DOI: https://doi.org/10.17921/2447-8938.2021v23n1p68-71

Evaluation of the Light Intensity Emitted by the Light-curing Devices of a Dental School Clinic in the North of Brazil: a Pilot Study

Avaliação da Intensidade de Luz Emitida Pelos Fotopolimerizadores de uma Clínica-Escola da Região Norte do Brasil: um Estudo-Piloto

José Henrique Nascimento Souza-Junior[a]; André Farias Andrade[b]; Luiz Evaristo Ricci Volpato*[c]; Mateus Rodrigues Tonetto; Aurélio Rosa da Silva Junior; Bruno Sindi Hirata[b]

[a]University of Cuiabá, MT, Brazil.
[b]Faculty of Biomedical Sciences of Cacoal. RO, Brazil.
[c]University of Cuiabá,, Stricto Sensu Graduate Program in Dental Sciences. MT, Brazil,
*E-mail:odontologiavolpato@uol.com.br
Recebido em: 30/09/2020
Aprovado em: 22/01/2021

Abstract

Photoactivated composite resins are among the most widespread restorative materials in dentistry, particularly in cosmetic dentistry. To obtain the best properties of the material, the resins must have their polymerization reaction initiated by means of the light-curing device, which activates the photoinitiators present in the composites. For this process to occur in the desired way, it is essential that the light-curing device emits light at the intensity necessary to properly activate the photoinitiators. Thus, a pilot study was carried out to assess the light intensity emitted by the light-curing devices used in a school clinic. To assess the light intensity emitted by the devices, a radiometer was used. Twenty-four light-curing devices were evaluated, 13 Optilight Max devices, 8 Optilight LD MAX 440 devices, 3 Emitter C. devices. All the devices had an emitted light below 400 mW / cm² and 67% of the devices had intensity above 300 mW/cm². The average light emission values of the light-curing devices were Optilight Max 334mW/cm², Emitter C 275mW/cm², Optilight LD MAX 440 296mW/cm². It was concluded that no light-curing device emitted light at the recommended intensity (400 mW/cm²), two thirds of the devices emitted light in intensity above the minimum required for photopolymerization of composite resin increments of up to 2mm and one third emitted light in intensity below the required minimum. There was no difference among the light-curing device models tested in this study.

Keywords: Photoinitiators, Dental. Dental. Tooth. Composite Resins.

Resumo

As resinas compostas fotoativadas estão entre os materiais restauradores mais difundidos em odontologia, particularmente na odontologia estética. Para obtenção das melhores propriedades do material, as resinas precisam ter sua reação de polimerização iniciada por meio do fotopolimerizador, que ativa os fotoiniciadores presentes nos compósitos. Para que esse processo ocorra da forma desejada, é fundamental que o fotopolimerizador emita a luz na intensidade necessária para ativar adequadamente os fotoiniciadores. Assim, foi realizado um estudo piloto para avaliadar a intensidade da luz emitida pelo fotopolimerizadores utilizados em uma clínica-escola. Para avaliar a intensidade da luz emitida pelos dispositivos, foi utilizado um radiômetro. Vinte e quatro fotopolimerizadores foram avaliados, 13 aparelhos Optilight Max, 8 aparelhos Optilight LD MAX 440, 3 aparelhos Emitter C. Todos os dispositivos tiveram a luz emitida em intensidade inferior a 400 mW/cm² e 67% dos dispositivos apresentaram intensidade acima de 300 mW/cm². As médias de valores de emissão de luz dos fotopolimerizadores foram, Optilight Max 334mW/cm², Emitter C 275mW/cm², Optilight LD MAX 440 296mW/cm²Concluiu-se que nenhum fotopolimerizador emitiu luz na intensidade recomendada (400 mW/cm²), dois terços dos aparelhos emitiram luz em intensidade acima da mínima necessária para fotopolimerização de incrementos de resina composta de até 2mm e um terço emitiu luz em intensidade abaixo da mínima necessária. Não houve diferença entre os modelos de fotopolimerizador testados neste estudo.

Palavras-chave: *Fotoiniciadores Dentários. Dente. Resinas Compostas.*

1 Introduction

The use of photoactive composite resins has been universalizing for the restoration of anterior and posterior teeth. This is due to the characteristics of the material that mimic adjacent dental tissues[1]. Another characteristic of this material is to undergo polymerization initiated by a photo initiator, a molecule responsible for capturing light, usually canforoquinone and a tertiary amine. Canforoquinone absorbs the visible blue light emitted by the light-curing device at a wavelength of approximately 470nm, excites and reacts with the amines, generating free radicals that initiate a cascade of effects that convert monomers into polymers[2].

The high degree of conversion of monomers into polymers is responsible for maximizing the chemical, mechanical and biological characteristics of the composite resin[3]. Thus, it is essential that the light-curing unit emits light at sufficient intensity at the appropriate wavelength and at the indicated exposure time[4].

Thus, the quality of composite resin restorations is directly linked to the light emission capacity of light-curing apparatus[3]. A wide range of devices based on various technologies are available nowadays in the market: argon laser devices, quartz tungsten halogen(QTH), plasma arc lamps and light emitting diode (LED) devices. The evolution of the light-curing devices was quick, and nowadays it is possible to find devices emitting up to 2000mW/cm^2 monochrome light radiation in the blue spectrum, without requiring filters[5].

The recommended light intensity for correct polymerization is 400mW/cm^2, however, values above 300mW/cm^2 are acceptable for the start of the polymerization process in resin increments of up to 2mm, respecting the light exposure time at each increment. Devices with light output below 300mW/cm^2 are considered unfit for the polymerization process because the light penetration force is insufficient and can lead to only superficial polymerization[6].

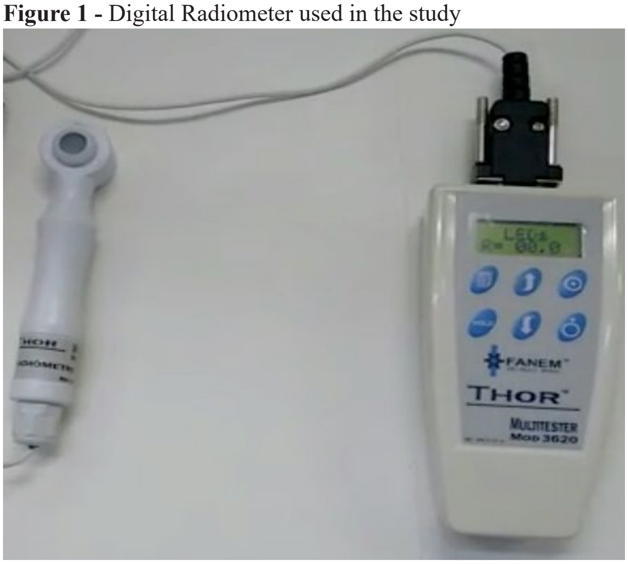
Thus, this pilot study aimed to evaluate the light intensity emitted by the light-curing devices used in a school clinic in the Northern Region of Brazil.

2 Material and Methods

This study followed the methodology used by Ribeiro et al.[7]. The light-curing systems used in the clinical school of Faculdade Ciências Biomédicas de Cacoal (FACIMED), located in the city of Cacoal, RO, Northern Region of Brazil. All the 24 devices analyzed were LED technology, namely: 13 devices Optilight Max (Gnatus, Barretos, Brazil) with battery power supply; 3 devices Emitter C (Schuster, Santa Maria, Brazil) with battery power supply; 8 devices Optilight LD MAX 440 (Gnatus, Barretos, Brazil) with electric power supply, via wire, connected in the same socket.

To measure the light intensity of the devices, THOR Multitester digital radiometer, model 3620 (FANEM, Sao Paulo, Brazil) was used (Figure 1). This radiometer has a sensitivity to measure light intensity between 100mW/cm^2 and 3000mW/cm^2, and was in perfect conditions of use, and was verified by the manufacturer recommendations (Figure 1), contained in their instructions manual.

Figure 1 - Digital Radiometer used in the study



Source: Authors.

The measurement of the devices light intensity followed the following dynamics:

- The light-curing units were separated by their brands and models, with wire and with battery(Figure 2);
- The light-curing tips were standardized for active tip type with central action, respecting the reading requirements of the radiometer.
- The light-curing devices were placed with close contact in the radiometer reading unit.
- The emission mode chosen for the reading was mode 1, continuous emission;
- The light-curing units were activated for 20 seconds, thus favoring a correct reading by the radiometer (Figure 3).

Figure 2 -Light-curing units evaluated in the study

Source: Authors.

Figure 3 -Light intensity reading emitted by the device

Source: Authors.

After reading and recording the light intensity emitted by each device, a statistical analysis was performed comparing the different light-curing units modes. To this end, Analysis of Variance was performed, where the results exhibited normal distribution. Therefore, Tukey's test with a significance level of 5% was used.

3 Results and Discussion

The light-curing devices, with the light intensity emitted measured by the radiometer, is shown in Table 1. It is noted that there is a variation in the values obtained by each device, with the lowest value being 202 mW/cm^2 emitted by a Gnatus - Optilight Max device and the highest value 394 MW/cm^2

emitted by a Gnatus - Optilight LD MAX 440 device.

Table 1 - Presentation of the light-curing devices with their corresponding light intensity (mW/cm²)

Brand/ Model	Intensity (mW/cm²)
1. Gnatus - Optilight Max	272
2. Gnatus - Optilight Max	362
3. Gnatus - Optilight Max	290
4. Gnatus - Optilight Max	270
5. Gnatus - Optilight Max	328
6. Gnatus - Optilight Max	304
7. Gnatus - Optilight Max	234
8. Gnatus - Optilight Max	202
9. Gnatus - Optilight Max	320
10. Gnatus - Optilight Max	253
11. Gnatus - Optilight Max	334
12. Gnatus - Optilight Max	321
13. Gnatus - Optilight Max	320
14. Gnatus - Optilight Max	342
15. Shuster - Emitter C	325
16. Shuster - Emitter C	250
17. Shuster - Emitter C	252
18. Gnatus - Optilight LD MAX 440	321
19. Gnatus - Optilight LD MAX 440	394
20. Gnatus - Optilight LD MAX 440	339
21. Gnatus - Optilight LD MAX 440	368
22. Gnatus - Optilight LD MAX 440	320
23. Gnatus - Optilight LD MAX 440	385
24. Gnatus - Optilight LD MAX 440	213

Source: Authors.

It was tried to evaluate whether there was a difference in the light intensity emitted considering the light-curing device model used, so the means of the values of each device were compared, however no statistically significant difference was found among the models (Table 2).

Table 2 - Comparison of the light intensity emitted by each light-curing device model

Group	Mean (± sd)	*p*
Gnatus Optilight Max	296.6ᵃ (± 45.2)	0.173
Schuster Emitter	275.7ᵃ (± 42.7)	
Gnatus Optilight LD Max 440	334.3ᵃ (± 61.1)	

ANOVA test with Tukey post-hoc test with significance of 5%. Equal letters mean absence of statistical differences ($p > 0.05$).

Source: Authors.

When analyzing the light intensity emitted by the light-curing units used in a school clinic in the North Region of Brazil, it was found that none of the tested devices presented light output at the recommended intensity, which is 400mW/cm²[8]. Two-thirds of the devices reached 300mW/cm² intensity, acceptable as a minimum for light-curing of resin increments composed of up to 2mm and considering that composite resins polymerization is continued for up to 72hrs after light exposure[8]. The remaining third displayed light intensity in the range between 201 to 299mW/cm², acceptable if the light exposure time is doubled, i.e., 80 seconds of exposure for each 2 mm increment[9]. It is interesting to note that there was no statistical difference in the light intensity emitted by the different models of light-curing units.

Composite resins are extremely sensitive materials to technique. Carelessness at some stage may compromise the clinical success of restoration, such as the application of light at inadequate intensity[10]. Failure in the polymerization process will lead to the non-conversion of monomers into polymers and will change the chemical and biological characteristics of the restorative material. Residual monomers that have not been polymerized can also cause clinical problems, such as postoperative sensitivity, due to their high levels of toxicity. The under polymerization is directly associated to the inadequate light intensity emitted by the light-curing unit[11]; therefore, the device must be in a position to emit light at sufficient intensity to ensure quality in restorative treatment. Thus, it is of paramount importance its maintenance periodically, both in the part of the components, and to clean and check the light intensity, as its continuous use may lead to natural wear[5].

In addition to the variation caused by the components degradation of the light-curing unit, the light intensity emitted may also be influenced by a drop in electrical voltage, or by inadequate electrical contact[12,13]. In this study, 17 devices (70%) had as their source of rechargeable battery power, allowing their use "wireless". Among them, 8 (56%) presented light intensity higher than 300mW/cm². The loss of efficiency of battery-operated appliances is directly connected to the amount of times the device is charged. The power supply is compromised, decreasing the device performance[14]. Whereas among the 7 (30 %) operating devices connected to the power line (Optilight LD MAX 440), 6 (87.5%) had a light intensity higher than 300mW/cm².

All the devices tested in this study used LEDs. In these devices, the light emitted is blue and cold, generated by IN-Ga-N semiconductors, which, when subjected to a certain electric current, are capable of producing enough luminous flow to excite the photo initiating molecule, usually the canforoquinone, present in most composite resins. LEDs have a better useful life of approximately 10,000 hours compared to halogen light emitters, 100 hours[15].

In this study, the light intensity was verified with the use of a digital radiometer. The radiometer measures light intensity from the number of photons emitted that affect a given surface at an instant[13] and quantifies it in mW/cm²[12]. It is an instrument of paramount importance for the clinic, since it allows to determine whether light emitted by the light-curing unit is at the appropriate intensity[16].

As previously stated, sufficient light output is crucial for a good restorative procedure with composite resins[17,18]. Whereas light at a higher intensity than recommended may cause excessive heat, causing lesions to periodontal and pulp tissues. Thermal trauma may be induced by the incidence of excessive luminosity in the restorative material, distance from the tip of the light-curing device and the device model used, recommended most of the time cooling, in case the intensity is above the desired[20]. None of the light-curing units analyzed in this study had light output higher than 400mW/cm².

The identification of one third of the clinic-school devices emitting light of less than 300mW/cm² is important, but it is not an isolated fact. Problems related to light emission of light-curing devices are common even in private clinics. It is common the lack of knowledge or negligence of professionals regarding the need to maintain light-curing devices [21].

4 Conclusion

Considering the limitations of this pilot study, it can be concluded that no light-curing unit emitted light at the recommended intensity (400 mW/cm²), two thirds of the devices emitted light at intensity above the minimum needed for light-curing of resin increments composed of up to 2mm (300mW/cm²) and one light at intensity below the minimum required. There was no difference among the light-curing device models tested in this study.

References

1. Werlang JFG, Dalfovo RJ, Neiva IF, Obici AC. Atenuação da intensidade de luz e profundidade de polimerização de resinas compostas. Arq Odont 2013;49(1):12-8
2. Accetta DF, Magalhães Filho TR, Weig KM, Fraga RC. Influência dos fotopolimerizadores (luz halógena x LED) na resistência à compressão de resinas compostas. Rev Fac Odontol Porto Alegre 2008;49(3):17-9. doi: https://doi.org/10.22456/2177-0018.3454
3. Borges A, Chasqueira F, Porgutal J. Influência do tempo de exposição e distância à luz na capacidade de fotopolimerização de compósitos. Rev Port Estomatol Cir Maxilofac 2015;56(3):166-72. doi: http://dx.doi.org/10.1016/j.rpemd.2015.07.001
4. Freitas SAA, Costa JF, Bauer JRO. A valiação da intensidade de luz dos fotopolimerizadores utilizados no curso de Odontologia da Universidade Federal do Maranhão. Rev Ciênc Saúde 2011;13(1):26-30.
5. Borges A, Chasqueira F, Portugal J. Grau de conversão de resinas compostas. influência do método de fotopolimerização. Rev Port Estomatol Cir Maxilofac 2009;50(4):197-203. doi: https://doi.org/10.1016/S1646-2890(09)70019-6
6. Baldi RL, Teider LD, Leite TM, Martins R, Cotrina LAD, Pereira SK. Intensidade de luz de aparelhos fotopolimerizadores utilizados no curso de odontologia da universidade estadual de Ponta Grossa. Publication UEPG 2005;11(1):621-3. doi: https://doi.org/10.5212/publicatio%20uepg.v11i1.408
7. Ribeiro RAO, Lima FFC, Lima IM, Nascimento ABL, Teixeira HM. Evaluation of light intensity and maintenance of light curing units used in clinics in the city of Recife. Rev Odont UNESP 2016; 45(6):351-5. doi: https://doi.org/10.1590/1807-2577.06916.
8. Beltrani CB, CaldareliPG,Kossatz S,Hoeppner MG. Avaliação da intensidade de luz e dos componentes dos aparelhos fotopolimerizadores da Clínica Odontológica da Universidade Estadual de Londrina. Braz J Health Res 2012;3(5):231-4.
9. Barbon FJ, Perin L, Domêncio PBD, Pancotte L. Interferência da distância de fotopolimerização na intensidade da luz emitida pelos fotopolimerizadores à luz led. J Oral Invest 2015;4(1):4-8. doi: https://doi.org/10.18256/2238-510X/j.oralinvestigations.v4n1p4-8
10. Loretto SC, Silva AKS, Brandão RKZ, Carneiro MCM, Junior MHSS. Avaliação in vitro da fenda de contração de polimerização formada por diferentes resinas compostas universais. Rev Sul-Bras Odontol 2010;7(4):56-8.
11. Laskieviscz RBC, Boaventura JC, Gaião U, Saad JRC. Efeito de fontes de luz na microdureza de resinas compostas. Rev Gaucha Odontol. 2011; 59(2):229-36.
12. Bonna AD, Cassali JL, Schleder PV. Eficácia dos fotopolimerizadores utilizados em clínicas odontológicas. Rev Fac Odontol UPF.2010; 2(1):34-8.
13. Oliveira MIL. Contribuição para o estudos da eficácia da fotopolimerização na clínica da FMDUP. Avaliação do desempenho dos seus aparelhos fotopolimerizadores. Porto: Universidade do Porto; 2014.
14. Schneider EL, Henriques RVB, Dill RB, Dresch RFV, Berbmann GBV. Reuso de células de baterias em sistemas de iluminação com LEDS. 2010. [acesso em 30 out 2020]. Disponível em https://www.abcm.org.br/anais/conem/2010/PDF/CON10-1416.pdf
15. Owens BM, Rodriguez KH. Radiometric and spectrophotometric analysis of third generation light-emitting diode (LED) light-curing units. J Contemp Dent Pract 2007;8(2):43-51.
16. Caetano GG, Nascimento LC, Azenha NS, Machado NR, Pereira LCG. Intensidade de luz e manutenção dos aparelhos fotopolimerizadores utilizados em consultórios odontológicos. 2010. [acesso em 30 out 2020]. Disponível em: http://ppstma.unievangelica.edu.br/sncma/anais/anais/2011/2011_pibic_007.pdf

Pereira SK. Resina composta fotopolimerizável. Avaliação da dureza superficial em função de: cor, tempo de exposição, intensidade de luz e profundidade do material. Araraquara: Universidade Estadual Paulista; 2007.

17. Conceição AAB, Conceição EN, Dantas D, Rhost D, Carboni A. Mensuração da contração de polimerização de resinas compostas através da microscopia eletrônica de varredura. Rev Fac Odontol 2008;49(1):31-3 doi: https://doi.org/10.22456/2177-0018.4965
18. Assis C. Instruções e cuidados com a fotopolimerização do dia a dia. Rev Bras Odontol 2014;71(2):172-5.
19. Godoy EP, Pereira SK, Carvalho BM, Martins GC, Franco APGO. Aparelhos fotopolimerizadores: elevação de temperatura produzida por meio da dentina e durante a polimerização da resina composta. Rev Clín Pesq Odontol 2007;3(1):11-20. doi: http://dx.doi.org/10.7213/aor.v3i1.23062
20. Krämer N, Lohbauer U, García-Godoy F, Frankenberger R. Light curing of resin-based composites in the LED era. Am J Den 2008;21(3):135-42.