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Communication

Evaluation of intensity standards of tungsten-halogen and led curing units.

Evaluación de estándares de intensidad de unidades de curado tugsteno-halógenas y leds.

Jaime Sarmiento-Cornejo.[1]
María Mackenney-Palamara.[2]

Affiliations: [1]Facultad de Odontología, Universidad de Valparaíso, Chile. [2]Central Odontológica 1ª Zona Naval, Servicio Odontológico, Armada de Chile, Valparaíso, Chile.

Corresponding author: Jaime Sarmiento-Cornejo. Subida Adolfo Carvallo 211 Playa Ancha Valparaíso, Chile. Phone: (56-9) 98271533. Email: jaime.sarmiento@uv.cl

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Abstract: Current evidence indicates that the minimum light intensity of photo curing units required to polymerize in a reliable way a composite resin, in increments of 2mm, is 300mW/cm^2. The recent introduction of new generations of composite resin materials for large volume increments, partially contrasts with ISO 4049 (2009), calling for the use of light intensity of 1,000mW/cm^2. Therefore, it is considered relevant to carry out periodic measurements of the emission intensity of light-curing units of clinical use. The aim of this study was to test the intensity [mW/cm^2] of a representative sample of tungsten-halogen and LED photopolymerization units used in private and public health service in different areas of the Valparaíso Region in Chile. This was achieved through the use of dental radiometers, without considering the variables of intensity modification over time (either spontaneously, by undesirable inherent characteristics of the device, or by programs of intensity modification in time), or the density of accumulated power needed. This *in vitro* diagnostic test, evaluated a sample of 507 units, 107 halogen and 400 LED, for a period of around one month, using two radiometers as measuring instruments. For LED units the Bluephase Meter® radiometer, from Ivoclar-Vivadent™ was used, and for halogen units we used the Coltolux® from Colténe™. As a result, 85% of the LED and halogen units achieved the minimum requirements of intensity needed for the polymerization of conventional dental biomaterials. However, only 25% from the tested units achieved a power density of 1,000mW/cm^2.

Keywords: Curing lights, dental; efficiency; halogen dental curing lights; led dental curing lights; composite resins.

Resumen: La evidencia indica que la intensidad de luz mínima requerida de una unidad de fotocurado para polimerizar en forma confiable una resina compuesta, en incrementos de 2mm, es de 300mW/cm^2. La reciente introducción de nuevas generaciones de resinas compuestas para incrementos de gran volumen, se contraponen parcialmente con la norma ISO 4049 (2009) obligando a rangos de intensidad de 1.000 mW/cm^2. Por lo anterior, se estima relevante efectuar mediciones periódicas de la intensidad de emisión de unidades de polimerización por luz de uso clínico. El objetivo del presente trabajo fue testear la intensidad [mW/cm^2] de una muestra representativa de unidades de fotopolimerización halógenas y LED usadas en el servicio particular y público de distintas localidades de la Región de Valparaíso– Chile, mediante el uso de radiómetros odontológicos, sin considerar las variables de modificación de intensidad en el tiempo (ya sea de carácter espontánea por características inherentes indeseadas del dispositivo, o por programas de modificación de la intensidad en el tiempo), o la densidad de poder acumulada necesaria. Este ensayo diagnóstico *in vitro* evalúa una muestra de 507 unidades, 107 halógenas y 400 LED, durante un periodo de alrededor de un mes, utilizando dos radiómetros como instrumentos de medición: para unidades LED se empleó el radiómetro modelo Bluephase Meter®, marca Ivoclar-Vivadent™; y para unidades halógenas, el radiómetro modelo Coltolux® marca Colténe™. Bajo las condiciones del presente trabajo, el 85% de las unidades LED y Tungsteno-halógenas, cumplen con los parámetros mínimos de intensidad necesarios para la polimerización de los biomateriales odontológicos de uso convencional. Sin embargo, solo el 25% de las unidades registradas proporcionan una intensidad que supere los 1.000mW/cm^2.

Palabras Clave: *Luces de curación dental; luces de curación dental halógenas; luces de curación dental led; eficiencia; resinas dentales.*

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INTRODUCTION.

Light-curing biomaterials that require visible light units for their activation are one of the most frequently used products worldwide by dentists.[5] In Chile and elsewhere, it coexist the use of halogen polymerization units and diodes of diverse characteristics, origin and ages, for the light activation of biomaterials.[7]

Evidence suggests that halogen or LED light intensity of 300mW/cm^2 is the minimum necessary to effectively cure a composite resin in 2mm increments.[1] According to the manufacturers, new generations of composite resins such as bulk-fill-resins would allow for the restoration of cavity preparations with large volume increments (4mm to 5mm).

However, application in increments of more than 2mm is partially opposed to the ISO 4049 (2009) standard, which imposes a higher requirement of more than 1,000mW/cm^2.[5]

Efforts to comply with the requirements for the use of bulk-fill resins that require a higher depth of cure have been made, by incorporating photoinitiators additional to camphorquinone, of greater light sensitivity, such as Lucirin® and Ivocerin®, as well as the introduction of polywave LED or third generation[3] units into the market.

Nevertheless, there are still a significant number of units that seem to be functional, but that are not regularly tested. As such, it is important that dentists maintain the units, with particularly care regarding the intensity and density of power produced by the light units1, since these factors affect the process of clinically accepted polymerization (65% approximately), especially when light-curing a bulk-fill[4] resin.

Objetives

The aim of the present study was to test the immediate intensity [mW/cm^2] of a representative sample of tungsten-halogen and LED light curing units used in the private and public service in the Valparaiso Region of Chile, using appropriate dental radiometers as measuring devices.

We seeked to determine how many units comply with the minimum acceptable standard of 300mW/cm^2 for traditional polymerization products in layers of 2mm or less. Also we aimed to assess how many units comply with the polymerization standard of 1,000mW/cm^2.[5-6]

MATERIALS AND METHODS.

We evaluated the instantaneous light intensity in mW/cm^2 of a sample of 507 units, 107 halogen and 400 LED, for a period of around one month, using two radiometers as measuring instruments. For LED units the Bluephase Meter® radiometer (Ivoclar-Vivadent™) was used, and for halogen units we employed the Coltolux® radiometer from Colténe™.

For each measurement, the light probe was placed directly centred on the radiometer's sensor. Afterwards, the light-curing unit was turned on, keeping it on the sensor for 5 seconds; the detected light intensity was displayed on the screen of the radiometer.

The inclusion criteria included units used actively in clinical practice (within the last 30 days), units that had identification about its LED or halogen nature (brand and model), units manufactured from 1990 onwards, and that had all their components and light probes, and were equipped with a standard circular emission nozzle.

The study also evaluated the type of light, brand, model, and the condition of the optical fibre and of the active parts (adequate, contaminated, damaged), as well as the declared intensity of each analysed unit. Finally, two standards were considered: 300mW/cm^2 and 1000mW/cm^2.

RESULTS.

Out of the total number of light units (507), 85% (428) had a light intensity equal or superior to 300mW/cm^2. Halogen light units and LED units exceed this figure by 99% and 80%, respectively. (Table 1)

One hundred and twenty-five light units were damaged or contaminated, 46% of which had an intensity higher than 300mW/cm^2, with halogen light units and LED units exceeding this value in 94% and 34% of cases, respectively. (Table 2)

Regarding the higher light intensity, 59 out of 400 LED units (14.75%) exceeded 1000mW/cm^2. (Table 1)

Out of the 107-quartz tungsten halogen units, 73 (68.2%) exceed 1000mW/cm^2.

Therefore, out of the total number of light units (507), only 26.03% complied with this level of intensity.

Table 1. Number of light units (halogen and LED), with an intensity higher and lower than 300mW/cm².

Intensity [mW/cm²]	Total number of light units	%	Number of halogen units	%	Number of LED units	%
Lower than 300	79	15%	1	1%	78	20%
Higher than 300	428	85%	106	99%	322	80%
Total	**507**	**100%**	**107**	**100%**	**400**	**100%**

Table 2. Number of damaged or contaminated halogen and LED light units with an intensity higher and lower than 300mW/cm².

Intensity [mW/cm²]	Total number of light units	%	Number of halogen units	%	Number of LED units	%
Lower than 300	68	54%	1	4%	67	66%
Higher than 300	57	46%	23	96%	34	34%
Total	**125**	**100%**	**24**	**100%**	**101**	**100%**

Table 3. Number of halogen and LED light units, with an intensity higher or lower than 1,000mW/cm².

Intensity [mW/cm²]	Total number of light units	%	Number of halogen units	%	Number of LED units	%
Lower than 1000	375	15%	34	31%	341	85.25%
Higher than 1000	132	26.03%	73	68.2%	59	14.75%
Total	**507**	**100%**	**107**	**100%**	**400**	**100%**

DISCUSSION.

The results show that the optical fiber affects light intensity. In fact, its deterioration is the cause of weak light intensity. In this context, it is important to mention the conclusions obtained by Omidi *et al.,*[7] who showed that the gradual accumulation of composite resins residue in the optical fiber can significantly reduce light intensity. Given the vulnerability of the optical fiber, it is important to measure the light intensity of the device periodically as well as to repair the unit when needed, which can improve the efficiency of the device. Damage to the optical fiber is the main reason for unit replacement.

Measuring the intensity (and indirectly the density of power when considering exposition time) is a critical parameter when light curing a composite resin, given that the lack of light intensity can carry as much severe clinic implications as an excess of it (or density of power in time). A deficient polymerization can negatively affect certain properties of composite resins, such as wearing, level of conversion from monomer to polymer, quality of restauration margins, adhesive resistance to dental structures, and depth of curing, among others. Conversely, an increase in light intensity, or density of power accumulated, may result in a higher risk of thermic damage to the gum and dental pulp.[5] Different authors[3] warn that clinicians must limit the light exposure time to 20 seconds when the intensity is in a range between 1,200 and 1,600mW/cm².

Given the need of using a light intensity above 1,000 mW/cm² for the curing of bulk-fill resins, it is worrisome that only about a quarter of the evaluated units comply with that number. A result not so different to the one obtained by Nassar *et al.,*[1] where the intensity of 166 light units, 24 QHT and 140 LED from a state university in Saudi Arabia was evaluated, and in which only 9.4% of light units exceeded 1,200mW/cm², and 7.6% had values lower than 600mW/cm². In the present study, the situation notably worsens when the light intensity limit is

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set at 1,200mW/cm^2: only eight LED units (2.00%) pass that range, and 33 halogen units (30.85%) comply with that value. Therefore, only 8.08% of total units pass the 1,200mW/cm^2 intensity threshold. As for the limitations of this study, it is important to mention that the measurement of light intensity was registered by a standard radiometer, which does not take into account the diameter of the optical probe, thus, affecting the accuracy of the register.

Moreover, it is important to warn that conventional methods for light intensity measurements register a mean of the radiant exit intensity, just as if the beam of light was uniform. Conversely, the beam of light can present less than 400mW/cm^2 in some areas, and almost 5,000mW/cm^2 in others. This is important, since some dental preparation areas could be exposed to an insufficient[8] amount of light.

CONCLUSION.

Out of 507 LED or halogen light units, 85.00% reached at least the 300mW/cm^2 defined standard, and 20.03% reached the 1000mW/cm^2 threshold standard. Most LED and halogen light units comply with the minimum parameters of required intensity to polymerize conventional dental biomaterials.

A relation between the status of the optical fiber and the measured intensity was confirmed. Therefore, it is recommended to keep a proper maintenance of the components of the light units, particularly of those related to optical fiber or nozzles of the LED units. It was shown that only one quarter of the registered units provide an intensity above 1000mW/cm^2, suitable for curing bulk-fill resins.

Conflict of interests: None.

Ethics approval: The project was pre-analyzed and did not require evaluation by the Bioethics Committee of Universidad de Valparaíso, Chile.

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Authors' contributions: Both authors carried out the entire study, and approved the final manuscript.

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