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The influence of translucent barriers on the effectiveness of dental light curing

A influência das barreiras translúcidas na eficácia da fotopolimerização odontológica

La influencia de las barreras translúcidas en la eficacia de la fotopolimerización dental

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Abstract
The aim of the present study was to evaluate the irradiance of different light-curing devices when subjected to the use of different types of biological protection barriers. The tested devices were: Bluephase N. Radii-Cal and VALO wireless. The biosafety barriers were: Polyethylene and Polyvinyl Chloride with one and two turns. The tips of the devices had their diameters measured on a digital pachymeter and the area of each tip was calculated. The power (mW) of the devices was measured with a potentiometer for 20 seconds and three times for each device. Then. the irradiance (mW / cm²) was calculated by the quotient of the power of the device by the cross-sectional area of the tip of the photoactivator. The irradiance data for each group were collected and subjected to two-way ANOVA analysis of variance (SPSS). with Tukey's post-hoc. As a result. a statistically significant interaction between the different types of light-curing device and translucent protection barriers ($p < 0.05$) were observed. It can be concluded that the protective barrier made with 1-turn polyvinyl chloride demonstrated the best irradiance results and among the light-curing devices. regardless of the type of barrier used. Bluephase obtained the best irradiance results. followed by Valo and Radii.
Keywords: Polymerization; Curing lights, Dental; Composite resins.

Resumo
O objetivo do presente estudo foi avaliar a irradiância de diferentes fotoativadores quando submetidos a utilização de diferentes tipos de barreiras de proteção biológica. Os aparelhos testados foram Bluephase N. Radii-Cal e VALO cordless. As barreiras de biossegurança foram: Polietileno. Policloreto de vinila com 1 volta e Policloreto de vinila com 2 voltas. As pontas dos aparelhos tiveram seu diâmetro aferido a partir de um paquímetro digital e a área de cada ponteira foi calculada. A potência (mW) dos aparelhos foi medida com um potenciômetro por 20 segundos. e três vezes para cada aparelho. E então. a irradiância (mW / cm²) foi calculada pelo quociente da potência do aparelho pela área da seção transversal da ponta do fotopolimerizador. O teste anova dois fatores demonstrou interação estatisticamente significante entre os diferentes tipos de aparelhos fotopolimerizadores e barreiras de proteção biológica ($p < 0.05$). Dentre os fotopolimerizadores. Bluephase N obteve os maiores valores de irradiância independente do tipo de barreira. seguido do VALO cordless e Radii-Cal. Todos os aparelhos obtiveram maior irradiância no grupo controle. quando não faziam uso de barreiras descartáveis. Dentre as barreiras. o policloreto de vinila com 1 volta obteve o melhor desempenho em todos os grupos de fotopolimerizadores. Apesar do uso de barreiras de biossegurança terem reduzido a irradiância dos aparelhos. esses valores não foram inferiores ao mínimo adequado para a polimerização de resinas compostas convencionais (400 mW/cm²).

Palavras-chave: Polimerização; Luzes de cura dentária; Resinas compostas.

Resumen

El objetivo del presente estudio fue evaluar la irradiancia de diferentes fotoactivadores al ser sometidos al uso de diferentes tipos de barreras de protección biológica. Los dispositivos probados fueron Bluephase N. Radii-Cal y VALO inalámbricos. Las barreras de bioseguridad fueron: Polietileno. Cloruro de polivinilo con 1 capa y Cloruro de polivinilo con 2 capas. Se midió el diámetro de las puntas de los dispositivos con un calibre digital y se calculó el área de cada punta. La potencia (mW) de los dispositivos se midió con un potenciómetro durante 20 segundos y tres veces para cada dispositivo. Luego. se calculó la irradiancia (mW / cm²) por el cociente de la potencia del dispositivo por el área de la sección transversal de la punta de la lámpara de polimerización. La prueba muestra dos factores y demostró una interacción estadísticamente significativa entre los diferentes tipos de dispositivos fotopolimerizables y barreras de protección biológica ($p < 0.05$). Entre los fotopolimerizadores. Bluephase N obtuvo los valores de irradiancia más altos independientemente del tipo de barrera. seguido de VALO inalámbrico y Radii-Cal. Todos los dispositivos obtuvieron mayor irradiancia en el grupo control. cuando no utilizaron barreras desechables. Entre las barreras. el cloruro de polivinilo de 1 vuelta logró el mejor desempeño en todos los grupos de fotopolimerizadores. Aunque el uso de barreras de bioseguridad redujo la irradiancia de los dispositivos. estos valores no fueron inferiores al mínimo adecuado para la polimerización de resinas compuestas convencionales (400 mW / cm²).

Palabras clave: Polimerización; Luces de curación dental; Resinas compuestas.

1. Introduction

Light curing is an important step on dental restorative process once the mechanical properties of composite resins may be affected negatively when the light use is neglected (Shimokawa, et al;, 2018). Light curing is influenced by several factors, including the operator's technique and the photoinitiator properties. Devices containing LEDs (Light Emitting Diode) are the first choice for photoinitiation of composite resins and are classified as monowave (emitting only blue light) or multiwave (combining two or more chips with different bands of light spectrum) (Sinhoretti, et al., 2018). They have low weight, long useful life, small dimensions and no need for prism filters compared to halogen light devices (Soares, et al., 2017; Ajaj, et al., 2018; Sinhoretti, et al., 2018; Cadenaro, et al., 2019).

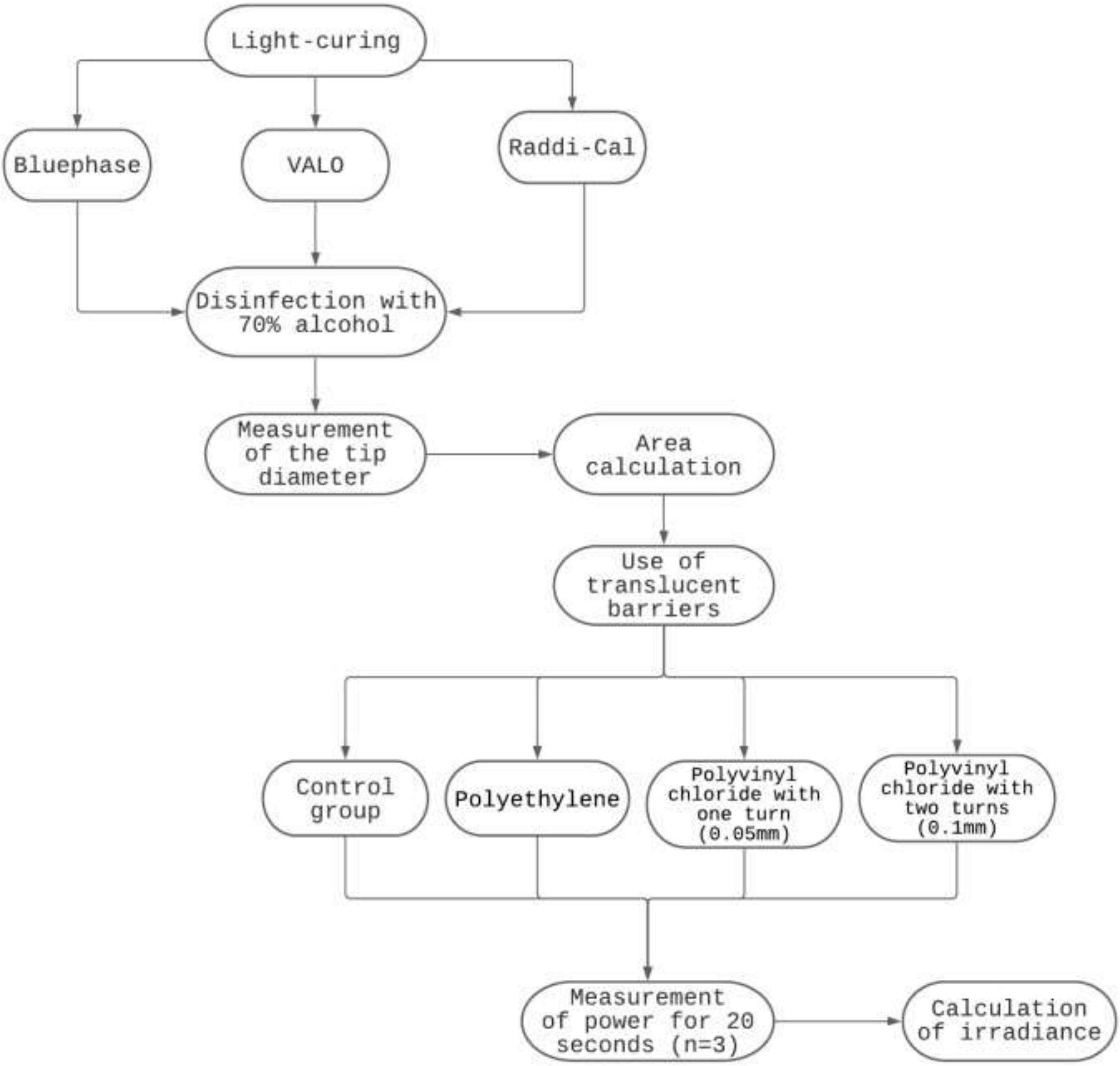
To protect the tip of the device and avoid cross-contamination during clinical light-curing procedure, translucent barriers are recommended, to prevent the direct contact of the light curing devices with the oral tissues and favor infection control, preventing diseases transmission, such as Hepatitis B, Acquired Immunodeficiency Syndrome and, more recently, the COVID-19 (Verbeek, et al., 2020; Sabino-Silva, Jardim & Siqueira 2020). However, these barriers influence the irradiance, which is the amount of light distributed in each area and, consequently, the curing quality of the materials. In addition to subpolymerization, biocompatibility and premature clinical failures may occur, such as restoration fracture, marginal infiltration and color changes (McAndrew, et al., 2011; Sinhoretti, et al., 2018; Mendoza, et al., 2020; Soares, et al., 2020).

Knowing the importance of light curing device tip protection and its irradiance for patient’s safety and quality of the cure of the materials, this study aimed to evaluate the irradiance of different light-curing devices to different types of biological protection barriers. The null hypotheses of this study were: (1) Irradiance is not different among light-curing devices; (2) Protection barriers do not affect the irradiance of different light-curing units.

2. Methodology

This exploratory and descriptive research assessed two independent variables: (1) Type of translucent barrier (on 4 levels) and (2) Light activation (on 3 levels). Polyethylene (plastic bag), polyvinyl chloride (plastic film) with one turn (0.05 mm) and two turns (0.1 mm) were the protection barriers. For light activation, Bluephase N (Ivoclar-Vivadent, Schaan, Liechtenstein), Radii-Cal (SDI -Victoria, Australia), and VALO cordless (Ultradent - South Jordan, UT, United States) were used. The control group was made up of all light-curing devices without translucent barriers (Figure 1).

Figure 1 – Flowchart of the research.



Research methodology flowchart
Source: Authors.

2.1 Characterization of light-curing devices and measurement of irradiance

The irradiance of all light-curing devices was obtained before and after the insertion of the translucent barriers. Before measurements, devices had their batteries fully charged and were disinfected with 70% alcohol to remove any residues. A digital caliper (Mitutoyo, Suzano, São Paulo, Brazil) was used to measure the area of each light-curing tip, which was calculated using the formula $A = \pi.r^2$. The power (mW) was measured with a potentiometer (Ophir 10A-V2-SH, Ophir Optronics, Har - Hotzvim. Jerusalem, Israel) for 20 seconds, three times for each device. Then, irradiance (mW / cm^2) was calculated by the quotient of the power by the cross-sectional area of the light-curing device tip.

2.2 Statistical analysis:

The irradiance data for each group were collected and subjected to normality and homoscedasticity by Shapiro-Wilk and Levene tests, respectively. After, two-way ANOVA (SPSS), and Tukey's post-hoc were applied to….

3. Results

Table 1 shows the interaction between different types of light-curing devices and translucent protection barriers ($p < 0.05$).

Table 1.

Light-curing device	Translucent barrier	Means and standard deviation
VALO Cordless	Control group	857.12 ± 7.86 Ba
	Polyethylene	804.17 ± 15,11 Bb
	Polyvinyl chloride (one turn)	828.81 ± 9.56 Bab
	Polyvinyl chloride (two turns)	811.51 ± 8.32 Bb
Bluephase N	Control group	960.08 ± 7.01 Aa
	Polyethylene	893.41 ± 7.24 Abc
	Polyvinyl chloride (one turn)	924.84 ± 6.74 Ab
	Polyvinyl chloride (two turns)	883.65 ± 15.19 Ac
Radii-cal	Control group	718.72 ± 34.77 Ca
	Polyethylene	580.84 ± 28.19 Cc
	Polyvinyl chloride (one turn)	658.96 ± 18.13 Cb
	Polyvinyl chloride (two turns)	632.74 ± 32.08 Cb

*Tukey test: different capital letters indicate differences among light curing devices; lowercase letters indicate the differences among the biological protection barriers for the same light-curing device. Source: Authors.

Among the light-curing devices, Bluephase obtained the highest irradiance values regardless of the protection barrier, followed by Valo and Radii-Cal. All light-curing devices achieved great irradiance values in the control group when barriers were not used. Regarding the protection barriers, polyvinyl chloride with one turn presented the best performance for all groups of light-curing devices. In the Bluephase device, the polyethylene protection barrier showed the same results as the polyvinyl chloride group with one and two turns. On the other hand, for Radii-cal device, polyvinyl chloride with one or two turns showed better results. For the Valo device, polyvinyl chloride with one turn was similar to the control group, polyethylene, and polyvinyl chloride with two turns.

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4. Discussion

The two hypotheses tested in this study were denied. since among the photoactivators regardless of the type of barrier. the Bluephase device exhibited higher values of irradiance. followed by Valo and finally Radii-Call and among the protective barriers the polyvinyl chloride with one turn demonstrated less interference in the delivered irradiance.

Soares et al. (2017) tested 22 different light-curing devices and concluded that Bluephase was responsible for the greatest radiant energy. These results were also confirmed by Nassar et al. (2020), showing Bluephase irradiance values from 800 to 1000 mW/cm^2, while Valo presented values was <800 mW/cm². As described by De Oliveira et al. (2019), Bluephase devices offer a better polymerization profile of TPO when compared to Valo, which is explained by the lack of homogeneity during light emission. Notwithstanding, André et al. (2018) reported that Radii-Cal was responsible for the lowest radiant exposure.

All light-curing devices of control group had the greatest irradiance values. Despite reducing irradiance, protection barriers are essential for maintaining biosafety since the direct contact of light-curing devices and oral tissues increases the risk of disease transmission (Mendonza et al., 2020). Therefore, in face of the current COVID-19 pandemic, the correct handling of these devices is necessary to avoid adverse effects related to cross-contamination. Not only the devices' tip, but also the entire equipment and the control buttons must be covered. Thus, translucent barriers are an essential, efficient, economical, and easy-to-use method (Ajaj, et al. 2018; Soares et al., 2020; Haenel et al., 2015).

Another advantage of using disposable barriers is the protection against deposition of materials on the tip surface, which usually occurs in many dental offices. Mitton and Wilson (2001) reported that 35% of the light-curing devices had materials adhered to the light tip, reducing the irradiance (Cadenaro et al., 2019; Soares et al., 2020).

Regarding the translucent barriers, polyvinyl chloride with one turn presented better results for all light-curing devices. Corroborating our findings, Soares et al. (2020) also showed that polyvinyl chloride-based barriers interferes less in irradiance (5%). Multiple layers, presence of wrinkles, lines, or folds can be recurrent, increasing the thickness of the barrier; thus, a thin layer of this material provides less changes in irradiance (Soares, et al., 2020). Another reason to be considered is the good adherence of polyvinyl chloride to the tip of the device due to its characteristics and ability to be molded, reducing bubbles between the barrier and light-curing device. Air bubbles can further increase the amount of refraction, decreasing the passage of light and the effectiveness of curing the material. This effect probably occurred in polyethylene groups as the material does not overlap with the LED tip, increasing the refraction of light (Khode et al.,2017; Shortall et al., 2016; Pollington et al.,2009).

According to Cadenaro et al. (2019) and Rueggeberg et al. (2017), biological barriers can reduce irradiance of up to 40%, which would compromise polymerization of conventional composite resins (Reis & Loguercio 2007; Mendonza et al.,2020). However, in the present study, no minimum reduction in irradiance (400 mW/cm²) was observed. This finding corroborates with Khode et al. (2018), who concluded that protection barriers did not affect the degree of conversion of composites. Moreover, this finding is an advantage once subpolymerization (<400 mW/cm²) of composite resin restorations can result in fractures and reduction in the mechanical properties of the resin, such as lower strength, increased water sorption, and changes in color stability of the material. In addition, it can cause pulp irritation and facilitate the incidence of secondary caries lesions, decreasing the clinical longevity of restorations (McAndrew et al., 2011). Thus, the barriers assessed by this study can be considered adequate for clinical use. The distance angle of the tip to the area to be polymerized may also change irradiance, reducing the light supply(Ajaj et al., 2018). In these cases, the plastic barriers help the operator to keep light-curing device tip as close as possible to the material without risk of contamination and, consequently, obtaining better results in the degree of conversion of the composite resin (Cadenaro et al., 2019).

Finally, dental surgeons are highly recommended to check the irradiance of light-curing devices with a translucent barrier, the polymerization of the material and the exposure time with frequency. This study has some limitations: the reduced number of light-curing devices and the absence of light beams characterization. Therefore, new studies should be carried out, allowing a better classification of the effects of biosafety barriers on the light pattern. Also, new devices and barriers should be tested to reinforce biosafety approaches and make dentists aware of the contamination sources and the effective forms of control.

5. Conclusion

Bluephase obtained better irradiance results. followed by Valo and Radii among light curing units. The materials evaluated for use as a protective barrier. polyvinyl chloride with 1 turn (0.05mm) demonstrated the best irradiance results. However. all the tested barriers presented the minimum irradiance recommended for the polymerization of conventional composite resins (400 mW / cm²).

References

Ajaj. R. A.. Nassar. H. M., & Hasanain. F. A. Infection control barrier and curing time as factors affecting the irradiance of light-cure units. *Journal of International Society of Preventive & Community Dentistry*. 8(6). 523.

André. C. B., et al (2018). Stability of the light output. oral cavity tip accessibility in posterior region and emission spectrum of light-curing units. *Operative dentistry*. 43(4). 398-407.

Cadenaro. M., et al (2019). The role of polymerization in adhesive dentistry. *Dental Materials*. 35(1). e1-e22.

De Oliveira, D. C. R. S., et al (2019). Effect of beam profiles from different light emission tip types of multiwave light-emitting diodes on the curing profile of resin-based composites. *Operative dentistry*. 44(4). 365-378.

Haenel, T., et al (2015). Effect of the irradiance distribution from light curing units on the local micro-hardness of the surface of dental resins. *Dental Materials*. 31(2).93-104.

Khode, R. T., et al (2017). Evaluation of effect of different disposable infection control barriers on light intensity of light-curing unit and microhardness of composite-An in vitro study. *Journal of conservative dentistry*. 20(3).180.

McAndrew, R., et al (2011). The effect of disposable infection control barriers and physical damage on the power output of light curing units and light curing tips. *British dental jornal*. 210(8). E12-E12.

Mendoza, F. M. V., et al (2020). Photopolymerization devises light intensity relation with physical translucid barriers use. *World Journal of Advanced Research and Reviews*. 8(1). 180-187.

Mitton, B. A., & Wilson, N. H. F. (2001). The use and maintenance of visible light activating units in general practice. *British Dental Journal*. 191(2). 82-86.

Nassar, H. M., Almutairi, M., & Makhdom. A (2020). Irradiance of different curing modes of common light cure devices: An in vitro study. *Journal of International Society of Preventive & Community Dentistry*. 10(2). 177.

Pollington. S, Kahakachchi. N., & van Noort. R (2009). The influence of plastic light cure sheaths on the hardness of resin composite. Operative dentistry. 34(6). 741-745.

Reis. A., & Loguercio. A. D (2007). Materiais dentários diretos: dos fundamentos à aplicação clínica. *Santos*. 277-278.

Rueggeberg, F. A., et al (2017). “Light curing in dentistry and clinical implications: a literature review.*” Braz. Oral Res*. 31(1). 64–91.

Sabino-Silva, R., et al (2020). Coronavirus COVID-19 impacts to dentistry and potential salivary diagnosis. *Clinical oral investigations*. 24(4). 1619-1621.

Shimokawa, C. A. K., et al (2018). Effect of light curing units on the polymerization of bulk fill resin-based composites. *Dental Materials*. 34(8). 1211-1221.

Shortall, A. C., et al (2016). Guidelines for the selection. use. and maintenance of LED light-curing units-Part 1. *British dental jornal*. 221(8). 453-460.

Sinhoreti, M. A. C., et al (2018). Fotopolimerização de materiais restauradores resinosos: uma abordagem com base em evidências para a prática clínica. *Journal of Clinical Dentistry and Research*. 15(1). 44-53.

Soares, C. J., et al (2020). Effect of infection control barriers on the light output from a multi-peak light curing unit. *Journal of dentistry*. 103. 103503.

Soares, C. J., et al (2017). An evaluation of the light output from 22 contemporary light curing units. *Brazilian dental jornal*. 28(3). 362-371.

Verbeek, J. H., et al (2020). Personal protective equipment for preventing highly infectious diseases due to exposure to contaminated body fluids in healthcare staff. *Cochrane Database of Systematic Review*. 4. 10.1002 / 14651858.CD011621.pub4