \left(1 - \frac{R\ polymerized}{R\ unpolymerized}\right)$$

Where R is the ratio of aromatic and aliphatic C=C bonds at peak intensities of 1638 cm-1/ and 1608 cm-1 in cured and uncured composite samples, respectively. The degree of conversion (DC) constitutes the segment of polymerized monomers after setting and it is acquired by subtracting the RDB value from 100.

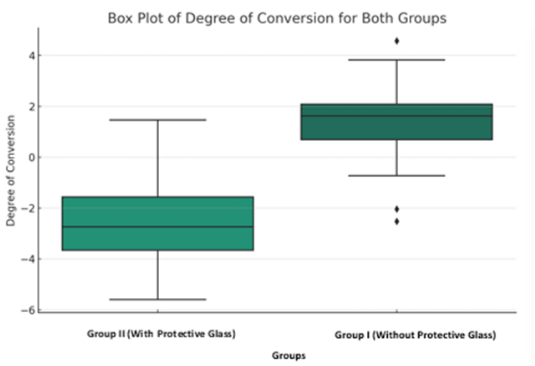
Fig 6. Group I samples

RESULTS

The data obtained were stastically analysed using one-way ANOVA, the significance level was maintained at 5% (α = 0.05). The mean values for degree of conversion in group I (without Protective glass) is 1.334 + 1.512 and for group II (with protective glass) is -2.623 + 1.544 Therefore Group

Fig 7. Group II samples

II (With Protective Glass) has a lower mean "Degree of Conversion" compared to Group I (Without Protective Glass). (Graph 1)



Graph 1: Comparative mean for degree of conversion in group I (without Protective glass) and for group II (with protective glass)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares	F Value	P-value
Between Groups	234.839	1	234.839	100.568	**0.000**
Error	135.438	58	2.335	-	
Total	370.277	59	-	-	

Table 1: One Way ANOVA for degree of conversion in group I (Without Protective Glass) and Group II (With Protective Glass)

One-Way ANOVA revealed statistically significant difference between Group I (Without Protective Glass) and Group II (With Protective Glass) with p = 0.000 (p<0.05).Hence it can be inferred that the presence or absence of protective glass has a significant effect on the "Degree of Conversion". (Table 1)

DISCUSSION

Over the last several decades, technology and lighting sources have revolutionised. Many facets of contemporary dentistry make use of light sources as a curing light in cavity restorations, veneer- and orthodontic bonding and fissure sealing for polymerization of monomer, which is typically triggered by light. Various type of curing lamps have different emission spectra within the electromagnetic 350–550 nm spectrum and have different intensity. The emission range of halogen lamps is between 470–490 nm and plasma arc and light emitting diodes has is between 400-450nm in the blue and blue-green light region. [7]

The majority of commercially available dental composites rely on photo-polymerization reaction triggered by blue visible light. It has been noted that prolong exposure to blue visible light with short wavelength, has tendency to damage eyes. The most significant biological damage caused by curing radiation is impaired vision, which can occur from scattered radiation build up from using curing lights without protection or from direct, unintentional eye exposure. Permanent retinal damage is sometimes interpreted as a blind spot in the middle of the visual field. Furthermore, it is thought that exposure to blue light accelerates ageing and cause macular degeneration in the eyes. [7] It is important to note that the emission of blue light from dental LCU significantly exceeds the potential thresholds, leading to significant blue light hazards. The most detrimental wavelength is between 420-455 nm. Blue light hazards pertains to retina's susceptibility to photochemical damage.[9] l professionals are at higher risk due to intense exposure to blue light during various dental procedures. In accordance with the exposure limit guidelines established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the American Conference of Governmental and Industrial Hygienists (ACGIH), the maximum exposure to blue light was calculated to be around 1min/day for reflected light, however a direct (accidental) exposure to blue light at zero distance from the eye should not be longer 1s. In order to prevent the over exposure and to exceed daily exposure limit the dental professional must use orange protective eyewear, sometimes referred to as "blue blockers". Failure to wear these glasses can surpass the daily limit for blue light exposure in as short as seven curing cycles.4 6 Protective glasses can significantly diminish the transmission of light with wavelengths below 500 nm by 99%. Moreover, these glasses offer an added advantage: by wearing them, operators can safely observe their work during the light-curing process instead of needing to avert their gaze from the intense blue light. [10]

Mitate E et al evaluated effectiveness of protective glasses in reducing the eye strain produce by blue light using flickers value and concluded that protective glasses has the potential to reduce eyestrain in dental practice.[11] Bruzel Em et al, assessed the filtering quality of different protective filters with respect to transmittance in the wavelengths prevalent for the blue-light hazard using Filter transmittance measurement setup and concluded that all the protective filters are adequate in filtering the blue light wavelength 2. There is lack of evidence in evaluating filtration of blue light by protective glasses during polymerization of composite resin.

The objective of this study is to evaluate the efficacy of wearing protective eyewear to prevent exposure to harmful dental light curing unit. Light curing units are used for photo-activation to initiate the polymerization reaction of resin composites, which is directly influenced by the degree of conversion attained during polymerization. The degree of conversion (DC) can be expressed as the ratio of C=C double bonds to C-C single bonds when resin composite is exposed to light.8 In the current study the mean degree of conversion of Group II (With Protective Glass) was lower compared to Group I (Without Protective glass). There is statistically significant evidence to conclude that the "Degree of Conversion" differs between Group I (Without Protective Glass) and Group II (With Protective Glass). This implies that protective glass has a significant effect on the polymerisation of composite resin and thus, there was a blocking effect on blue light with protective glasses. Thus, it can be inferred that absorption of blue light from dental curing units by the ocular tissues can be effectively reduced by wearing protective eye wear.

Though the study was performed under ideal conditions taking various factors into consideration, study has limitations. Further studies can be done with a larger sample size. The study utilises the reverse methodology process to evaluate filtering effect of eye glasses. A longer period of study in a clinical setup can validate the findings.

CONCLUSION

The orange-blue glasses are successful in filtering the harmful blue light emitted by LCU and also reduce the overexposure and supresses the daily limit of blue light exposure. Therefore orange-blue glasses can be used in day-to-day practice to prevent ocular damage both to the dentist as well as the patient. The operator can safely watch and improve the amount of light they deliver to the restoration from the LCU with eye protection and this should be mandatory in every dental office.

REFERENCES

1. Price R.B, Labrie D, Bruzell E.M, Sliney D.H, Strassler H.E. The dental curing light: a potential health risk. J Occup Environ Hyg 2016; 13: 639-646.
2. Bruzell E.M, Johnsen B, Aalerud T.N, Christensen T. Evaluation of eye protection filters for use with dental curing and bleaching lamps. J Occup Environ Hyg 2007; 4: 432-439.

3. Tosini G, Ferguson I, Tsubota K. Effects of blue light on the circadian system and eye physiology. Mol Vis 2016; 22: 61-72.
4. International Commission on Non-Ionizing Radiation Protection. Guidelines on limits of exposure to incoherent visible and infrared radiation. Health Phys 2013; 105: 74-96.
5. Price RBT. Light Curing in Dentistry. Dent Clin North Am. 2017 Oct;61(4):751-778.
6. 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. ACGIH, Cincinnati
7. Bruzell Roll E.M, Jacobsen N, Hensten-Pettersen A. Health hazards associated with curing light in the dental clinic. Clin Oral Investig 2004; 8:113-117.
8. Moldovan M, Balazsi R, Soanca A, Roman A, Sarosi C, Prodan D, Vlassa M, Cojocaru I, Saceleanu V, Cristescu I. Evaluation of the Degree of Conversion, Residual Monomers and Mechanical Properties of Some Light-Cured Dental Resin Composites. Materials (Basel). 2019 Jun 30;12(13):2109.
9. Yoshino F, Yoshida A. Effects of blue-light irradiation during dental treatment. Jpn Dent Sci Rev 2018; 54:160-168.
10. Soares CJ, Rodrigues MP, Vilela AB, Rizo ER, Ferreira LB, Giannini M, Price RB. Evaluation of Eye Protection Filters Used with Broad-Spectrum and Conventional LED Curing Lights. Braz Dent J. 2017;28(1):9-15.
11. Mitate E, Moriwaki S, Masui I. Blue-Violet Light-Blocking Eye Protectors in Dental Practice: A Preliminary Study. SciBase Dent Oral Sci. 2023; 1(2): 1007

Corresponding Author: Vidyashree V Nandini, Professor & Head, SRM Kattankulathur Dental College & Hospital, Kattankulathur,
E-mail: vidyashv@srmist.edu.in Ph.No.: 9444901719