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

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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.

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. 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.

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

Thus, the quality of composite resin restorations is directly linked to the light emission capacity of light-curing apparatus. 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 devices.
The evolution of the light-curing devices was quick, and nowadays it is possible to find devices emitting up to 2000mW/cm² monochrome light radiation in the blue spectrum, without requiring filters.

The recommended light intensity for correct polymerization is 400mW/cm², however, values above 300mW/cm² 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/cm² are considered unfit for the polymerization process because the light penetration force is insufficient and can lead to only superficial polymerization.

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. 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/cm² and 3000mW/cm², and was in perfect conditions of use, and was verified by the manufacturer recommendations (Figure 1), contained in their instructions manual.

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).

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/cm² emitted by a Gnatus - Optilight Max device and the highest value 394 MW/cm².
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         | 296.6 (± 45.2) | 0.173 |
| Shuster Emitter              | 275.7 (± 42.7) |       |
| Gnatus Optilight LD MAX 440  | 334.3 (± 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. 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. 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. 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. 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; 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.

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. 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. 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.

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 and quantifies it in mW/cm². 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.

As previously stated, sufficient light output is crucial for a good restorative procedure with composite resins. 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\textsuperscript{20}. None of the light-curing units analyzed in this study had light output higher than 400mW/cm\textsuperscript{2}.

The identification of one third of the clinic-school devices emitting light of less than 300mW/cm\textsuperscript{2} 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\textsuperscript{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/cm\textsuperscript{2}), 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/cm\textsuperscript{2}) and one light at intensity below the minimum required. There was no difference among the light-curing device models tested in this study.

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