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KNOWLEDGE OF BRAZILIAN DENTISTS ABOUT THE LIGHT CURING PROCESS

CONHECIMENTO DOS DENTISTAS BRASILEIROS SOBRE O PROCESSO DE FOTOPOLIMERIZAÇÃO

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ABSTRACT

Objective: to investigate the knowledge profile of dentists regarding the impact of the photopolymerization process and technique on the clinical performance of light-cured dental Polymer systems (LCUs). Materials and methods: data was collected through a questionnaire sent electronically to dental professionals working in private practice. The questionnaire consisted of 26 mandatory items, divided into 3 sections

(Professional profile; Knowledge about their LCUs; and Photopolymerization technique). Answers were collected for four weeks. Data analyses were performed using descriptive statistics and analyses of frequencies. Results: Most respondents (88.3%) did not regularly measure the irradiance of their LCUs. 30.2% did not check the condition of the tip (damage or dirt) weekly. More than half of the respondents (58.1%) stated that they performed the light-curing with the device tip at a distance from the curing site. Most respondents (65.3%) used ≤2-mm thick increments before light curing. Conclusion: specific knowledge gaps among dentists regarding the photopolymerization process of dental materials and variations in the polymerization techniques used were observed.

Keywords: Dental Bonding. Light-Curing of Dental Adhesives. Dentin-Bonding Agents. Dental Offices.

RESUMO

Objetivo: investigar o conhecimento dos dentistas sobre o processo e a técnica de fotopolimerização no desempenho clínico de aparelhos fotopolimerizadores odontológicos (AFO). Materiais e métodos: os dados foram coletados por meio de um questionário enviado eletronicamente a profissionais da área odontológica que atuam em consultório particular. O questionário foi composto por 26 itens obrigatórios, divididos em 3 seções (perfil professional; conhecimento sobre seus aparelhos fotopolimerizadores; e técnica de fotopolimerização). As respostas foram coletadas durante quatro semanas totalizando uma amostra de 487 profissionais. Os resultados obtidos foram analisados por meio de estatística descritiva tendo como base a frequência absoluta e o percentual das respostas. Resultados: a maioria dos entrevistados (88,3%) não mede regularmente a irradiância de seus AFO. 30,2% não verificavam o estado da ponta (danos ou sujeira) semanalmente. Mais da metade dos entrevistados (58,1%) afirmou realizar a fotopolimerização com a ponta do aparelho distante do local de fotopolimerização. A maioria dos entrevistados (65,3%) usou incrementos de espessura ≤ 2 mm antes da fotopolimerização. Conclusão: foram observadas lacunas de conhecimento específicos entre os cirurgiões-dentistas sobre o

processo de fotopolimerização de materiais odontológicos e variações nas técnicas de polimerização utilizadas.

Palavras-chave: Colagem dentária. Cura Luminosa de Adesivos Dentários. Adesivos Dentinários. Consultórios Odontológicos.

INTRODUCTION

The complete polymerization of light-cured dental materials depends on the luminous energy delivered by light-curing units (LCUs) to sensitize photoinitiator molecules inside the polymeric material[1]. Insufficient energy emission may result in under-cured composite resin restorations, which are more likely to fracture or wear due to a decrease in the bond strength between the tooth and the restoration[1,2]. Moreover, inadequate curing can affect the mechanical properties of the material such as surface roughness and water sorption and solubility, increasing the presence of microorganisms[3].

The introduction of light-induced polymerization in dental adhesives and composites allowed for greater control of the curing time, thus rendering the use of LCUs essential to any adhesive procedure[4,5]. The current LCUs are based on light-emitting diodes (LEDs), which are used daily by clinicians[4-6]. Compared to other light-emitting devices, LEDs present higher luminous efficiency, thereby wasting less energy and sensitizing photoinitiators and co-initiators in dental materials more effectively. Moreover, LED curing devices do not require filters to block the emission of unwanted wavelengths, and many devices present the advantage of being light and portable[1,4,5].

Several factors can affect the light-curing process, such as irradiance, the integrity of the tip of the device, the angle of incidence of light, the thickness of the material and the distance between the tip of the device and the material[1,3]. Many clinicians use 2-mm composite resin increments because the blue light can reach the bottom of the restoration, thus decreasing the total volumetric shrinkage and the stress caused by the shape of cavity[7]. However, when dealing with darker shades of composites, the thickness of the restoration becomes more critical[8].To solve this problem and allow the use of larger increments (4 to 5mm), bulkfill composites were developed[7]. In general, bulk-fill resins display a higher translucency than conventional

composite resin restorations, which can be achieved by a reduction in filler content[8]. Co-polymerization of monomers is usually utilized to increase the degree of conversion and create highly cross-linked, dense, and stiff polymer networks[7,8].

The light delivered by an LCU is known as irradiance and refers to the flux of radiant energy per unit area (International System of Units – SI)[9]. The irradiance value most commonly applied to sensitize photoinitiators of dental materials is approximately 600 mW/cm^2, with an exposure time of 40 s[10]. However, in battery-powered LCUs, these values may fluctuate, with a possible decrease in irradiance because of device limitations such as time in use and battery levels[10,11]. Some clinicians use infection control barriers in the LCU tip to avoid contamination and cross-infection during light exposure. However, some materials used as barriers may affect the irradiance of the LCU[12]. In these cases, the exposure time must be increased to avoid incomplete curing[10,12]. The LCU tip must be positioned as close as possible and perpendicularly to the surface of the material to ensure sufficient radiant exposure to sensitizing the photoinitiators [13].

In brief, the best way to operate an LCU and successfully light-cure composite resin resides in the adequate practice and consideration of the factors discussed above; however, some studies have evidenced gaps in the knowledge regarding the use and maintenance of LCUs as well as the curing process among dental clinicians, who were seemingly unaware of the importance of this clinical step[11-13].

Considering that variations in light-curing and incremental techniques have a crucial impact on the quality of restorations, the objective of this study was to investigate the knowledge profile of dentists regarding the adequate use and maintenance of LCUs as well as the incremental technique used by these professionals.

MATERIAL AND METHODS

This cross-sectional study used a structured electronic questionnaire targeted at dental surgeons working in private practice. This study was approved by the Research Ethics Committee of the Federal University of Ceará (protocol number: 4.346.028) (Appendix 1).

The questionnaire was hosted on the Google Forms© online platform, and the participants were able to access the questions (Annex A) through a link sent

electronically via e-mail, social media channels (Facebook©, Instagram©, and WhatsApp©). In addition, the respondents were asked to share the invitation to participate in the research on their social networks to reach a more significant number of participants. The responses were collected between February and April 2021.

Before disclosing the questionnaire, we performed a pilot test with ten dentists to analyse the clarity of the questions and the response time. The considerations made by the pilot respondents were used to adjust some of the questions; however, these respondents were instructed not to answer the final questionnaire and were, therefore, not included as participants.

The questionnaire consisted of 26 mandatory (25 objective and 1 subjective) and 2 non-mandatory (subjective) questions, divided into four sections. The first section included the participants' profiles (sex, age, undergraduate institution, type and location of the dental office/clinic, qualification, and years of experience). The second section had questions regarding the staff of the clinic and the light-curing devices used. The third section included questions related to the LCUs, such as maintenance, safety, and infection control. The fourth section consisted of questions about the photopolymerization and incremental technique, including the use of eye protection, increment thickness, distance, and angulation of the LCU tip to the restorative material.

Participation was voluntary and no remuneration was given to the interviewees. The anonymity of the participants was guaranteed, and only the professionals who agreed with the *Informed Consent Form* (Annex B) available on the first page of the questionnaire were able to participate.

Data analysis

Data analyses were performed using descriptive statistics and analyses of frequencies.

RESULTS

Sample Characterization

From the total number of participants (n= 487), 67.6% (329) were female, 43.5% (212) were aged between 30 and 39 years, 49.3% (240) were from the state of Ceará, 50.5% (246) graduated from public universities, and approximately 33% (118) had between six and ten years of experience. One quarter (127) of the respondents

worked in public health services in addition to working in private practice, 40.2% (196) were attending or had concluded at least one specialization or residency program, 40.4% (197) worked with four or more fellow dentists, and 71.7% (349) had at least two LCUs in their private clinics.

Knowledge regarding the functioning and adequate protection of the LCUs

As depicted in Table 1, most participants (36.1%) purchased their device between one and three years ago, and the most cited LCU brands were Schuster (22%), Ultradent (15.4%), and SDI (15%).

As for knowledge about the power output of the device, 73.9% of the participants did not know this information at the time of purchase, and 90.3% did not know the current value. Most respondents (88.3%) did not regularly measure the irradiance of their LCUs (Table 1).

It was also possible to observe that 27.1% of the respondents used each LCU between 10-20 min per day, 30.2% did not check the condition of the tip (damage or dirt) weekly, 56.3% used PVC plastic film or a barrier sleeve for device protection, 87.7% used 70% alcohol for device disinfection, and 38.4% had never checked whether the battery was properly functioning (Table 1).

Knowledge of light-curing and incremental technique

As shown in Table 2, 38,6% of the participants used the eye shield of the device only, whereas 32,6% did not use any protection during light-curing other than to look away from the light. Most respondents (65.3%) used ≤2-mm thick increments before light curing. In posterior teeth, more than 80% of the participants used oblique increments, whereas 19.5% claimed that they inserted the material in horizontal increments.

More than half of the respondents (58.1%) stated that they performed the light-curing with the device tip at a distance from the curing site, and the most used radiant exposure time for each increment was 20 s (50.3%). When asked about the angle at which the light beam reaches the surface of the material, 80.9% reported that they were concerned about this issue (Table 2).

DISCUSSION

This research investigated the general knowledge of dentists regarding the adequate handling of LCUs, the incremental technique, and the use of protection during the light-induced polymerization of dental materials, which has been brought to attention by previous investigations[14-16].

Table 1 — Questions about the photopolymerization device and maintenance procedures.

Variable/Category	n*	%
What is the brand of your device?	**487**	
Schuster (Emitter D)	107	22
Ultradent (Valo)	75	15.4
SDI (Radii Cal)	73	15
Gnatus (Super Dual)	62	12.7
Kavo (Poly Wireless)	30	6.2
Dabi Atlante (Optilight Max)	29	6
SDI (Radii Plus)	20	4.1
Ivoclar (Bluephase)	15	3.1
3M (Elipar deep cure)	12	2.5
Orthometric (LEDX – T 2400)	6	1.2
Woodpacker (iLED)	4	0.8
Voco (Ledlux)	0	0
Other	54	11
How old is your device?	**487**	
<1 year	84	17.2
Between 1 and 3 years	176	36.1
Between 3 and 5 years	134	27.5
Between 5 and 10 years	82	16.8
>10 years	11	2.3
Did you know the irradiance output of your device when you purchased it?	**487**	
Yes	113	23.2
No	360	73.9
I prefer not to answer	14	2.9
Do you know the current irradiance output of your device?	**487**	
Yes	37	7.6
No	440	90.3
I prefer not to answer	10	2.1
Do you regularly measure the irradiance output of your device?	**487**	
Yes	50	10.3
No	430	88.3
I prefer not to answer	7	1.4
How long do you use the device on average per day?	**487**	
<5 minutes	48	9.9
Between 5 and 10 minutes	106	21.8
Between 10 and 20 minutes	132	27.1
Between 20 and 30 minutes	99	20.3
>30 minutes	102	20.9
How often do you check for damage or dirt on the tip of your device?	**487**	

Once a week	340	69.8
Once a month	41	8.4
Once every 6 months	21	4.3
Once a year	6	1.2
Never	79	16.2
Use of protection or physical barrier on your device?	**487**	
Yes, I use a disposable protective film	274	56.3
Yes, I use the protection indicated by the manufacturer	85	17.5
Yes, I use a physical barrier or sleeve that does not stick to the device	83	17
Yes, I use latex, gloves or similar	3	0.6
I do not use any	42	8.6
Do you disinfect your device?	**487**	
Yes, I use 70% alcohol	427	87.7
Yes, I use the substance indicated by the manufacturer	51	10.5
Yes, I use absolute alcohol	1	0.2
Yes, I use a soap/chlorine-based disinfectant	1	0.2
I do not use any	7	1.4
How often do you check whether the battery is properly working?	**487**	
Once a week	224	46
Once a month	48	9.9
Once every 6 months	21	4.3
Once a year	7	1.4
Never	187	38.4

Fonte: Os autores

Table 2 — Questions about the photopolymerization and incremental technique.

Variable/Category	n*	%
Do you use any eye protection?	**487**	
Yes, the light shield of the curing device	188	38.6
Yes, blue-light filtering glasses	54	11.1
Yes, a handheld shield.	35	7.2
Yes, transparent protective glasses	30	6.2
No, I try to look away from the light	159	32.6
No	21	4.3
Approximate increment thickness?	**487**	
<1 mm	73	15
≤2mm	318	65.3
≤3mm	82	16.8
≤ 4mm	14	2.9
> 4mm	0	0
Increment Type	**487**	
Oblique incremente	392	80.5
Horizontal incremente	95	19.5
Distance from the device tip to the curing material	**487**	
0 mm (the tip of the device touches the curing site)	177	36.3
1 mm	163	33.5
2 mm	81	16.6
3 mm	39	8
I do not know	27	5.5
Are you concerned about the angle of the light beam?	**487**	
Yes	394	80.9
No	88	18.1
I prefer not to say	5	1

Light exposure time for each increment	**487**	
10 seconds	57	11.7
20 seconds	245	50.3
30 seconds	72	14.8
40 seconds or more	113	23.2

Fonte: Os autores.

Brazilian LCU brands were the most cited by the participants (Schuster© Equipamentos Odontológico, 2019 and Gnatus – S/A dental products), possibly because of greater availability and lower price compared to international brands.

The other two brands (Ultradent® Salt Lake City, UT, USA and SDI, Bayswater, Victoria, Australia) have devices with comprehensive scientific knowledge regarding their effectiveness in the photopolymerization process[16,17] and were preferred by 30.4% of the participants.

Regardless of the selected brand, knowledge about irradiance is essential for the correct execution of clinical procedures involving light curing[1]. It is concerning that most participants

in this study did not know the current power output of their devices (90.3%) or did not regularly measure their irradiance (88.3%). Furthermore, when asked about the irradiance output of their devices, some participants reported unrealistic values, such as 70,000 mW/cm^2. This scenario could be partially explained by the difficulty of access to radiometers or even the lack of general knowledge about the light-curing process of dental materials. Although some LCUs, such as Radii-cal (SDI; Bayswater, Victoria, Australia), have irradiance value indicators displaying colour scales, the numerical irradiance of these devices remains unknown.

The lack of knowledge about the irradiance output of the device may result in under-curing or over-curing. Under-curing (<400 mW/cm^2) may hinder the adequate polymerization of the material, negatively affecting the material's properties, while over-curing (>1200 mW/cm^2) may cause thermal damage to the adjacent tissues and increase chair time. The optimal radiant exposure proposed by the literature is between 800 and 1000 mW/cm^2 [1,18].

Another important factor related to irradiance is the daily LCU usage time. In the present study, almost half (41.3%) of the participants used their device for at least 20 minutes per day, which is a considerable amount of time for a working day, further

indicating that this procedure is one of the most common in daily practice. When the device is used for long periods and is not returned to the charging station, the irradiance may decrease, which is why it is recommended to always keep the LCU on the charging station when not in use [13,19].

Inadequate handling and maintenance of the LCUs may also impact the irradiance parameters indicated by the manufacturer. It was surprising to find that 16.2% of the dentists had never checked whether the tip of their LCU was dirty or damaged, which could significantly compromise the polymerization of the light-cured dental polymer system[19].

Another parameter that should be periodically monitored is the battery status, as it provides the energy that will be converted into light emission by the device. In the present work, 38.4% of the participants answered they had never checked whether the battery of their devices was properly functioning. Several studies have evaluated the light intensity of different LED curing units and found that the decrease in the ability to polymerize composite resin was proportional to the decline in battery charge[10,11,19]. The frequency of monitoring the batteries will depend on the amount of use of the device. However, most batteries are designed to withstand two to three years of normal use[1].

Most participants (56.3%) use plastic films as a physical barrier to protect the LCUs. Studies have shown that the protection provided by PVC plastic films is effective and does not interfere with light emission[10,20]. Some fibre-optic light guides can be autoclaved; however, this decontamination procedure may wear the guide over time and affect the radiant exitance, which may also happen when thick layers of thephysical barrier are covering the LCU tip. Thus, the protective material must be applied with caution[21].

Almost 90% of the participants use 70% alcohol for device disinfection. Some manufacturers recommend 70% alcohol or alcohol-based substances after each use (Ultradent® Salt Lake City, UT, USA; Ivoclar Vivadent, Schaan, Liechtenstein). The solution should be sprayed onto a piece of cloth to wipe the external areas according to the SDI guidelines (Radii-cal, SDI, Bayswater, Victoria, Australia). However, other manufacturers recommend the use of paper towels with a disinfectant agent (e.g.,

The use of 2-mm increments for conventional composite resins followed by light-curing at a minimum distance from the device tip to the restorative material is the most efficient polymerization technique, which most participants (65,3%) declared to perform in this study. Composite resin increments with a thickness greater than 2 mm may hinder the light from reaching the base of the restoration, resulting in incomplete polymerization, which could cause tooth hypersensitivity, colour instability, microleakage, and subsequent recurrent caries development[6,22].

The type of increment directly impacts the polymerization shrinkage. Although most participants in this research responded that they use oblique increments of composite resin (80.5%), a considerable number (19.5%) responded that they use horizontal increments. In conventional composite resins (not including Bulkfill composite resin), the composite material must be inserted incrementally and obliquely to reduce shrinkage stress and the possibility of debonding[23].

The distance between the light source and the material can affect the energy density that the material will receive. During photopolymerization, the increase in the distance between the device and the restoration can negatively impact the clinical performance of the composite. In the present study, most participants (58.1%) performed the light-curing at a distance of 1 to 3 mm from the material. However, the optimal distance for curing is as close as possible to the restoration. Otherwise, a considerable amount of light energy may be lost[13].

Exposure time is one of the most important clinical variables in light-induced photopolymerization and can significantly affect the material's performance. In this study, more than half of the participants (50.3%) used 20 seconds of light exposure in each increment. The determination of an ideal exposure time might not be achievable, as the irradiance received by the material is also affected by other factors such as the device's potency, the position and distance of the device tip to the restoration, the type of material, and its thickness[24].

When asked about the angle at which the light beam reaches the material's surface, 80.9% of the participants reported that they were concerned about this issue. According to the ISO 4049 recommendations, the light tip must be placed in a perpendicular position, as close as possible to the surface of the increment to ensure that sufficient light reaches the restorative material. Changes in the inclination and the

increase of the distance between the tip of the LCU to the surface of the composite may decrease the amount of energy density delivered, resulting in incomplete polymerization and unfavourable restoration prognosis[16,25].

The habit of looking directly at the irradiated site is not recommended, as prolonged exposure to blue light can cause retinal damage. On the other hand, looking away, which was reported by 32.6% of the participants, is not the best approach either, as the operator might move the device and the light away from the proper place and not correctly light-cure the material[26,27]. The use of appropriate light filters, such as handheld shields, the LCU shield, or blue-light filtering glasses, is the only measure that enables the operator to look directly at the restoration during radiant exposure while almost completely blocking the light transmission of <500 nm wavelengths[28,29]. Only 18.3% of the dentists reported using adequate eye protection in this survey. It is worrying that 81.7% of professionals were unaware of the importance of this type of protection.

It is important to highlight the difficulty of obtaining responses from dental professionals and the limitation of our methodology related to the sample, as it is considered a convenience sample. The results of the present work suggest that measures focusing on the dissemination of information about the polymerization process and light-curing devices are needed to optimize the use of LCUs in daily practice.

CONCLUSION

This study shed light on specific knowledge gaps among dentists regarding the use of protective measures against the harmful effects of the blue light emitted by the LCUs, evidencing a lack of understanding of the photopolymerization process as well as its effect on the clinical performance of light-cured dental polymer systems.

DECLARATION OF INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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