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Conhecimento de estudantes de odontologia e dentistas clínicos da República Dominicana quanto aos seus equipamentos e protocolos de fotoativação

Patricia Grau Grullón

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Resumo

GRAU GRULLÓN, Patricia**. Conhecimento de estudantes de odontologia e dentistas clínicos da República Dominicana quanto aos seus equipamentos e protocolos de fotoativação.** 72p**.** Tese (Doutorado em Odontologia) – Programa de Pós-graduação em Odontologia. Universidade Federal de Pelotas, Pelotas, 2021.

O objetivo desta tese foi avaliar e mostrar aos alunos de graduação as características técnicas e mensuração da irradiância de seus dispositivos de fotoativação bem como avaliar o conhecimento de dentistas dominicanos sobre as características técnicas e protocolos de fotoativação. O trabalho foi dividido em dois estudos: (1) uma conferência acompanhada dos equipamentos em um experimento *in vitro* e (2) aplicação de um questionário aos cirurgiões-dentistas da Republica Dominicana. No primeiro estudo, um grupo de 30 alunos recebeu uma aula teórica sobre fotoativação e foram convidados a se apresentarem com seus dispositivos para aferição. Cada aluno mediu a irradiância de seu equipamento por meio de um espectroradiômetro e um radiômetro digital com distâncias de 0 mm e 6 mm. Todos os fotopolimerizadores utilizados pelos alunos foram classificados como equipamentos de baixo custo. Os valores de irradiação foram influenciados pelo equipamento utilizado para avaliar esta característica (radiômetro ou espectroradiômetro) e pela distância (0mm ou 6mm). O segundo estudo envolveu a elaboração de um questionário online autoaplicável, composto por cinco seções, para indagar sobre: 1. Perfil profissional e dados sociodemográficos; 2. Características técnicas do dispositivo; 3. Avaliação das características técnicas do dispositivo; 4. Conhecimento sobre o risco de lesões oculares; e 5. Recursos a serem considerados ao adquirir novos equipamentos. O questionário final foi escrito no Formulários Google e consistia em 60 perguntas obrigatórias. Um total de 374 respostas válidas foram recebidas em 10 dias. Foi calculada a diferença de média com o test T-student e a quantidade de redução de intensidade produzida pela distância também foi calculada em porcentagem. Nos dados do questionario foram realizada análise estatística univariada e uma análise bivariada entre diferentes grupos de variáveis. As variáveis categóricas foram avaliadas com o teste do qui-quadrado. Nos casos de variáveis do tipo escala Likert, foi realizado o teste estatístico Kruskall-Wallis para estabelecer diferenças nos escores obtidos entre os grupos. Os dentistas dominicanos reconhecem que é extremamente importante conhecer as características técnicas de seus equipamentos, embora a maioria não tenha conhecimento dos detalhes técnicos de seus dispositivos. Eles também não têm boa compreensão dos efeitos da luz azul na visão. Com esta tese podemos concluir que estudantes e dentistas dominicanos desconhecem as características técnicas de seus equipamentos e como esses detalhes podem afetar a qualidade da fotoativação de materiais odontológicos fotoativados.

Palavras-chave: Polimerização. Equipamentos odontológicos. Resinas compostas

Abstract

GRAU GRULLÓN, Patricia. **Knowledge of dentistry students and clinical dentists in the Dominican Republic regarding their photoactivation equipment and protocols**. 2021. 72p. Thesis (PhD in Dentistry). Graduate Program in Dentistry. Federal University of Pelotas, Pelotas, 2020.

The aim of this thesis was to evaluate and show undergraduate students the technical characteristics and measurement of the irradiance of their photoactivation devices, as well as to assess the knowledge of Dominican dentists about the technical characteristics and photoactivation protocols. The work was divided into two studies: (1) a conference accompanied by the equipment in an *in vitro* experiment and (2) application of a questionnaire to dentists in the Dominican Republic. In the first study, a group of 30 students received a theoretical class on photopolymerization and were invited to present themselves with their photoactivation devices for measurement. Each student measured the irradiance of their equipment using a spectroradiometer and a digital radiometer with distances of 0 mm and 6 mm. All light curing lights used by the students were classified as budget equipment. The irradiation values were influenced by the equipment used to assess this characteristic (radiometer or spectrophotometer) and by the distance (0mm or 6mm). The second study involved the development of a self-administered online questionnaire, consisting of five sections, to inquire about: 1. Professional profile and sociodemographic data; 2. Technical characteristics of the device; 3. Evaluation of the technical characteristics of the device; 4. Knowledge about the risk of eye damage; and 5. Features to consider when purchasing new equipment. The final questionnaire was written in Google Forms and consisted of 60 mandatory questions. A total of 374 valid responses were received in 10 days. The mean difference was calculated using a T-student test and the amount of intensity reduction produced by distance was also calculated as a percentage. Univariate statistical analysis and bivariate analysis between different groups of variables were performed on the questionnaire data. Categorical variables were evaluated using the chi-square test. In cases where Likert scale variables were present, the Kruskall-Wallis statistical test was performed to establish differences in the scores obtained between the groups. Dominican dentists recognize that it is extremely important to know the technical characteristics of their equipment, although most are unaware of the technical details of their devices. They also don't have a good understanding of the effects of blue light on vision. With this thesis we can conclude that Dominican students and dentists are unaware of the technical characteristics of their equipment and how these details can affect the photoactivation quality of light curing of resin materials.

Keywords: Polymerization. Dental equipment. Polymers. composite resins.

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1 Introdução

Para atingir uma melhor conversão de monômeros em polímeros de materiais resinosos fotoativados é imprescindível ter um aparelho de fotoativação, como consequência esses equipamentos se tornaram essenciais em qualquer consultório odontológico(PRICE; CHRISTENSEN; BRAGA, 2021; ALHADDAD *et al.*, 2021; SHIMOKAWA *et al.*, 2021). O processo de fotoativação poderia parece simples: basta expor o material resinoso à luz azul do equipamento durante alguns segundos, entretanto é mais complicado do que parece, uma vez que depende de vários fatores, sendo o mais relevantes a técnica do operador e as características técnicas do equipamento. (DE OLIVEIRA; ROCHA; ROULET, 2018).

Há muitos tópicos a serem conhecidos e discutidos sobre a fotoativação, como as características técnicas do aparelho e o protocolo usado pelo clínico no processo de fotoativação. Las propriedades químicas e mecânicas, necessárias para o sucesso clínico previsível, podem ser afetadas quando os materiais resinosos fotoativados não recebem suficiente energia (SHORTALL *et al.*, 2016a; SHORTALL *et al.*, 2016b; BESEGATO *et al.*, 2019). Um grau insuficiente de conversão de monômeros em polímeros tem sido associado a menor dureza superficial, descoloração, menor resistência ao desgaste, menor resistência adesiva, citotoxicidade e maior suscetibilidade a defeitos marginais. (PRICE; SHORTALL; PALIN, 2014; SHIMOKAWA *et al.*, 2016; PRICE, 2017; RUEGGEBERG *et al.*, 2017)

Ao utilizar o termo em inglês "*light curing*" na base de dados *PubMed*, surgem 7.957 artigos sobre o tópico, dos quais 1.903 têm menos de 5 anos, portanto, pode-se considerar que é um assunto bastante discutido e pesquisado. Sabe-se que para os alunos de graduação e para o clínico-dentista a leitura e interpretação das pesquisas pode ser desafiante(CHIAPPELLI, 2019; NEUPPMANN FERES *et al.*, 2020) mas tem sido publicada guias de fácil leitura sobre os aspetos técnicos a serem levados em consideração nos aparelhos de fotoativação e como influenciam, juntamente com a técnica, no grau de conversão de materiais monoméricos (ROULET; PRICE, 2014; DE OLIVEIRA; ROCHA; ROULET, 2018; PRICE; CHRISTENSEN; BRAGA, 2021; SHIMOKAWA *et al.*, 2021). Apesar disso tem sido relatado baixo conhecimento sobre o tópico, revelando que há necessidade de mais educação e orientação a esse respeito. (SANTINI; TURNER, 2011; KOPPERUD *et*

al., 2017; DE OLIVEIRA; ROCHA; ROULET, 2018; BANSAL *et al.*, 2019; GEORGIEV, 2019; ALAM *et al.*, 2020; AL-SENAN *et al.*, 2021; PRICE; CHRISTENSEN; BRAGA, 2021)

Nos cursos de graduação, deve ser ensinado com precisão que os materiais resinosos precisam receber suficiente exposição radiante (quantidade total de energia necessária para se oferecer uma adequada polimerização do material), bem como uma técnica correta para atingir esse objetivo (MUTLUAY; RUEGGEBERG; PRICE, 2014; DE OLIVEIRA; ROCHA; ROULET, 2018; SULIMAN; ABDO; ELMASMARI, 2020). Outro tópico essencial que deve ser discutido são as considerações na hora de comprar do aparelho, uma vez que o mercado odontológico está saturado de equipamentos que são facilmente adquiridos a custos baixíssimos, que não possuem as certificações necessárias para serem utilizados em pacientes (ALSHAAFI *et al.*, 2016; TONGTAKSIN; LEEVAILOJ, 2017). Para muitos profissionais, o custo de um equipamento de fotoativação de qualidade pode ser extremamente elevado (SOARES; BRAGA; PRICE, 2021) contudo, economizar na compra do aparelho de fotoativação pode ser prejudicial. Professores e pesquisadores devem ser mais enfáticos na explicação desses conceitos, a fim de se conseguir um impacto e uma mudança de atitude em relação à fotoativação. (PRICE; FERRACANE; SHORTALL, 2015; SHORTALL *et al.*, 2016a; SHORTALL *et al.*, 2016b; RUEGGEBERG *et al.*, 2017)

Constitui imprescindível avaliar as áreas de conhecimento sobre o tópico que precisam ser melhoradas, como reconhecer as características técnicas de um equipamento de fotoativação certificado, técnicas de fotoativação e protocolos de manutenção de equipamentos, com a finalidade de desenvolver iniciativas que acrescentem o conhecimento do tema e como resultado uma melhora na qualidade dos procedimentos utilizando materiais resinosos fotoativados, realizado por alunos de graduação e dentistas clínicos. Baseado nisso os objetivos da presente tese foram:

Identificar os aparelhos de fotoativação dos alunos de graduação de uma universidade dominicana e verificar a irradiância por meio de um radiômetro digital e espectrorradiômetro, em diferentes distâncias (0mm e 6mm).

Avaliar o conhecimento e ponderação dos dentistas dominicanos em relação à fotoativação, características técnicas de seus aparelhos, técnicas de fotoativação utilizadas, rotinas de manutenção e conscientização da proteção ocular. Também fexpor os motivos considerados para comprar sua equipamento atual e as considerações na compra de um novo equipamento.

2 Capítulo 1

Title: Technical features and irradiance output of light curing units of undergraduate Dominican students[1].

Short running title: Irradiance output light curing units

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Title: Technical features and irradiance output of light curing units of undergraduate Dominican dental students.

Abstract

Objective: Identify the light curing technical features and appraising the irradiance, using a conventional radiometer and spectroradiometer, at different distances (0mm and 6mm). Material and methods: A group of 30 students received a theoretical lecture on photoactivation with a requested to assist with their Light Curing Unit, then each student was invited to measure the irradiation of their equipment using a spectroradiometer and a digital radiometer with a distance of 0mm and 6mm. The mean difference between groups was analyzed by Student test for paired example (P=0.05). Results: The paired T-tested showed difference between the irradiance means at 0mm and 6mm with the radiometer ($p<0.001$) and the spectroradiometer ($p<0.001$). Difference between both measuring equipment at 0mm ($p<0.001$) and 6mm ($p<0.001$) were also founded. Conclusion: All the light curing units used by students at a Dominican university were classified as budget equipment. The irradiation values were influenced by the equipment used to measure (radiometer- spectroradiometer) and by the distance (0mm-6mm).

Key words: dental curing lights, polymerization, dental equipment

1. Introduction

Although much of today's dentistry depends on adequate resin photopolymerization, it appears that many dentists take light curing for granted. It is known that correctly photoactivation resin-based materials (RBM) are essential for the conversion of monomers to polymers since the chemical and mechanical properties depend largely on polymerization (1-4). Therefore, it could be understood that photoactivation is fundamental for the clinical performance and longevity of RBM. The relationship between the technical characteristics of the light curing unit (LCU) and the protocols to perform this process is also clearly established, as consequence practitioners must comprehend this process, before handling photoactivated dental materials. (5-7)

For dental students, even for clinical dentists with years of experience, understanding the science of photoactivation can be complex, therefore, teaching-learning methods that can easily illustrate the relevance of knowing this subject should be integrated into the classroom. Various studies (6, 8-16) have shown the influence of teaching on the amount of energy that restorations receive, concluding that it is essential to receive correct training to achieve a better degree of conversion of RBM.

It is common that in dental schools, students are given a list of instruments and equipment necessary to perform, initially, preclinical practices, within this list is the LCU. If the student does not receive correct guidance on the technical characteristics required to purchase this equipment, they will probably acquire an LCU that is beautiful, colorful, easy to buy, and above all, inexpensive. Dental students have been able to purchase directly over the Internet dental equipment, including LCU, some for as little as US$9.00(17). Most of them have been classified as "low budget equipment" distinguished by their lack of validation and license to be operated, smaller tip diameters, very poor beam uniformity, higher levels of nonuniform power emission, low effective emission ratios, not able to maintain their initial light output after repeated exposures and not provide an adequate indication for battery drain during use. (3, 18-20)

Dental students must identify the importance of photoactivation and the purchasing equipment that meets the characteristics widely described in the literature (1, 5, 21-22), hence the teachers should not only discuss the subject but also include some type of experiment or practice. One of the experiences that can easily be incorporated into the classroom is the use of radiometers to measure the irradiation of

the LCU, knowing that these equipment have limitations. The MARC's is a spectroradiometer that can measure irradiation and includes a plastic piece that simulates a tooth with a 6mm cavity to determine the effect of distance on irradiation, which is a widely debated topic. This MARC has been used in other investigations to measure the irradiance of LCU(6, 8, 9, 12, 13, 15, 23-27) and to the best knowledge of the authors, is the first investigation conducted in the Dominican Republic on the subject.

The purpose of this study was to identify the technical features of the LCU owed by undergraduate students at a Dominican university. Furthermore, the irradiance using a conventional radiometer and spectroradiometer, at different distances (0mm and 6mm) was evaluated. Finally, each student calculated the percentage of irradiance decrease with the distance and compared the values reported by the manufacturer with the acquired with the meters.

2. Material and methods

This study was approved by the ethics committee of Iberoamerican University (Santo Domingo, Dominican Republic) protocol number CEI2018- 117E. Since the LCU belonged to the undergraduate students, it was necessary to sign the informed consent to be able to perform the measurement. A total of 30 students agreed to participate and allowed their equipment to be evaluated.

Initially, preclinical dental students were invited to receive 2 hours of theoretical lecture on photoactivation with a request to assist with their LCU. During the conference, the main technical features that must be identified in LCU were cited and the attendees were asked to confirm which ones were present in their equipment. The model, manufacturer, technical features, and price were collected. Then, each student was invited to measure the irradiation of their equipment, write it down and calculate the percentage of irradiation decrease as a consequence of the distance. Before each measurement, it was confirmed if the LCU presented the orange protector against blue light. Also, the tip was examined to check the existence of any type of damage or contamination by residues of RBM.

The irradiance (mW/cm^2) of each unit was evaluated using the Spectroradiometer (Check MARC^{tm} equipment/Blue Light Analytics) and a digital radiometer (Curing Light Meter Power Tester LM-1/ Woodpecker) whose range, according to the manufacturer, goes from 0 up to 3,500 mW / cm^2.

The measurements were made in the operative dentistry laboratory of the Universidad Iberoamericana (UNIBE). It was confirmed that the LCU was fully charged and set up in the "Normal" and continuous mode for those that presented different curing options. Using both meters, each LCU was examined at two distances: at 0 mm positioned as close to the sensor without touching it, and 6 mm away from the sensor using a spacer appliance that simulates a molar with a 6mm deep cavity included in the spectroradiometer. The measurements were made with each LCU by a single researcher under the observation of the student, the time established to activated the LCU was 10 seconds for each distance, following the requirements of the ISO 10650-2.

To culminate the educational experience, the students were asked to compare the irradiance results obtained with the meters with those reported by the manufacturer at the distance of 0mm. In the same way, they were taught to calculate the percentage of irradiance reduction by subtracting the value obtained from 0mm with the obtained at 6mm distance.

The mean and standard deviation of the irradiance values of the 30 tested equipment and commercial control LCU were calculated, as well as the maximum and minimum irradiance values at both distances (0mm – 6mm). The mean difference between groups was analyzed by Student test for paired example (P=0.05). The amount of intensity reduction produced by distance was also calculated in percentage. Descriptive statistic was performed in the program STATA 16 (StataCorp LP, College Station, TX, USA).

3. Results.

The characteristics of each unit are described in Table 1 (supplementary data). Out of the 30 LCU that were evaluated, 19 belonged to the manufacturer BoNew, 7 belonged to Woodpecker® with 4 different models 2 belonged to MVM, 1 belonged to Aphrodite and 1 belonged to Foshan. All units belonged to the LED classification and were new or had been used for a very short time. The wavelength reported by the manufacturers varies between 385 to 515 nm. All models have the option of programming different photoactivation times, most between 5 to 20 seconds. Two manufacturers presented the high/turbo or normal programming, while 5 others presented full/all light, ramping/gradually or pulse/flashing modes. According to AlShafie et al. (19) all the student's curing devices belonged to the Budget

classification with a range price between $32.99 to $202.78, so it was decided to include the Elipar Deep Cure (3M / ESPE) as commercial control equipment (CCE).

Of the 30 LCU evaluated, 4 had damage on the tip. Only one had damage to the body. Contamination by remains of RBM was observed in 8 equipment. The frequency of the orange protector was observed in 19 of the evaluated LCU.

The irradiance mean and standard deviation of the LCU evaluated at 0mm and 6mm distance with the radiometer and spectroradiometer are described in Table 2. The paired T-tested showed difference between the irradiance means at 0mm and 6mm with the radiometer ($p<0.001$) and the spectroradiometer ($p<0.001$), detail in Table 3. Also, difference between both measuring equipment at 0mm ($p<0.001$) and 6mm ($p<0.001$) were founded.

Finally, the percentage of irradiance decrease was calculated with each equipment used (Table 4). To observe how the distance can affect the irradiance of the LCU, the difference between the irradiance at 0 mm and 6 mm was calculated. It was observed that a greater percentage of reduction was obtained when the LCU was evaluated with the radiometer. After associating the irradiation reported by the manufacturers and those obtained in this study, it could be observed that 23 of the LCU showed less irradiation than described, when evaluated by the radiometer and 7 equipment's using the spectroradiometer (Table 5 - supplementary data).

4. Discussion

An ideal LCU should have technical features that allow the operator to achieve a correct conversion of RBM, the LCU must have an adequate intensity of light homogeneous throughout the tip output with a wavelength that excited all photoinitiators (7, 28). The technical characteristics of the students' LCU were described, according to the information provided by the manufacturer. A quite noticeable aspect was, the great variability of terms in the descriptions of the equipment, especially in relation to the photoactivation modes, that are named with different terminologies (high, turbo, normal, full, ramping, gradually, flashing, pulse) this lack of homogeneity could create confusion, particularly in students.

All the students' LCU belonged to the classification of budget units, as had been widely described, lack of validation and most presented questionable technical characteristics (2-3, 29-30). Availability and price can be two important variables at the moment of purchasing an LCU, being the value of the most common equipment among students $38.99 USD, compared to the $980.00 USD of the commercial control

equipment. For this, it is essential that the student understands the importance of the LCU and its clinical implications, in order to be able to choose correctly.

Most of the LCU evaluated do not show the irradiance described by the manufacturer, as reported by Konerding et al. (23) which also found irradiance values higher and lower than those reported in the LCU technical profile. As a conclusion, they recommended to place the tip of the LCU directly on the RBM at an angle of 0° and a distance of 0 mm. Therefore, it can be inferred that the lack of knowledge can lead to acquiring unqualified equipment and that the photoactivation process is carried out without really understanding the LCU and its importance.

The minimum of irradiance established to properly photopolymerize a 1.5 to 2mm thickness increment of composite resin is between 300-400 mW/cm^2(31-32), however, the recommendation is to use an LCU with an irradiance between 1,000 to 2,000 mW/cm^2 following the time recommended by the manufacturer of the resin material(34). The LCU evaluated in this study showed values of irradiance when measured with the radiometer at 0mm between 275 to 2600 mW/cm^2. Unexpectedly, 4 equipments presented scores below 500 mW/cm^2, specifically 2 units presented irradiance below 400 mW/cm^2. It is known the relationship between irradiance, distance and exposure time, as consequence, longer photoactivation times have been suggested to compensate the irradiance reduction by distance (8, 25). Nevertheless, Haenel et al. (4) concluded that longer exposure times do not lead to a complete conversion since exposure reciprocity is not a valid rule. Ideally, the irradiance and time indicated by the RBM manufacturer should always be followed.

By increasing the distance using the plastic simulator of a 6mm class I cavity, almost all LCU reduced significantly their intensity, to values below 500mW/cm^2. Specifically, 27 units showed a range of 400 mW/cm^2 or below. Although this data at first seems alarming, it must be emphasized that the assessment of the effect of distance with the simulation of the 6mm cavity is designed to be used with the spectroradiometer; besides several publications indicate that radiometers are inexact. Considering the inaccuracy of values provided by radiometers, professionals should not trust entirely on their measures, most radiometers do not contemplate the different tips areas, consequently, the sensors are smaller, which can be an important variable in the specificity of the results (34-35). However, portable radiometers can be used to monitor changes in light output from LCU over time (2, 29, 31,36-37). The purpose of this simulation was to show the students how the distance would affect the irradiance,

and the relevance of monitoring the LCU to make the necessary adjustments, such as increasing the photoactivation time, when necessary.

When the same LCU was evaluated with the spectroradiometer, different results were obtained. None of the equipment presented irradiation values below 500 mW/cm^2 at 0mm, being the lowest value obtained of 596 mW/cm^2. The same LCU with the radiometer had a measurement of 325 mW/cm^2. The Check MARC^{tm} spectroradiometer and the integrating sphere system are considered the two most accurate systems to measure the irradiance of photoactivation equipment. (36)

Operating the spectroradiometer at a distance of 6mm, several LCU significatively reduced their values below 500 mW/cm^2. Only 2 presented ranges below 400 mW/cm^2. Most of the LCU presented values between 500-999 mW/cm^2. Just 2 presented irradiance over 1000 mW/cm^2, one of these being the control commercial equipment, also statistical difference between the means from 0mm to 6mm where found. The range of irradiance reduction with the distance increase, was considerably high, almost 40% when measured with the spectroradiometer. The irradiance reduction with the distance increase, was considerably high, almost 40% when measured with the spectroradiometer. Price (2) explains that some LCU have an irradiance reduction of 75% or more with a distance of 8mm between the light output and the RBM, therefore the dentist must know how the distances can affect the irradiance provided by their curing light (1,3-4, 23). Beolchi et al. (27) also found that curing lights had a significant loss of irradiance as increased the distance from the tip to the meter sensor, that was related to the type of LCU, as observed in the present study.

During the 10-second blue light emission in the spectroradiometer, the control commercial equipment maintained the same intensity and presented results similar to those reported by the manufacturer. Differently, the student's LCU irradiance varied repetitively during the 10 seconds, showing that this equipment lacks homogeneity in beam profile (38). It seems that this behavior is known by manufacturers since most of them, report a range of irradiation on their LCU, which results in worrying information, as RBM needs a stable emission of blue light for a while.

Studies evaluating the irradiance of photoactivation equipment had been executed (25,32,39-40), but to the author's best knowledge, this is the first in the Dominican Republic. The limitations of this study included that only the irradiance of the LCU was evaluated. It would be interesting for future research to verify the accuracy of the other

characteristics described by the manufacturers, such as the wavelength and the homogeneity of the beam profile (41). Only the effect of distance was demonstrated from the photoactivation protocol, so the position effect and the stabilization of LCU could be included. The findings can contribute to verify the university dental programs, in order to rectify or elaborate LCU guides describing the recommended technical characteristics needed to purchase a LCU, and also to review the number of credits on this topic, including activities such as those described in this article, which can provide significant learning.

During the lecture, students were able to verify the main technical aspects of their equipment, with the help of their manuals and the information provided by the manufacturers on their internet pages. It is essential that, from the beginning of the dental career, the characteristics of the LCU and how it can influence the quality of photoactivation are taught, and interconnected to the importance of evidence-based dentistry and the value of continuing education. (6, 8-9, 12-16, 23, 38, 42)

5. Conclusion

The 30-light curing units belonging to the undergraduate dental students from a Dominican university were described as LED equipment, from 5 different manufacturers that reported irradiation between 900 to 2,500 mW/cm^2 and wavelengths of 385-515 nm, with different settings and activation modes. The irradiation values were influenced by the equipment used to measure (radiometer-spectroradiometer) and by the distance (0mm-6mm). A considerable decrease in irradiance was noted with both measuring equipment when the distance is increased from 0 mm to 6 mm. It is important to know the intensity of the LCU and how the distance influences this technical feature, in order to establish a correct photoactivation protocol that meets the energy requirements that the RBM requires.

6. Declaration of interest

The authors report no conflicts of interest.

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Tables

Table 1. LCU Description

Model	Brand	Characteristics †	Price ††	N
LED H Ortho	Woodpecker®	Rapid orthodontics, 3 seconds for curing brackets. Light output: 1800mW/cm^2 Modes: Ortho (P1): 3, 5, 10sec. (1.800 mW/cm²) Normal (P2): 5, 10, 15 o 20 Sec. (1.100 mW/cm²) Wavelength: 440 - 490 nm	US$130.00	2
DTE iLED	Woodpecker®	Wavelength: 385nm-515nm 2 working modes: Normal (5, 10, 15 o 20 sec) and Turbo (1 o 3 sec). Light output: 1000 – 2500 mW/cm^2	US$202.78	3
LED B	Woodpecker®	Light output: 1000mW/cm² - 1700mW/cm² Wave length: 420nm to 480nm Constant light intensity. Time setting: 5s, 10s, 15s, 20s.	US$166.33	1
LED D	Woodpecker®	Three working modes:- Full, Ramping, Pulse. Time setting:- 5s, 10s, 15s, 20s, 25s, 30s, 35s, 40s. Light Intensity: 1000mW/cm² - 1700mW/cm² Wavelength- 420nm - 480nm	US$94.00	1
Wireless Cordless Big Power LED Light	Aphrodite	Four sets of working time: 5s, 10s, 15s, 20s. Three working modes: All light; Gradually; Flashing. Light source: blue light wave length: 430nm-485nm Intensity:900mW/cm^2-1500mW/cm^2	US$32.99	1
CICADA	Foshan	Light intensity: ≥1600mW/cm2 3 versatile curing modes for every indications. Wavelength: 430-485nm	US$30.00	1
Dental Wireless LED	MUW®	Length Range: 420-480nm Light Intensity: 1000-1500mW/cm^2 3 Solidification Working Mode:Full Mode; Ramp-up Mode; Pulse Mode.	US$53.99	2
LED Light Wired & Wireless Cordless Dentist Cure Lamp	BoNew	Light source: blue light Wave length: 430nm-485nm Output intensity:900mW/cm^2-1500mW/cm^2 Four sets of working time: 5s, 10s, 15s, 20s. Three working modes: All light; Gradually; Flashing.	US$38.00	19
DeepCure	3M/ESPE	Wavelength range 430-480 nm 1,470 mW/cm^2 (-10%/+20%)	US $980.00	1

†Characteristics according to the manufacture.
† †Internet purchased

Table 2. Descriptive statistic of the irradiance results at 0mm and 6mm

Irradiance (mW/cm^2)	Mean †	SD ††	Max	Min
Radiometer 0mm Students LCU	870.87	453.14	2600	275
Radiometer 0mm Commercial control group	1525	0		
Spectroradiometer 0mm Students LCU	1,167.03	352.56	2483	668
Spectroradiometer 0mm Commercial control group	1439	0		
Radiometer 6mm Students LCU	336.67	114.8	700	150
Radiometer Commercial control group	625	0		
Spectroradiometer 6mm Students LCU	716.27	210.18	1502	326
Spectroradiometer 6mm Commercial control group	1261	0		

†MW ††standard deviation

Table 3. Inferential statistic of the Students LCU irradiance results by Student t-test paired sample.

	Mean	Std. Deviation	t	df	Significance†
Radiometer 0mm *vs* Radiometer 6mm	534.20	383.67	7.626	29	<.001
Spectroradiometer 0mm *vs* Spectroradiometer 6mm	450.76	165.59	14.91	29	<.001
Radiometer 0mm *vs* Spectroradiometer 0mm	-296.16	414.91	-3.91	29	<.001
Radiometer 6mm *vs* Spectroradiometer 6mm	-379.60	131.48	-15.81	29	<.001

†Differences between mean values were significantly different (P<_.05).

Table 4. Percentage reduction from 0mm to 6mm distance

Radiometer	Percentage reduction
Students LCU	58.36%
Commercial control group	59%
Spectroradiometer 6mm	Percentage reduction
Students LCU	38.39%
Commercial control group	5.83%

Table 5. Comparison of the irradiance results between the radiometers, spectroradiometer and the manufacture in mW/cm^2

LCI	radiometer 0mm	spectroradiometer 0mm	Reported by manufacture
1	2600	1005	1000- 2500
2	750	1196	900-1500
3	875	1065	1100-1700
4	900	1140	1000- 1700
5	800	1038	900- 1500
6	650	1166	900- 1500
7	275	668	900- 1500
8	850	1287	900- 1500
9	1950	2483	≥1600
10	1125	1402	900- 1500
11	950	1393	900-1500
12	1050	1217	1100- 1800
13	1100	924	1000-2500
14	575	733	900-1500
15	825	904	900-1500
16	1200	1038	1000- 2500
17	775	1373	900-1500
18	375	766	900-1500
19	325	596	900-1500
20	750	1294	900-1500
21	750	1252	1000- 1500
22	775	1262	900-1500
23	775	1391	900-1500
24	625	1003	1000- 1500
25	750	1299	900-1500
26	350	670	900- 1500
27	825	1270	900-1500
28	800	1540	900-1500
29	1075	1404	900- 1500
30	750	1241	1100- 1800
CCG	1525	1439	1470 (-10%/+20%)

3 Capítulo 2

Title: Knowledge and assessment of light curing protocols among Dominican dentists[1].

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Title: Knowledge and assessment of light curing protocols among Dominican dentists.

Abstract

Objective: The purpose of this survey was to assess the knowledge, protocols and safety awareness of Dominican dentists regarding photoactivation. Also, to expose the reasons considered to purchase their actual and a new light curing unit (LCU).

Methods: A self-administered online survey consisting of 60 questions was elaborated, validated and disseminated among Dominican dentists.

Results: A total of 374 valid responses were received over 10 days. The most common procedure was the placement of direct restorations (77.3%). The 87.7% of the dentists reported to having a LED LCU from 32 different manufacturers. The average curing time informed was 20 seconds (60.4%), following the instructions of the material's manufacturer (58.0%). The contestants did not know the direct (94.4%) and indirect (96.8%) dose of blue light that a human eye can tolerate in 24 hours, and only 10.7% uses orange protective eyeglasses. The prestige of the manufacturer (54.0%) and teacher recommendation (50.0%) were the two main aspects considered when they purchased their current LCU. For new purchases, they will consider the irradiance (78.1%), wavelength (77.0%) and tip diameter (71.9%).

Conclusion: Dominican dentists recognize it is extremely important to know the technical characteristics of their equipment and recognize that a correct photoactivation protocol is extremely important for the longevity of the RBM. Most dentists were unaware of their LCU technical features. The awareness about the effects of blue light on the eyes was also slightly known. To purchase new equipment, dentists would consider the technical characteristics of the LCU.

Key words: dental curing lights, polymerization, dental equipment, dental resin.

Clinical relevance: It's essential to recognize the technical features of the photoactivation curing unit to achieve a proper monomeric conversion of resin-based materials. Establishing an accurate protocol and biosafety measures is also crucial for the longevity of procedures with photoactivated materials.

1. Introduction

Light Curing Unit (LCU) plays a crucial role in the degree of conversion of Resin-Based Materials (RBM) since is essential that the photoinitiator receives enough energy within a specific wavelength to achieve an optimum polymerization [1-4]. The LCU's requirements have been widely discussed in guidelines [5] and scientific articles [6-13]. However, for some dentists accessing and reading scientific articles is a difficult time-consuming task, especially if the information is in a different language which could influence the quality of the treatments that patients receive [14-18]. The photoactivation process appears to be as simple as putting the LCU over the RBM, and press a button for a few seconds. But, every year hundreds of restorations are repaired or replaced as a result of wear, marginal discoloration, debonding or fracture [6, 10, 14, 19-20] that is related to polymerization deficiencies, that can also cause allergic and cytotoxic effects. [3, 21]

The LCU's technical details such as irradiance (mW/cm^2), radiant energy (J/cm^2) and wavelength (nm) should be provided by the manufacturer [1, 6, 11]. Nevertheless, clinicians should be aware that there are other factors that can influence the quality of photoactivation such as the light curing protocol [22][23][1][24], the battery charge [1, 25-26], the size of the tip [11, 25, 27], the distance and position between the tip and the restoration [12, 28], the uniform or homogeneity of the beam profile [1, 8, 27], the wavelength type (monowave or polywave) [2, 4, 23, 29], the material and thickness of the restorations to be cemented [30-33], and the type of photoinitiator contained in the RBM. [34-36]

Throughout understanding the relevant factors of photoactivation and the main technical features of their LCU, dentists could optimize the degree of conversion of polymeric materials and thus improve mechanical properties as hardness and wear resistance, which translates into increasing the longevity of restorations [6-7, 9, 27, 37]. Also it is important to discuss the maintenance [38][39] and the biosecurity of the LCU concerning cross contamination and the possible risk of eye damage to the patient and operator [9,11,13, 40-42].

The attitude and knowledge of dentists towards photoactivation and their LCU's had been accessed by many international researchers [41-46], but similar information

in the Dominican Republic, to the author's best knowledge, is inexistent. This research not only includes inquiring about the knowledge, it also incorporates the dentist's assessment of how important it is to identify the technical features related to their LCU and the specifications to consider when purchasing a new equipment.

The purpose of this investigation was to evaluate the knowledge and assessment of Dominican dentists regarding photoactivation, technical features of their LCU's, photoactivation techniques employed to photocured RBM, routines for maintenance and eye protection awareness. Another objective was to expose the reasons considered to buy their LCU's and the aspect to contemplate when purchasing new equipment. The hypothesis of this study was that dentists who know the technical feature of their LCU give greater importance to knowing these characteristics.

2. Material and methods

2.1 Study design

An open survey with a sample of dentists in Dominican Republic was developed and validated with the objective of address the dentist knowledge about the technical features of their LCU. In addition, the questionnaire was designed to know if the years of the the LCU was influenced by monthly income, the most common type of procedure performed by dentits, the number of procedures performed per week, the type of practice and the graduation years. In the same order, it was evaluated whether the photoactivation time used is related to the most common procedure performed by the dentist. The assessment of each technical aspect was also related to the knowledge about it. Finally, the aspects taken into account for the purchase of their current equipment were interrelated with the same consideration for buying a new equipment.

2.2 Ethical considerations

This project was approved by the Ethics Research Committee of the Universidad Iberoamericana, Dominican Republic (protocol CEI2021-10). The Checklist for Reporting Results of Internet E-Surveys – CHERRIES [47] was reviewed for writing this report.

2.3 Questionary design

This cross-sectional study involved the design of a self-administered online questionnaire consisting of five sections to inquire about: 1. Professional profile and socio-demographic data; 2. Technical features of their LCU; 3. Assessment of the technical features of their LCU; 4. Knowledge about the risk of eye damage; and 5. Characteristics to consider when buying a new LCU. The questions were generated from the evidence provided by the guides and articles [8-9] as well as the instruments developed in previous studies. [41, 44-46]

Initially, the questionnaire was pretested by 13 verified dentists in terms of writing style, sequence, internal consistency and clarity using a Linkert scale scored from 1 (unclear) to 5 (very clear). There was a text box after every question to place comments, critics, and suggestions. Questions rated 3 or less by at least 3 pre-testers (n=10) were edited until consensus was reached. Ultimately the questionnaire was reviewed and revised for final approval. Dentists who contributed to the validation process were asked not to participate in the definitive study.

2.4 Questionnaire Content

The first form page presented the purpose of the study and the estimated time to answer it. Emphasis was placed on the request that only dentists respond to the questionnaire and submit one response, since no other means to prevent duplicated answers were used. To access the questionnaire, the respondent must agree to participate in the study. Thus, the first page of the questionnaire served as an Informed Consent Form and recorded the agreement to participate in the study voluntarily, anonymously and without remuneration.

The final questionnaire was hosted on Google Forms (Google Inc., Mountain View, CA, USA) (complementary data) including 60 mandatory questions, divided into 5 sections: Section 1: Nine required multiple-choice questions with one answer option related to the professional profile. Section 2: Eighteen required multiple-choice questions with one answer choice about technical features of their LCU. Section 3: Ten linear scale from 1 (least important) to 10 (very important) questions about the assessment of the technical features of their LCU. Section 4: Five questions about eye hazards related to photoactivation: four required multiple-choice questions with one answer option and one multiple-choice question with several options. Section 5:

Eighteen required questions on a linear scale from 1 (least important) to 5 (very important) related to the reasons for selecting the actual and new LCU.

2.5 Sample calculation and collection of responses

Dominican dentists practicing in the Dominican Republic (DR) were eligible for this study. According to the Dominican College of Dentists (CDO) there are 7,156 registered dentists. A sample calculation was performed with the Open Epi program at a 95% confidence interval and 5% margin of error, resulting in 365 participants. Responses were collected between May 29 and June 18, 2021.

2.6 Participant recruitment and survey administration

The strategy for recruiting participants included sending the questionary via e-mail, WhatsApp and an open social media campaign targeting dentists. A cover e-mail invited the dentist to respond to the survey, presented the purpose of the questionnaire and the time estimated to answer it (about 8 min). Also, a video introducing the study, requesting collaboration and explaining how to access the link to the online survey, was recorded and broadcasted by the abovementioned networks. Survey access was the same, irrespective of the invitation mode, since they all led to the Google Forms link. Reminder emails and messages were sent after one week. The open social media campaign included asking dentists with professional social media profiles to enlarge the promotion and diffusion of the invitation [48]

2.7 Statistics

The data were summarized as percentages. Univariate statistical analysis was conducted, where the qualitative variables were summarized by absolute and relative frequency. Also, a bivariate analysis was executed between different groups of variables (years of the LCU - monthly income, the most common type of procedure performed by dentits, the number of procedures performed per week, the type of practice and the graduation years. The photoactivation time used - to the most common procedure performed by the dentist). Categorical variables were evaluated using the chi-square test. In cases where Likert scale-type variables were present, the Kruskall-Wallis statistical test was performed to establish differences in the scores obtained between groups. All data were analyzed with STATA 16 (StataCorp LP, College Station, TX, USA).

3. Results

3.1. Demography

A total of 374 valid responses were received over 10 days from all 31 cities and 1 National District of Dominican Republic. The number of rejections/losses cannot be calculated because we cannot estimate how many dentists actually received the questionnaire and decided not to respond. As shown in Table 1 (supplementary data), respondents were most female (88.5%), the age range of the participants was mostly between 26 and 36 years (63.4%). Meanwhile, the 89.3% were working in private clinics with monthly income between $10,000 – $24,999.00 pesos (27.5%) and $25,000 - $49,999.00 pesos (25.1%), the equivalent based on the dollar rate ($57.56) is a monthly income between US$173.3 to $434.3 and $434.3 to $868.6 dollars. Only 16.6% of the respondents had no specialized dental course, while 31.3% had completed master's courses (MSC), 28.6% training courses and 23% residency or advance special training (Table 1).

3.2. Photoactivation equipment (LCU)

The most common procedure with RBM reported by the participants was the placement of direct restorations in 77.3%, with an average of 6 to10 procedures per week (31%), described in Table 2 (supplementary data),. The type of practice and the number of procedures is not influenced by the years of the LCU (p=0.60 / p=0.84), although the graduate years (p=0.00), the monthly income (p=0.01), the type of procedures (p=0.03) are. It is important to note that 90.6% of dentists value that correct photoactivation is extremely important for the longevity of the resins (Table 3 - supplementary data).

87. 7% of the dentists report having a LED LCU, while 32 dentists do not know their type of LCU (table 2). Great variability of models was reported, for a total of 32 different manufacturers. Models from Woodpecker® manufacturer were related by 37.4% of respondents, being the LED H model the most common (19.3%), followed by Delux (9.6%) and X-cure (7.2 %). The LED curing light equipment (generic) was reported by 7.8% of dentists, Elipar Deep Cure (3M/ESPE®) by 7.2% and Valo (Ultradent™) by 6.7%, detailed in graphic 1. To simplify these results, the models were

classified as: 1. Major dental manufacturers and 2. Not major dental manufacturers (budget LCU), following the criteria of Al Shaffi [25] as described in Table 2. The majority of the respondents (62.3%) were unaware of the irradiance range of their LCU, but 61.2% considered that it is an important feature to know (Table 3). Of the technical aspects of the LCU investigated in this study, the best known as the type of material of the LCU tip (73.5%) and the different irradiance levels of LCU (58.3%). The tip diameter (33.9%) and the type wavelength (22.2%) were the least identified features. Likewise, the dentist evaluated with a Likert scale of importance of these technical features, the highest percentages of “extremely important” were granted to irradiance, modes (58.3%) and the wavelength (55.1%), as described in Table 3 (supplementary data).

When inquiring about the different photoactivation modes of their LCU, 20 different answers were received, since it was a question with the possibility of several answer options. In table 2 the answers were classified with "different modes" when more than one option was selected. Graphic 2 details the different response options received.

The average curing time reported by the interviewees was 20 seconds (60.4%), with a curing protocol following the instructions of the manufacturer of the material (58%) at a distance of 1 to 2 mm (58.6%) using a procedure of stabilizing the LCU over the photoactivated material (85.4%). The curing time reported by the dentist was not related to the most common type of procedure in their practice (p=0.93). The distance and the manufacturer’s LCU instructions were considered “Extremely important” during the curing process (75.4% - 78.9%).

A total of 191 dentists stated that they had no routines for regular maintenance of their LCU. Visual control of LCU was performed habitually by 153 of the respondents, while 23 used a radiometer regularly to monitor the irradiance. It is important to highlight that there was no association between the maintenance protocol to the years of the equipment (p=0.45).

When asked about when they charged their LCU, the most common answer was when has a low battery or is completely discharged (41.4%). There was no

association between the number of weekly procedures and the protocol to charge the LCU (p=0.38).

In order to relate the knowledge about the technical features of their LCU with the importance of knowing these characteristics, the answers were categorized as No (answered that they did not know) and Yes (answered among the response options). The knowledge about the wavelength of the equipment is associated with the importance of knowing this characteristic (p=0.0001). Similar behavior was observed when studying the knowledge about the diameter of the LCU tip with the importance of this knowledge (p = 0.04).

Among dentist photoactivation routine and the importance of following the material manufacturer's instruction, a relation was found (p=0.0001), while the association between dentist photoactivation routine and the importance of following the LCU manufacturer's indication was not established (p=0.85). The answers on the maintenance protocols of the equipment were associated with the importance of having a maintenance routine or protocol (p=0.02).

3.2. Biosecurity and risk related to photoactivation

The respondents reported using the orange shield mounted to LCU (56.7%) or orange protective glasses (10.7%) and 3 dentists reported that “they look away” when the blue light is emitted by the LCU. Regarding the patient’s eye protection, 244 dentists testified that they do not use any type of shield. Also, it was informed that they asked the patient to “close their eyes” (6 participants) or “cover their eyes with their hands” (1 participant). On the consequences of prolonged exposure to blue light, the majority of respondents answered that is degeneration of the retina (166 responses) and acceleration of retinal aging (148 responses). The participants did not know the direct (94.4%) and indirect (96.8%) doses of blue light that the human eye can tolerate in 24 hours. The use of eye protection when using their LCU related to the knowledge about the indirect maximum dose was not established (p=0.97).

3.2. Criteria to purchase the actual LCU and for buying a new LCU.

Finally, dentists were asked about the criteria used to purchase their current equipment. The extremely important characteristics for selecting their actual LCU were

irradiance (56.4%), wavelength (53.75%) and model (51.9%). The prestige of the manufacturer (54%) and teacher recommendation (50.0%) were the two main aspects considered when they purchased their actual LCU.

If they have to purchase a new LCU, the dentist will consider irradiance (78.1%), wavelength (77.0%) and tip diameter (71.9%). Also, the prestige of the manufacturer (62%) is the most important technical feature. In the same order, the importance of knowing the wavelength was related to the importance given when they bought their equipment ($p = 0.001$).

The Importance given to the model of the actual LCU at the time of purchase was also related to the importance at the time new equipment has to be purchased ($p=0.001$). Also was related the importance given to the recommendation of a colleague for purchasing their current LCU with the importance given to the same recommendation for purchasing new equipment ($p=0.001$). Similarly, the importance given to the recommendation of a teacher at the time of purchase their current equipment was related to the importance for purchasing new equipment ($p= 0.001$) and the importance given to the prestige of the manufacture for purchasing its current LCU with the importance when buying a new equipment ($p <0.001$).

The LCU that dentists currently have was not related to the availability of dental suppliers ($p = 0.06$). The relationship between the importance given to the amount of use of the LCU with the prestige of a manufacturer was not established ($p = 0.1547$), but the importance given to the amount of use at the time of purchasing their current LCU with the importance given to the amount of use for purchasing new equipment was related ($p=0.001$).

4. Discussion

This survey provides evidence of the knowledge of Dominican dentists regarding the characteristic of their LCU's along with the maintenance protocol and the awareness about the potential damage of blue light. Also, the assessment of the features to consider when buying a new LCU was also evaluated. Thus, the dental professional should recognize that the appropriate photoactivation of RBM depends on the protocol and quality of light emitted by the equipment. [11-12]

It is interesting to remark that most of the respondents recognize that the photoactivation process is important for the longevity of dental procedures using RBM. Conversely, two thirds of the population interviewed didn't know the main technical features of their LCU. This could be due to the fact that dentists are aware that this equipment is necessary to achieve monomeric conversion of RBM. Perhaps the question is if they are properly instructed in the association between the technical features of their LCU and how they can influence the photoactivation process. Similar results, with deficient knowledge of their LCU have been reported by other investigators[41-45]. Therefore, it is evident that this topic needs to be widely discussed and understood by dentists.

A minor percentage answered that their LCU presented an irradiance of less than 500 mW/cm^2 or values greater than 2,000 mW/cm^2. Equipment that delivers too much energy cause an unacceptable temperature increase in the pulpal or soft tissues. In addition, high irradiance levels during fewer times offer no benefit when photoactivation RBM [1,6,8]. Due to fact that radiant exposure is calculated by multiplying the irradiance over a period of time [9] longer exposure times (40 to 60s.) are recommended when the irradiance of the equipment is close to 500 mW/cm^2. Is important to highlight that LCU with intensities of under 300 mW/cm^2 is considered insufficient for monomeric conversion [7, 27]. Although most dentists reported photoactivation for 20 seconds, depending on the LCU technical features, this time may not be enough to achieve a correct polymerization.

Soares et al. [49] showed that infection control barriers caused approximately 5–8% of light attenuation when used correctly, nevertheless, to prevent cross-infection the entire LCU and the light tip must be covered with a specific plastic barrier or plastic food wrap [42]. Only a few dentists reported not covering their LCU with biosecurity barriers. Most dentists reported cover just the handle, probably due to fear that wrapping the entire LCU including the light output will affect the irradiance of the equipment. Protecting the complete LCU will not only help decrease cross infection but also could reduce contamination with RBM residues, which can decrease the radiant energy. [50]

The material of the LCU tip and the different photoactivation modes were the best-known technical features, possibly because they are the easiest characteristic to recognize and the most detailed by the manufacturers, unlike the wavelength that is

slight discuses and difficult to measure in clinical practice. Researchers and manufacturers of LCU must provide all technical details about the irradiance, the effect of distance on irradiance, the wavelength and emission spectrum across the light tip [1,7,11,27, 51]. The tip diameter is also an important feature since the RBM has to be enterally covered by the light tip to be correctly photoactivated [9].

The question about the photoactivation modes was focused on knowing if their LCU has this feature, for a future study it would be interesting to investigate if dentists change the photoactivation modes in different clinical situations and the criteria used. This research could be directed to identify the knowledge of polymerization shrinkage and polymerization shrinkage stress.

The protocol used to photoactivate is also important for monomeric conversion. When the tip is a far distance from the material, the irradiance dropped as consequence, low amounts of light energy is delivered and increase the risks of undercuring restorations [12], but the effect of distance is not the same for all LCUs [9,52]. Remarkably, most dentists reported positioning their equipment at a very short distance, stabilizing the LCU on top of the RBM. This photoactivation protocol is widely disseminated by many researchers and professors, additionally, due to the nature of the dental practice, training in protocol and procedures may be more valued than technical knowledge of equipment.

Since the battery charge of some LCU has an influence on the power of the equipment, it is recommended to monitor both regularly during a dental procedure [1, 26], especially if many consecutive procedures such as cementation of veneers or brackets are performed, since the irradiance may decrease between 2% and 8% after 25 exposures of 10 seconds [28]. Disappointing, almost half of the interviewed reported charging their equipment when it’s almost or totally discharged.

The knowledge of Dominican dentists about the maximum doses of direct and indirect blue light to which they can be exposed daily is worrying. High levels of blue light cause immediate and irreversible retinal burning, and chronic exposure to low levels of blue light can cause premature aging and degeneration of the retina [9, 12-13, 40]. Normally during photoactivation training of RBM materials it is mentioned "do not look at blue light", but its effects and dosage seem to be little discussed. Additionally, to stabilize the LCU dentist should wear eye protection to keep monitoring the curing light tip during all photoactivation procedures [13]. It is also important to note that the practice of "not looking directly into the light" is used with patients and

possibly with the dental assistants when it is well known that all people exposed to blue light must use special protective equipment such as orange blocking eyeglasses [9, 12, 40].

The great quantity of LCU from not major dental manufacture (budget LCU) is also disappointing. Dentists should be alert about the danger of operating equipment that is not properly evaluated and certified. This is an important topic of discussion due to the cost of LCU from major dental manufacturers (between 800 to 1500 dollars), if we contemplate that half of the participants have incomes below 900 dollars per month (according to the exchange rate of the DR). Recently, Soares, Braga and Price [53] showed that LCU that had a higher cost (from major manufacturers) delivered more power (mW) and had a bigger tip diameter (mm) compared to low-budget LCUs. According to Shortal [10] the price should not be a priority over the quality of the RBM conversion. Budget LCU have smaller tip diameters, very poor beam uniformity, higher levels of nonuniform power emission, low effective emission ratios, not able to maintain their initial light output after repeated exposures and not provide an adequate indication for battery drain during use. [8-9, 12, 25, 53]

Most of the responders testified working in private practices, although it was not evaluated in this study, these practices could be in major dental clinics where they have to photoactivate the RBM with the available equipment. The technical feature of LCU, which is often described in the manufacturer instructions documents, may not be accessible. In the same way, the lack of knowledge may be due to the fact that dentists answered this survey outside their work area (small private practice, major private practice, university or hospital) and they will not remember some of the technical features asked in this research.

This investigation has limitations related to questionnaire studies corresponding to response bias, where individuals were free to accept or not to participate. They're also a bias related to responding accordingly to what is considered correct and not to the reality of their practice. The strength of the present study is the adequate response rate, furthermore the design and validation of a questionary that can be used to collect valuable information on the topic in other countries.

Dentists are encouraged to follow the guidelines [5] to maximize the light energy their RBM received, by placing the tip of the LCU as close as possible and covering the entire RBM and stabilizing for the entire curing time [37]. Recently Shimokawa et al., [54] published a question-and-answer article on instructions for correctly LCU use

and maintenance, likewise Price et al. [55] enlisted the desirable feature to consider in an LCU. The dental professionals should give photoactivation the importance it deserves, showing interest in knowing the main technical features of their LCU, reviewing the photoactivation protocols and equipment maintenances, and above all taking care of their health by protecting their eyes during the activation of blue light. The results of this study contribute to show that more efforts are needed, especially from the university professors and researchers, so the information on the importance of knowing the relationship between the technical characteristics and the photoactivation protocols, guided by correct biosafety, are taught, learned and fallowed when photoactivating. From these data, strategies can be designed to increase knowledge and contribute correct photoactivation techniques. Strategies should be designed to create awareness among clinical dentists about the importance of correctly photoactivating RBM.

5. Conclusion

According to the data collected, Dominican dentists recognize it is extremely important to know the technical features of their equipment and acknowledge that a precise photoactivation protocol is very important for the longevity of RBM. Most of the interviewees used LED equipment, between 0 to 7 years of age from 32 different manufacturers. More than half of the participants were unaware of their LCU characteristics, being the wavelength and irradiance the least known. A great percentage use photoactivation protocols that include following the RBM manufacturer's instructions, stabilizing the LCU on the material at a distance between 0 to 2 mm.

Regarding the awareness of blue light damage, a few dentists reported using orange eyeglasses. Only some participants know the maximum direct and indirect light that the human eye can tolerate in 24 hours. To purchase a new LCU, the irradiance, wavelength and diameter of the tip were considered as extremely important or very important. The teacher's recommendation, as well as the prestige of the manufacture, were also contemplated as important.

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Tables

Table 1. Demographic and work practice characteristics of the respondents (N = 374)

Variable/category	**n***	**%**
Sex	**374**	
Male	42	11.2
Female	331	88.5
Prefer not to answer	1	0.3
Age (years)	**374**	
18-25	73	19.8
26-36	237	63.4
37-47	53	14.2
48-58	9	2.4
59-69	1	0.3
University	**374**	
Pontificia Universidad Católica Madre y Maestra (PUCMM - CSD)	12	3.2
Pontificia Universidad Católica Madre y Maestra Santiago (PUCMM - CSTI)	38	10.2
Universidad Autónoma de Santo Domingo (UASD)	93	24.9
Universidad Católica Nordestana (UCNE)	12	3.2
Universidad Católica Tecnológica del Cibao (UCATECI)	9	2.4
Universidad Central del Este (UCE)	12	3.2
Universidad Eugenio María De Hostos (UNIREMHOS)	3	0.8
Universidad Federico Henríquez y Carvajal (UFHEC)	10	2.7
Universidad Iberoamericana (UNIBE)	118	31.6
Universidad Nacional Pedro Henríquez Ureña (UNPHU)	41	11
Universidad Odontológica Dominicana (UOD)	18	4.8
Universidad Tecnológica de Santiago (UTESA)	6	1.6
Other	2	0.6
Years in practice	**374**	
0-5	199	53.2
6-10	67	24.6
11-20	9	17.9
31-40	7	2.4
City	**374**	
Azua	1	0.3
Bahoruco	1	0.3
Barahona	2	0.5
Distrito Nacional	202	54
Duarte	12	3.2
Espaillat	4	1.1
Hato Mayor	1	0.3
La Altagracia	5	1.3
La Romana	3	0.8
La Vega	3	0.8
María Trinidad Sánchez	2	0.5
Monseñor Nouel	7	1.9
Monte Plata	1	0.3
Pedernales	1	0.3
Peravia	1	0.3
Puerto Plata	3	0.8
San Cristóbal	6	1.6
San Juan	3	0.8
San Pedro de Macoris	4	1.1
Sánchez Ramírez	7	1.9
Santiago	35	9.4
Santo Domingo	61	16.3
Valverde	9	2.4

Main work sector	**374**	
Public	25	6.7
Private	334	89.3
Teaching	6	1.6
Administrate	5	1.3
Other	4	1.1
Postgraduate education (completed)	**374**	
None	62	16.6
Training courses	107	28.6
Residency or advance special training	86	23
MSC	117	31.3
PhD	2	0.5
Incomings*	**374**	
10,000 to 24,999	103	27.5
25,000 to 49,999	94	25.1
50,000 to 74,999	59	15.8
75,000 to 99,999	49	13.1
100,000 to 149,999	34	9.1
150,000 or more	35	9.4

*Incomings monthly in Dominican pesos. The dollar rate is 1 dollar - $57.56 Dominican pesos.

Table 2. Knowledge about LCU equipment (N = 374)

Variable/category	**n***	**%**
Most frequently adhesive procedure	**374**	
Cementation of brackets	27	7.2
Adhesive cementation of indirect restorations	48	12.8
Direct restorations	289	77.3
Other	10	2.7
Type of LCU	**374**	
Halogen	14	3.7
LED	328	87.7
Don't know	32	8.6
LCU model	**374**	
I don't know	83	22.2
Major dental manufacture	98	26.2
Not major dental manufacture (budget LCU)	193	51.6
Ages of the LCU (years)	**374**	
I don't know	46	12.3
0-3	235	62.8
4-7	81	21.7
8-11	9	2.4
12-15	2	0.5
16-20	0	0
More than 20	1	0.3
Number of procedure/weeks	**374**	
1-5	106	28.3
6-10	116	31
11-20	98	26.2
21-30	43	11.5
More than 31	11	2.9
Knowledge about LCU Tip diameter	**374**	
Don't know	247	66
Less than 7mm	42	11.2
Between 8 – 10 mm	67	17.9
Between 10 to 11 mm	10	2.7
More than 12 mm	8	2.1

Knowledge about the Type of Tip	**374**	
Don't know	126	33.7
Fiber optic	147	39.3
Polymer	8	2.1
LED in the tip	92	24.6
Other	1	0.3
Knowledge about LCU Irradiance (mW/cm^2)	**374**	
Don't know	233	62.3
< 500	10	2.7
500-999	27	7.2
1000 - 1499	72	19.3
1500 - 1999	11	2.9
>2000	21	5.6
Knowledge about LCU Wavelength	**374**	
Don't know	291	77.8
Monowave	45	12
Polywave	37	9.9
Other	1	0.3
Knowledge about LCU different irradiance levels	**374**	
Don't know	156	41.7
Yes	130	34.8
No	88	23.5
Knowledge about LCU mode	**374**	
No, only continue mode	67	17.9
I don't know	41	10.9
Yes, ramped	23	6.2
Yes, pulse delay	69	18.4
Yes, progressive	40	10.7
Yes, different mode	134	35.8
Curing time per layer (seconds)	**374**	
5	9	2.4
10	62	16.6
20	226	60.4
30	44	11.8
40	33	8.8
Recommendation for light curing time	**374**	
According to the manufacture of the material	217	58
According to the manufacture of the LCU	18	4.8
According to the instructions learned in the university	95	25.4
According to my workspace/ clinic protocol	9	2.4
According to a conference instruction	31	8.3
Other	4	1.1
Distance between the LCU and the material	**374**	
I don't consider the distance	12	3.2
I place the LCU directly in contact (0mm)	117	31.3
I place the LCU at short distance (1 - 2 mm)	219	58.6
I place the LCU at a distance (3 or more mm)	23	6.1
Other	3	0.8
Photoactivation protocol	**374**	
I stabilize the LCU on the increment that is being photoactive	316	85.4
I place the LCU on the increment without stabilizing it	26	7
I do mesial - distal / cervical - incisal movements during photoactivation.	30	8
Other	2	0.5
Maintenance routine for the LCU	**374**	
No	191	51.1
Yes, visual inspection of the LCU tip to detect scratches or remains of material	153	40.9

Yes, I regularly use a radiometer to check irradiation	7	1.9
Yes, I regularly use a spectroradiometer to check irradiance	23	6.1
Charging the LCU battery	**374**	
I put it to charge when I get to the clinic	62	16.6
The LCU remains in the charging base at all times.	75	20.1
When the LCU has a low battery or is completely discharged.	155	41.4
I put the LCU to charge at the end of the day	63	16.8
The LCU has a cable	14	3.7
Other	5	1.3
How do you check the battery of the LCU	**374**	
The LCU does NOT have a battery charge tester	247	66
The LCU or base DOES have a battery charge tester	120	32.1
Other	7	1.9
Biosafety barriers	**374**	
No	74	19.8
Yes, I use adhesive plastic only on the handle	136	36.4
Yes, I use adhesive plastic on the handle and the tip (without covering the tip)	80	21.4
Yes, I use adhesive plastic on the handle and the tip (covering the light tip)	31	8.3
Yes, I use a specific plastic protector for LCU	49	13.1
Yes, with autoclave cycles at the tip of the LCU	3	0.8
Other	1	0.3

Table 3. Importance of the LCU (N = 374)- Likert scale* 1- not important – 10 extremely important

Variable/category	n*	%
How important do you consider that proper photoactivation is for the longevity of restorations with photoactivated materials	**374**	
1 Not important	0	0
2	0	0
3	1	0.3
4	0	0
5 Important	0	0
6	1	0.3
7	1	0.3
8	9	2.4
9	23	6.1
10 Extremely important	339	90.6
How important do you consider it is to know the irradiance (mW / cm^2) of your LCU?		
1 Not important	1	0.3
2	0	0
3	1	0.3
4	2	0.5
5 Important	12	3.2
6	19	5.1
7	16	4.3
8	50	13.4
9	44	11.8
10 Extremely important	229	61.2
How important do you think it is to know the wavelength (nanometers) of your LCU?	**374**	
1 Not important	2	0.5
2	0	0
3	2	0.5
4	3	0.8
5 Important	14	3.7

6	20	5.3
7	29	7.8
8	54	14.4
9	44	11.8
10 Extremely important	206	55.1
How important do you think it is to know the diameter of the tip of your LCU?	**374**	
1 Not important	1	0.3
2	0	0
3	1	0.3
4	4	1.1
5 Important	19	5.1
6	30	8
7	27	7.2
8	77	20.6
9	41	11
10 Extremely important	174	46.5
How important do you consider it to be to know the photoactivation modes of your LCU?	**374**	
1 Not important	0	0
2	1	0.3
3	1	0.3
4	2	0.5
5 Important	5	1.3
6	16	4.3
7	18	4.8
8	53	14.2
9	60	16
10 Extremely important	218	58.3
Do you consider the distance between the restoration and / or procedure and the LCU important?	**374**	
1 Not important	1	0.3
2	0	0
3	0	0
4	0	0
5 Important	3	0.8
6	5	1.3
7	9	2.4
8	20	5.3
9	54	14.4
10 Extremely important	282	75.4
Do you consider it important to follow the photoactivation time indicated by the manufacturer of the material?	**374**	
1 Not important	0	0
2	0	0
3	0	0
4	2	0.5
5 Important	2	0.5
6	6	1.6
7	8	2.1
8	19	5.1
9	42	11.2
10 Extremely important	295	78.9
Do you consider it important to follow the photoactivation time indicated by the manufacturer of the LCU?	**374**	
1 Not important	2	0.5
2	2	0.5
3	2	0.5

4	3	0.8
5 Important	5	1.3
6	11	2.9
7	16	4.3
8	43	11.5
9	52	13.9
10 Extremely important	238	63.6
Do you consider it important to have a maintenance routine or protocol for your LCU?	**374**	
1 Not important	0	0
2	0	0
3	2	0.5
4	2	0.5
5 Important	4	1.1
6	9	2.4
7	9	2.4
8	31	8.3
9	66	17.6
10 Extremely important	251	67.1
Do you consider it important to know the heat emitted by your LCU?	**374**	
1 Not important	0	0
2	0	0
3	1	0.3
4	2	0.5
5 Important	2	0.5
6	7	1.9
7	14	3.7
8	30	8
9	60	16
10 Extremely important	258	68.9

Table 4. Eye hazards related to photoactivation (LCU) (N = 374)

Variable/category	**n***	**%**
Do you wear eye protection when using your photoactivation lamp?	**374**	
No	114	30.5
Yes, the orange protector that includes the LCU.	212	56.7
Yes, orange protective glasses	40	10.7
Other	8	2.1
Do you protect the eyes of your patients when using the photoactivation lamp?	**374**	
No	244	65.2
Yes, glasses with UV protection	58	15.5
Yes, orange protective glasses	60	16
Other	12	3.3
Which of the following consequences can prolonged exposure to blue light (photoactivation lamps) have? *	**657***	
I do not know the consequences of prolonged exposure to blue light	98	26.2
Acceleration of retinal aging	148	39.6
Degeneration of the retina	166	44.4
Photoretinitis	47	12.6
Corneal damage or photokeratitis	108	28.9
Cataractgenesis	24	6.4
Transient or permanent opacification of intraocular lenses	30	8.0
Acceleration of macular degeneration	33	8.8
Other	3	0.8

You know the maximum DIRECT dose of blue light that the human eye can tolerate in 24 hours.	**374**	
Yes	19	5.1
No	355	94.4
You know the maximum INDIRECT dose of blue light that the human eye can tolerate in 24 hours.	**374**	
Yes	12	3.2
No	362	96.8

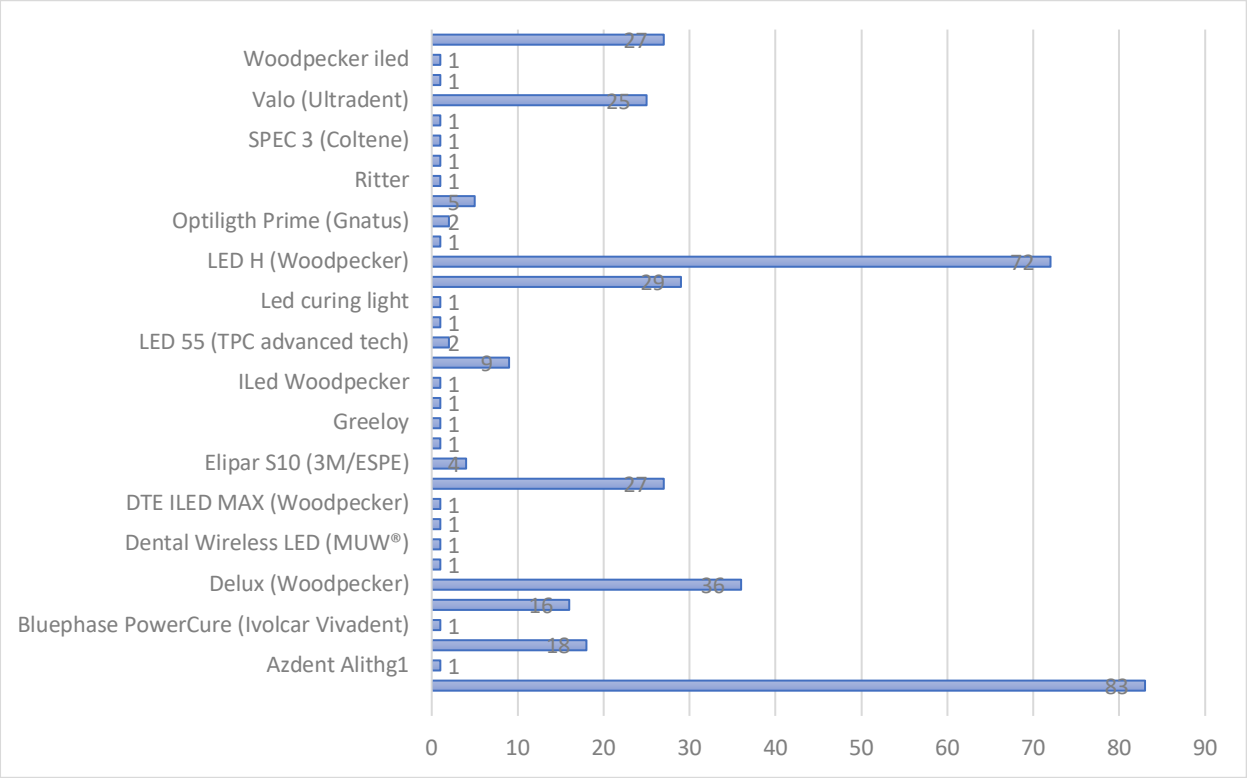
* Multiple-choice question with several answers' options

Table 5. Motives for selecting your actual and a new LCU (N = 374)- Likert scale*

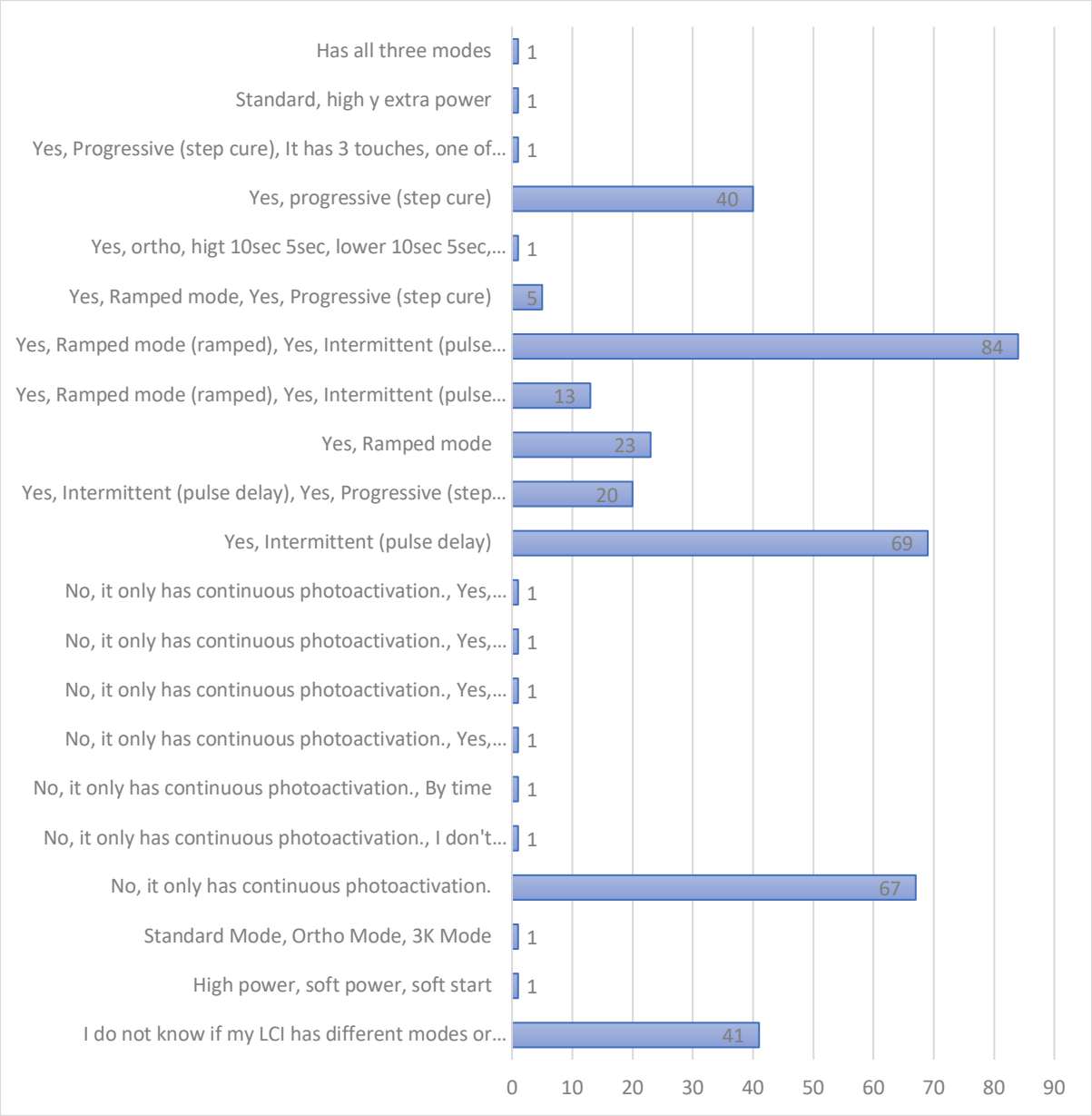
	Actual	LCU	New	LCU
Variable/category	**n***	**%**	**n***	**%**
LCU characteristics - irradiance	**374**		**374**	
1 Not important	11	2.9	4	1.1
2 Less important	19	5.1	5	1.3
3 Important	57	15.2	22	5.9
4 Very important	76	20.3	51	13.6
5 Extremely important	211	56.4	292	78.1
LCU characteristics - wavelength	**374**		**374**	
1 Not important	16	4.3	4	1.1
2 Less important	19	5.1	8	2.1
3 Important	72	19.3	25	6.7
4 Very important	66	17.6	49	13.1
5 Extremely important	201	53.7	288	77.0
LCU characteristics - tip diameter	**374**		**374**	
1 Not important	17	4.5	4	1.1
2 Less important	20	5.3	7	1.9
3 Important	91	24.3	36	9.6
4 Very important	79	21.1	58	15.5
5 Extremely important	167	44.7	269	71.9
LCU model (color, size, wireless)	**374**		**374**	
1 Not important	14	3.7	15	4.0
2 Less important	14	3.7	14	3.7
3 Important	70	18.7	54	14.4
4 Very important	82	21.9	60	16.0
5 Extremely important	194	51.9	231	61.8
Colleague recommendation	**374**		**374**	
1 Not important	16	4.3	13	3.5
2 Less important	26	7.0	26	7.0
3 Important	96	25.7	79	21.1
4 Very important	100	26.7	84	22.5
5 Extremely important	136	36.4	172	46.0
Teacher recommendation	**374**		**374**	
1 Not important	17	4.5	9	2.4
2 Less important	23	6.1	20	5.3
3 Important	58	15.5	53	14.2
4 Very important	87	23.3	63	16.8
5 Extremely important	189	50.5	229	61.2
Prestige of the manufacture ("known" manufacture)	**374**		**374**	

1 Not important	12	3.2	3	0.8
2 Less important	17	4.5	12	3.2
3 Important	52	13.9	51	13.6
4 Very important	91	24.3	76	20.3
5 Extremely important	202	54.0	232	62.0
Availability in dental supplies	**374**		**374**	
1 Not important	30	8.0	31	8.3
2 Less important	30	8.0	24	6.4
3 Important	74	19.8	77	20.6
4 Very important	85	22.7	68	18.2
5 Extremely important	155	41.4	174	46.5
Amount of use (I don't do many adhesive procedures)	**374**		**374**	
1 Not important	23	6.1	23	6.1
2 Less important	21	5.6	20	5.3
3 Important	70	18.7	49	13.1
4 Very important	94	25.1	75	20.1
5 Extremely important	166	44.4	207	55.3

Graphic 1. LCU models reported by dentist.



Graphic 2. Different polymerization modes of the LCU reported by dentist.



Questionary

Section 1: Questions related to your professional profile

1. What is your gender?

- Male
- Female
- I prefer not to answer

2. How old are you?

- 18 to 25 years
- 26 to 36 years
- 37 to 47 years
- 48 to 58 years
- 59 to 69 years
- More than 70 years

3. In which university did you graduate in Dentistry?

- Pedro Henríquez Ureña National University (UNPHU)
- Federico University. Henríquez and Carvajal (UFHEC)
- Universidad Iberoamericana (UNIBE)
- Autonomous University of Santo Domingo (UASD)
- Central University of the East (UCE)
- Nordestana Catholic University (UCNE)
- Dominican Dental University (UOD)
- Pontificia Universidad Católica Madre y Maestra de Santiago (PUCMM - CSTI)
- Universidad Católica Tecnológica del Cibao (UCATECI)
- Eugenio María De Hostos University (UNIREMHOS)
- Pontificia Universidad Católica Madre y Maestra (PUCMM - CSD)
- Technological University of Santiago (UTESA)
- Technological Institute of Santo Domingo (INTEC)
- Other: _____

4. How many years ago did you graduate?

- 0-5 years of graduate
- 6- 10 years of graduate
- 11-20 years of graduate
- 21-30 years of graduate
- 31-40 years of graduate
- More than 41 years of graduate

5. In which city do you practice dentistry most of the time?

- Azua
- Bahoruco
- Barahona

- Dajabón
- Distrito Nacional
- Duarte
- Elías Piña
- El Seibo
- Espaillat
- Hato Mayor
- Hermanas Miraval
- Independencia
- La Altagracia
- La Romana
- La Vega
- Maria Trinidad Sánchez
- Monseñor Nouel
- Monte Cristi
- Monte Plata
- Pedernales
- Peravia
- Puerto Plata
- Samaná
- Sánchez Ramírez
- San Cristóbal
- San José de Ocoa
- San Juan
- San Pedro de Macorís
- Santiago
- Santiago Rodríguez
- Santo Domingo
- Valverde

6. What type of professional practice do you do most of the time?

- 0 - Dentist in public practice
- 1 - Dentist in private practice
- 2 - Teaching
- 3 - Administrative management
- 4- Other: _

7. Have you completed any postgraduate courses in Dentistry? Select the highest grade

- 0 - No
- 1 - Yes, graduate
- 2 - Yes, specialization

- 3 - Yes, Mastery
- 4 - Yes, PhD

8. Which of the options describes your personal monthly income (Dominican pesos)?

- From $ 10,000 to $ 24,999
- From $ 25,000 to $ 49,999
- From $ 50,000 to $ 74,999
- From $ 75,000 to $ 99,999
- From $ 100,000 to $ 149,999
- $ 150,000 Dominican pesos or more

9. What is the adhesive procedure with photoactivated materials that you perform most frequently in your practice?

- Cementation of brackets
- Adhesive cementation of indirect restorations
- Direct restorations with photoactivated materials
- Other: _____

Section 2: Questions regarding your photoactivation equipment (light curing unite LCU)

10. What type of photoactivation lamp do you use in your practice?

- Halogen lamp
- LED lamp
- I do not know what type of photoactivation lamp I have
- Other: ____

11. What is the manufacture and model of your photoactivation lamp?

- I do not know the manufacture and / or model of my photoactivation lamp
- Bluephase N (Ivolcar Vivadent)
- Bluephase PowerCure (Ivolcar Vivadent)
- CICADA (Foshan)
- Coltolux (Coltene / Whaledent)
- CuringPen (Eighteeth)
- Delux (Woodpecker)
- Demi Plus (Kerr Corporation)
- Dental Wireless LED (MUW®)
- Elipar DeepCure (3M / ESPE)
- Elipar S10 (3M / ESPE)
- Essentials Curing Light (essentials healthcare products)
- Fusion 5.0 (DentLight, Inc)
- KP dent light cure (generic)
- LED Curing Light (generic)
- LED H (Woodpecker)
- LED 55 (TPC advanced tech)

- Optilight Prime (Gnatus)
- Radii Plus (SDI)
- Slim- Blast (First medical)
- SmartLite Pro (Dentsply)
- SPEC 3 (Kerr Corporation)
- Start Light 1 (Mectron)
- Tranlux (Kulzer)
- Valo (Ultradent)
- X-cure (Woodpecker)
- Other:

12. How many years of use is your current photoactivation lamp?

- 0 - 3 years
- 4 - 7 years
- 8 -11 years
- 12 - 15 years
- 16 -20 years
- More than 20 years

13. On average, how many adhesive procedures (bracket cementation, adhesive cementation, direct composite restorations, pit and fissure sealants) do you perform per week?

- 1. 1 to 5 adhesive procedures
- 6 to 10 adhesive procedures
- 11 to 20 adhesive procedures
- From 21 to 30 adhesive procedures
- 31 or + adhesive procedures

14. Do you know the diameter (cm) of the tip of your photoactivation lamp? (according to the manufacturer)

- I don't know him
- Less than 7mm
- Between 8 to 10 mm
- Between 10 to 11 mm
- 12 mm or more

15. What type of tip does your photoactivation lamp use?

- I don't know
- Fiber optic tip
- Polymer tip
- LED on the tip of the lamp
- Other: _____

16. Do you know the irradiance (mW / cm2) of your photoactivation lamp? (according to the manufacturer)

- I do not know the irradiation of my photoactivation lamp
- <500 mW / cm2
- 500 - 999 mW / cm2
- 1000 - 1499 mW / cm2
- 1500 - 1999 mW / cm2
- 6-> 2,000 mW / cm2

17. Do you know the wavelength (nanometers) of your photoactivation lamp (according to the manufacturer)?

- I do not know
- Monovawe
- Polywave
- Other: _____

18. Does your photoactivation lamp have different levels of irradiation? Example: VALO offers three different levels: Standard (1000 mW / cm2), High Power (1400 mW / cm2) and Extra Power (3200 mW / cm2).

- Yes
- No
- I don't know if my lamp has different levels of irradiation

19. Does your photoactivation lamp have different photoactivation modes? You can select more than one answer

- No, it only has continuous photoactivation.
- I don't know if my lamp has different modes or photactivation programs
- Yes, ramp mode
- Yes, intermittent
- Yes, progressive
- Other:

20. For how many seconds do you normally photoactive a layer or increment of direct composite resin that you are used to using in your practice?

- 5 seconds
- 10 seconds
- 20 seconds
- 30 seconds
- 40 seconds or more

21. When performing an adhesive procedure, what recommendations about the photoactivation time do you follow?

- According to the recommendations of the material manufacturer
- According to the lamp manufacturer's recommendations
- According to the recommendations of the university
- According to the protocols of the office or clinic where I work

- According to the recommendations of a course or conference
- Other:

22. At the time of photoactivation, how far from the restoration and / or adhesive procedure do you place the photoactivation lamp?

- I do not take into account the distance between the restoration and / or adhesive procedure and the photoactivation lamp.
- I place the photoactivation lamp directly in contact (0mm) with the tooth receiving the restoration and / or adhesive procedure.
- I place the photoactivation lamp a short distance (1 - 2 mm) from the tooth receiving the restoration and / or adhesive procedure.
- I place the photoactivation lamp at a distance (3 or more mm) from the tooth receiving the restoration and / or adhesive procedure.

23. At the moment of photoactivation, how do you carry out the photoactivation ?

- I stabilize the lamp on the increment that is being photoactivated
- I place the lamp on the increment without stabilizing it
- I make mesial - distal / cerival - incisal movements during photoactivation.
- Other: _____

24. Do you have a maintenance routine or protocol for your photoactivation lamp?

- No
- Yes, visual inspection of the tip of the lamp to detect scratches or foreign bodies (for example, remains of material)
- Yes, I regularly use a radiometer to monitor irradiation
- Yes, I regularly use a spectrophotometer to monitor irradiation

25. When do you charge the battery of your LCU?

- I put it to charge when I arrive at the dental office, before using it I verify that it is fully charged.
- I put it to charge when I arrive at the dental office, I verify that it has a charge, but I do not know the exact amount.
- The lamp remains in the charging base at all times.
- When the LCU has a low battery or is completely discharged.
- I put it to charge at the end of the day, before using it I verify that it is fully charged.
- I put it to charge at the end of the day, before using it I verify that it has charge, but I do not know the exact amount.
- The LCU I use has a cable
- Other: _____

26. How do you check if the battery of your LCU is fully charged?

- The LCU does NOT have a battery charge tester
- The LCU or base DOES have a battery charge tester
- Other

27. Do you use biosafety barriers in your photoactivation lamp?

- No
- Yes, you used plastic adhesive only on the handle of the photoactivation lamp.
- Yes, you used adhesive plastic on the handle and tip (without covering the light outlet) of the photoactivation lamp.
- Yes, you used adhesive plastic on the handle and tip (covering the light outlet) of the photoactivation lamp.
- Yes, you used a specific plastic protector for photoactivation LCU on the handle and tip (covering the light output) of the photoactivation lamp.
- Yes, I autoclave the LCU tip
- Other: _____

Section 3: Questions about photoactivation assessment (curing light)

28. On a scale of 1-10, how important do you consider that proper photoactivation is for the longevity of restorations with photoactivated materials? 1 not important - 10 very important

29. On a scale of 1-10, how important do you consider it is to know the irradiance (mW / cm2) of your photoactivation lamp? 1 not important - 10 very important

30. On a scale of 1-10, how important do you think it is to know the wavelength (nanometers) of your photoactivation lamp? 1 not important - 10 very important

31. On a scale of 1-10, how important do you think it is to know the diameter of the tip of your photoactivation lamp? 1 not important - 10 very important

32. On a scale of 1-10, how important do you consider it to be to know the photoactivation modes or schedules of your photoactivation lamp? 1 not important - 10 very important

33. On a scale of 1-10, do you consider the distance between the restoration and / or procedure and the photoactivation lamp important? 1 not important - 10 very important

34. On a scale of 1-10, do you consider it important to follow the photoactivation time indicated by the manufacturer of the material? 1 not important - 10 very important

35. On a scale of 1-10, do you consider it important to follow the photoactivation time indicated by the manufacturer of the photoactivation lamp? 1 not important - 10 very important

36. On a scale of 1-10, do you consider it important to have a maintenance routine or protocol for your photoactivation lamp? 1 not important - 10 very important

37. On a scale of 1-10, do you consider it important to know the heat emitted by your photoactivation lamp? 1 not important - 10 very important

Section 4: Questions about eye hazards related to photoactivation (curing light)

38. Do you wear eye protection when using your photoactivation lamp?

- No
- Yes, the orange protector that includes the photoactivation lamp.
- Yes, orange protective glasses
- Other: _____

39. Do you protect the eyes of your patients when using the photoactivation lamp? 1. No

- Yes, lenses with UV protection
- Yes, orange protective glasses
- Other: _____

40. Which of the following consequences can prolonged exposure to blue light (photoactivation lamps) have?

- I do not know the consequences of prolonged exposure to blue light (photoactivation lamp).
- Acceleration of retinal aging
- Degeneration of the retina
- Photoretinitis
- Damage to the cornea or photokeratitis
- Cataractgenesis
- Transient or permanent opacification of intraocular lenses
- Acceleration of macular degeneration
- Other: _____

41. Do you know the maximum DIRECT dose of blue light (photoactivation lamp) that the human eye can tolerate in 24 hours

- Yes
- No

42. You know the maximum INDIRECT dose of blue light (photoactivation lamp) that the human eye can tolerate in 24 hours:

- Yes
- No

Section 5: Questions related to the reasons or reasons for selecting your photoactivation lamp

1. What reasons did you consider important for the purchase of your photoactivation lamp?

- Characteristics of the equipment - irradiation

Not important Slightly important Modernly important Important Very important

- 1.5 Equipment characteristics - wavelength

Not important Slightly important Modernly important Important Very important

- 43.3 Equipment characteristics - tip size

Not important Slightly important Modernly important Important Very important

- LCU model (color, size, wireless)

Not important Slightly important Modernly important Important Very important

- Colleague recommendation

Not important Slightly important Modernly important Important Very important

- Teacher recommendation

Not important Slightly important Modernly important Important Very important

- Prestige of the commercial house (“known” commercial house)

Not important Slightly important Modernly important Important Very important

- Availability in dental warehouses

Not important Slightly important Modernly important Important Very important

- Amount of use (I don't do many adhesive procedures)

Not important Slightly important Modernly important Important Very important

44 What reasons would you consider for purchasing a new photoactivation lamp?

- Equipment characteristics - irradiation

Not important Slightly important Modernly important Important Very important

- Equipment characteristics - wavelength

Not important Slightly important Modernly important Important Very important

- Equipment characteristics - tip size

Not important Slightly important Modernly important Important Very important

- Lamp model (color, size, wireless)

Not important Slightly important Modernly important Important Very important

- Colleague recommendation

Not important Slightly important Modernly important Important Very important

- Teacher recommendation

Not important Slightly important Modernly important Important Very important

- Prestige of the commercial house (“known” commercial house)

Not important Slightly important Modernly important Important Very important

- Availability in dental warehouses

Not important Slightly important Modernly important Important Very important

- Amount of use (I don't do many adhesive procedures)

Not important Slightly important Modernly important Important Very important

6 Considerações finais

Este trabalho de tese teve como objetivo conhecer as características técnicas dos aparelhos de fotoativação de um grupo de alunos de graduação de uma universidade dominicana, assim como avaliar a irradiância de seus equipamentos e determinar se havia discrepâncias com a potência fornecida pelas empresas.

A avaliação do conhecimento sobre fotoativação de uma amostra de dentistas dominicanos também foi avaliado. Da mesma forma, seus protocolos de fotoativação, e conhecimento sobre possíveis lesões oculares e seus critérios para a compra de seu equipamento atual e novo também foram investigados. Embora seja um tema já explorado anteriormente, esta é a primeira vez que se realiza uma investigação e se informa os resultados sobre o tema na República Dominicana.

Para que o aluno alcance uma aprendizagem significativa, ele deve ser submetido a experiências educacionais impactantes, onde a importância dos novos conhecimentos adquiridos seja internalizada. Ao verificar seus equipamentos de fotoativação com duas metodologias distintas e calcular como a irradiância de seus equipamentos é influenciada pela distância, os alunos puderam aprimorar ainda mais os conhecimentos sobre o fotoativação, o que pode ter um impacto significativo na qualidade da conversão monomérica dos materiais fotopolimerizáveis.

Conhecer e verificar a atitude dos cirurgiões-dentistas em relação à fotoativação é fundamental para poder identificar lacunas de conhecimento quanto às características técnicas de suas lâmpadas, polimerização, protocolos de fotoativação e biossegurança. Embora os questionários apresentem limitações próprias deste tipo de estudo, nos resultados os cirurgiões-dentistas dominicanos reconhecem como muito importante a correta fotoativação para a longevidade dos Tratamentos que envolvem materiais fotopolimerizáveis, contudo muitos desconhecem os aspetos técnicos de seus aparelhos. É necessário que o clínico tenha conhecimento das especificações técnicas essenciais e do uso seguro dos dispositivos empregados no tratamento odontológico e sejam estabelecidos protocolos de fotoativação de acordo com os descritos na literatura.

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Apêndice A – Nota da tese

Nota da tese

Conhecimento de estudantes de odontologia e dentistas clínicos da República Dominicana quanto aos seus equipamentos e protocolos de fotoativação

Knowledge of dentistry students and clinical dentists in the Dominican Republic regarding their photoactivation equipment and protocols

Para se conseguir a polimerização dos materiais fotoativados é imprescindível conhecer as características técnicas do equipamento e do material aliadas a um protocolo de fotoativação validado pela literatura científica. Um grau de conversão insuficiente de monômeros em polímeros tem sido associado às baixas propriedades químicas e mecânicas dos materiais odontológicos fotoativados, podendo comprometer sua durabilidade. O objetivo deste trabalho foi mostrar aos alunos de graduação as características técnicas dos equipamentos e mensurar a irradiância de seu equipamentos de fotoativação. Do mesmo modo avaliar seu conhecimento sobre as características técnicas e protocolos de fotoativação de dentistas dominicanos. Todas as unidades fotopolimerizáveis dos alunos de graduação foram monowave LED. Quando a irradiância foi medida com o radiômetro a 0mm, 12,9% dos equipamentos apresentou valores de 499 MW/cm^2 ou menos. 90,3% apresentaram valores abaixo de 499 MW/cm^2 quando a distância foi de 6mm. O espectrorradiômetro mostrou que nenhum dos LCU apresentou resultados abaixo de 499 MW/cm^2 a 0mm. Todos os equipamentos de fotopolimerização utilizadas por alunos de uma universidade dominicana foram classificadas como equipamentos de baixo custo. Os valores de irradiação foram influenciados pelo equipamento utilizado para a medição (radiômetro-espectroradiômetro) e pela distância (0mm-6mm). No questionario, um total de 374 respostas válidas foram recebidas ao longo de 10 dias. O procedimento mais comum foi a colocação de restaurações diretas (77,3%). 87,7% dos dentistas relataram possuir LED LCU de 32 fabricantes diferentes. O tempo médio de fotoativação informado foi de 20 segundos (60,4%), seguindo as instruções do

fabricante do material (58,0%). Os dentistas não sabiam a dose direta (94,4%) e indireta (96,8%) de luz azul que um olho humano pode tolerar em 24 horas, e apenas 10,7% usa óculos de proteção laranja. O prestígio do fabricante (54,0%) e a recomendação do professor (50,0%) foram os dois principais aspectos considerados na aquisição do equipamento atual. Para novas compras, eles considerarão a irradiância (78,1%), comprimento de onda (77,0%) e diâmetro da ponta (71,9%). Os dentistas dominicanos reconhecem como extremamente importante conhecer as características técnicas de seus equipamentos e reconhecem que um protocolo de fotoativação correto é extremamente importante para a longevidade dos materiais. A maioria dos dentistas desconhecia as características técnicas de seus aparelhos. A consciência sobre os efeitos da luz azul nos olhos também era pouco conhecida. Para adquirir novos equipamentos, os dentistas devem considerar as características técnicas do LCU.

Campo da pesquisa: Biomateriais e Biologia oral/Materias Odontológicos.
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Data da defesa e horário: 04/10/2021 às 15:00 horas.
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Meeting ID: 968 1720 9653. Passcode: 451502

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Apêndice B – Súmula do currículo da candidata

Patricia Grau Grullón, nasceu em 15 de maio de 1981, em Santo Domingo, República Dominicana. Completou o ensino fundamental e médio no Colegio Serafín de Asís na sua cidade natal. Possui graduação em Odontología pela Universidad Iberoamericana (2001) y Mestrado em Odontología pela Universidade Estadual de Ponta Grossa (2005). Ingressou no doutorado em 2017 no Programa de Pós-graduação em Odontologia da Universidade Federal de Pelotas na área de concentração em Materiais Odontológicos. Tem orientação pelo Prof. Drª. Giana da Silveira Lima com o qual desenvolveu pesquisas relacionadas à fotoativação de materiais odontológicos.

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