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Knowledge and precautions of light-curing composite resin restorations by dental students

Conhecimento e cuidados de utilização sobre fotoativação de restaurações com resina composta por estudantes de Odontologia

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ABSTRACT

Composite resin is versatile material for performing several dental procedures in dentistry, and its use has already been consolidated in this field. The clinical success of adhesive restorations is directly related to the knowledge of restorative material properties and light-curing unit factors, among others. The aim of the study was to assess the knowledge about the technical characteristics of light-curing devices and the forms of use and maintenance employed by undergraduate dental students. A total of 230 students answered a questionnaire containing six questions on technical data, use, and maintenance of light-curing units. Of the total number of participants, the majority were students from private educational institutions attending the last two years. With 59.1% of them unaware of the ideal irradiance of a light-curing unit, 73.0% were careful to position the light-curing unit as close as possible to the restoration, and 42.6% followed the light-curing time recommended by textbooks and theoretical texts. As for use and maintenance, 50.4% used the protector attached to the light-curing unit, 57.4% used safety barriers, and 63.0% sanitized the light tip after use. The evaluation suggests that student's knowledge of "light-curing resin materials" is incomplete. Therefore, it can be inferred that the students have a good understanding of biosafety precautions when using light-curing units, but more knowledge is needed about the technical and clinical aspects of the devices.

Keywords: Composite resins. Education in Dentistry. Polymerization.

RESUMO

A resina composta é um material versátil utilizado para a realização de vários procedimentos clínicos em Odontologia cujo uso já está consolidado nesse meio. O sucesso clínico das restaurações adesivas está diretamente relacionado ao conhecimento das propriedades do material restaurador e dos fatores relacionados à unidade fotoativadora, dentre outros. O objetivo do estudo foi avaliar o conhecimento sobre as características técnicas dos aparelhos fotoativadores e as condutas de utilização e manutenção adotadas por estudantes de graduação em Odontologia. Foram entrevistados 230 estudantes que responderam a um questionário com seis perguntas relacionadas aos dados técnicos, ao uso e à manutenção dos aparelhos fotoativadores. Do total de participantes, a maioria era estudantes de instituições privadas de ensino, cursando os últimos dois anos. Com 59,1% os que não conheciam a irradiância ideal para fotoativar uma restauração com resina composta, sendo 73,0% que tomavam o cuidado de posicionar o aparelho fotoativador o mais próximo possível da restauração e 42,6% seguiam o tempo de fotoativação recomendado por livros e textos teóricos. Quanto ao uso e manutenção do aparelho, foram 50,4% que utilizavam o protetor acoplado ao aparelho fotoativador, com 57,4% que empregavam a barreira de segurança e 63,0% higienizavam a ponta óptica após utilização. A avaliação sugere que o conhecimento dos estudantes sobre o tema "fotoativação de materiais resinosos" é incompleto. Sendo assim, infere-se que os estudantes têm boa compreensão acerca dos cuidados de biossegurança com a utilização dos fotoativadores, porém faz-se necessário maior conhecimento sobre os aspectos técnicos e clínicos dos aparelhos.

Palavras-chave: Educação em Odontologia. Polimerização. Resinas compostas.

INTRODUCTION

Currently, most dental restorations are made with light-curing composite resins (Broadbent et al., 2020), due to its versatility in clinical dental practice (André, Nima, Sebold, Giannini, & Price, 2018; Rosa Rodolpho et al., 2022), and because of the Minamata agreement to phase down dental amalgam use (Policy Statement, 2022). Composite resin restorations have excellent performance and clinical durability (Moraes et al., 2022; Rosa Rodolpho et al., 2022), and the clinical behavior of posterior composite resin restorations has shown a 48% success rate after 33 years (Rosa Rodolpho et al., 2022).

Besides, factors related to the tooth, the patients, the professional, the restorative materials and techniques used contribute to the longevity of the material and minimize the risk of dental restoration failures (Policy Statement, 2022). Thus, the clinical success of adhesive restorations is directly related to the knowledge of restorative material properties and light-curing unit factors.

Inadequate light-curing may cause a lower degree of conversion of monomers into polymers, leading to undesirable clinical situations, such as microleakage, color instability, poorer physical and mechanical properties, lower bond strength and marginal integrity, increased wear, permeability, fracture, adjacent caries, higher water absorption, increased leaching of non-photoactivated monomers, pulp toxicity, and complete restoration failure (André et al., 2018). It is therefore necessary for professionals to know the exposure time and irradiance recommended by the manufacturer of each resin material (André et al., 2018). Light-curing unit irradiance is the radiant light power (flux) laid on a surface (Price, 2017), given in mW/cm^2, whose power is related to the radiant energy per time unit (Joules per second or W).

Knowledge of light-curing units is also essential, since their types may impair microhardness and depth of healing (Santini & Turner, 2011). For this reason, professionals need to select a light-curing unit with caution, as the clinical success of restorations depends on the device quality and technique used. Few studies in the literature report the knowledge about the technical characteristics of light-curing units, as well as their use and maintenance by students and professionals. Considering the learning curve required in any field, dental students and trainees tend to incorrectly use light-curing units, applying insufficient amount of light energy to the restoration (Suliman, Abdo &

Elmasmari, 2020). With regard to professionals, only a minority have an adequate understanding of light-curing, the relationship between degree of conversion and polymerization shrinkage, or the fact that poorly polymerized materials can release harmful substances (Santini & Turner, 2011).

The present study analyzed the knowledge about the technical characteristics of light-curing units and evaluated the conduct of use and maintenance of these devices by undergraduate dental students.

MATERIALS AND METHODS

This is an observational, cross-sectional and descriptive study carried out with 230 dental students who voluntarily answered a questionnaire administered between July and August 2019 at two higher education institutions.

Table 1
Questionnaire applied to undergraduate dental students.

Regarding light-curing units, answer:
1. Which recommendations below do you follow regarding the light-curing time of a 2mm increment of a conventional composite resin? a. Recommendations of the light-curing unit manufacturer. b. Recommendations from the dental clinic. c. Recommendations of the restorative material manufacturer. d. Recommendations from dental books. e. Others.
2. How do you position the light beam of the light-curing unit on a restoration? a. Parallel to the tooth and away from the restoration. b. Parallel to the tooth and close to the restoration. c. Parallel to the restoration and away from the composite resin. d. Parallel to the restoration and as close as possible to the composite resin without touching it. e. Parallel to the restoration and touching the composite resin.
3. Which light-curing unit irradiance do you consider ideal for light-curing a composite resin restoration? a. <1000 mW/cm2 b. 1000-1499 mW/cm2 c. 1500-1999 mW/cm2 d. ≥2000 mW/cm2 e. I do not know.
4. Do you wear any eye protection during light-curing? a. I do not use protection. b. I do not use it but try to look away from the light. c. Yes, I use the protector attached to the light-curing unit. d. Yes, I wear orange safety glasses. e. Yes, I use hand protectors (protective guards).
5. Regarding safety barriers during light-curing, answer one of the alternatives below that best represents your routine. a. I do not use it. b. I do not use it because it might interfere with restoration quality. c. I do not use it because it might interfere with light-curing unit light emission. d. I use it sometimes. e. I always use it without exceptions.
6. Regarding light-curing unit light tip cleaning, answer one of the alternatives below that best represents your routine. a. I do not do it. b. I do not do it because it might interfere with light emission quality in the long term. c. I do not do it because of the risk of corrosion. d. I always do it after using it. e. I do it just before using it.

Source: The authors.

The project was approved by the Research Ethics Committee (CAAE: 14283519.8.0000.0104). The inclusion criteria prioritized volunteers from the third, fourth, and fifth years of Dental School who performed clinical care in "Operative Dentistry". All the students signed an informed consent form.

The participants answered a questionnaire (Table 1) with six multiple-choice questions about technical data, usage, and maintenance of light-curing units, which covered information on the recommended light-curing time for a 2mm resinous increment, the use of a safety barrier to protect the light-curing unit, light tip cleaning, light beam position in a restoration, optimal irradiance of the light-curing unit, and the wear of eye protection during light-curing.

Thus, the studied variables were attention to the manufacturers' instructions regarding light-curing time for resins, light-curing unit position during light-curing, light-curing unit maintenance and cleaning, and knowledge about light-curing unit irradiance.

Two researchers applied the questionnaire and were responsible for informing the students of the research purpose, guiding questionnaire application and time stipulated for answering the questions, as well as solving doubts, and supervising students. No assistance or consultation from materials and colleagues was allowed during the questionnaire application. Each undergraduate class took around 15 to 20 minutes to answer the questionnaire, which was collected at the end.

The answers were tabulated in spreadsheets and analyzed descriptively in Excel (2013).

RESULTS AND DISCUSSION

The study included 230 students, with 162 (70%) studying dentistry at a private higher education institution, 90 (55%) in their third year, and 72 (45%) in their fourth year. Of the 68 (30%) participants from public institutions, 18 (26%) were in their third year, 31 (46%) in their fourth year, and 19 (28%) in their fifth year.

Regarding the recommended light-curing time for a 2mm increment of a conventional composite resin, 42.6% of students followed the recommendations of dentistry textbooks, with 27.0% adopting the instructions of the manufacturer of the restorative material, 17.4% obeyed the advice of the dental clinic, with 9.1% complying with the recommendation of the manufacturer of the light-curing unit, and 3.9% did not mention it.

As for the light-curing unit light beam position on the restoration, 73.0% of the participants placed the device parallel to the restoration and as close as possible to it, but without touching it, with 21.7% positioning it parallel to the tooth and close to the restoration, 2.6% putting it parallel to the restoration and far from the resin composite, 1.7% leaving it parallel to the restoration and touching the resin composite, only 0.9% parallel to the tooth and away from the restoration.

With regard to knowledge about the optimal irradiance of light-curing unit for a composite resin restoration, 59.1% of volunteers indicated not knowing it, 18.7% between 1500-1999 mW/cm², 11.3% between 1000-1499 mW/cm², 8.7% greater than or equal to 2000 mW/cm², and 2.2% lower than 1000 mW/cm².

As for the wear of eye protectors during light-curing, 50.4% of students reported using the protector attached to the light-curing unit, 30.9% stated that, although they use no protection, they try to look away from the light, with 14.3% using no protection, 3.5% used hand protectors (protective guards), and 0.9% used orange safety goggles.

When questioned about the use of safety barriers during light-curing, 57.4% of the participants said that they always used it, 28.7% used it sporadically, 7.0% did not use it, 5.2% did not use it because it might interfere with light emission, and 1.7% did not use it because it might interfere with restoration quality.

As for light-curing unit light tip cleaning, 63.0% of volunteers sanitized the light tip after use, 22.2% said that they did not sanitize it, 10.9% sanitized it only before use, 3.0% did not sanitize it because it might interfere with light emission quality in the long term, and 0.9% did not sanitize it because it might cause corrosion of the device.

The success of restorative treatment with resin materials is directly related to correct light-curing. Dental students and professionals should know the technical characteristics and ways to optimize the use and maintenance of light-curing unit to improve composite resin restorations. The results of this study showed that most of the students who answered the questionnaire have a good understanding of biosafety principles for using light-curing units, but there were limitations in terms of knowledge about the technical aspects regarding the irradiance characteristics of the devices and the adequate light-curing time for restorative materials.

Proper light-curing for composite resin restorations is related to material characteristics, such as shade, photoinitiator amount, and inorganic filler type. Therefore, the correct light-curing time should follow the material manufacturer's recommendations, as they may vary from one material to another, depending on its composition (McAndrew, Lynch, Pavli, Bannon & Milward, 2011). Approximately 70% of the students answered incorrectly the question about light-curing time. The other alternatives, such as recommendations from textbooks, dental clinics and manufacturers, are generalized responses that do not consider the material and its specific composition.

Adequate light-curing can occur by positioning the light beam directly on the restoration (André et al., 2018). Most students answered this question correctly (in Table 1, question 2). The longer the distance between the light-curing unit tip and the material surface, the lower the irradiation and the degree of conversion of the composite resin, which can cause marginal degradation, lower color stability, and higher susceptibility to staining. Thus, light-curing at a distance may harm restoration durability.

Hence, professionals must be attentive to the tooth region for light-curing, especially in Class II preparations. In these cavities, the base of the interproximal box remains away from the light source and the device tip must be as close to the cusp tip as possible so the resin receives more light and does not become undercured (Price, 2017; Rueggeberg, Giannini, Arrais & Price, 2017).

Light-curing units with larger tip diameters and more homogeneous light beams are better for curing extensive mesio-occlusal-distal Class II restorations (Shimokawa, Turbino, Giannini, Braga & Price, 2020). Also, adequate photoactivation requires more than one light-curing position, i.e., first light-curing one proximal box and then the other, especially when selecting bulk-fill resins (Shimokawa et al., 2020). When cementing several laminates, the light-curing tip must be fixed to only one dental element, as the sweeping movement from the light-curing agent also impairs the mechanical and physical properties of the resin cement (Bragança, Vianna, Neves, Price & Soares, 2020). All these clinical aspects about the correct use of light-curing units should be constantly reinforced in schools so that students can apply them routinely in practical classes.

The distance between the light source and the resin directly influences irradiance (the radiant energy supplied to the tooth surface), which decreases as the interval increases, usually staying between 1-8mm (Rueggeberg et al., 2017; Soares et al., 2018). The literature shows that 300-400 mW/cm² of irradiance is the minimum range accepted for light-curing units, but optimal irradiance is approximately 1000 mW/cm², applied for 20 seconds (Luca & Ilie, 2021). Devices delivering lower values may compensate by using a longer light-curing time than manufacturers recommend. However, exposure should be increased with caution because of the effect of higher temperatures, as heat higher than 5.5 °C can cause irreversible damage to the pulp tissue and adjacent soft tissues (Runnacles et al., 2019; Luca & Ilie, 2021).

Tooth position in the dental arch and operator placement affect the outcomes of the complete polymerization of composite resin restorations, and these clinical situations are worth noting (André, Nima, Sebold, Giannin & Price, 2018; Soares et al., 2018). Device manufacturers have sought to improve light tip production to minimize light beam divergence to optimize homogeneity, thus allowing higher irradiance (Rueggeberg et al., 2017).

The majority of the students (59.1%) did not know the optimal irradiance and many (18.7%) answered incorrect values, between 1500-1999 mW/cm². Although irradiance knowledge is essential for polymerization success, most dentists are somewhat unfamiliar with this subject (Soares et al., 2018). Considering the tendency of professionals to use more bulk-fill resins over time, carefully light-curing these materials should be reinforced to achieve satisfactory in-depth polymerization.

The thicker increment provided by bulk-fill resins decreases the working time compared to restorations made with the incremental technique, without introducing more bubbles in the restoration, regardless of whether they are performed by students or professionals (Soto-Montero et al., 2022). Thus, bulk-fill, flow, or regular resins may require a different light-curing time (Miletic, Pongprueksa, Munck, Brooks & Van Meerbeek, 2017).

Regarding eye protection during light-curing, although most light-curing unit manufacturers provide some eye protection, these items tend to remain unused (Price, 2017). The wavelength most harmful to the eyes is close to 440nm, and light-curing units emit wavelengths between 430-480nm, proving they may cause eye damage (Price, Ferracane, Hickel & Sullivan, 2020). Exposure to high levels of blue light can cause immediate and irreversible damage to the retina, while chronic exposure to low levels can accelerate retinal aging and macular degeneration (Price, 2017).

Most students (30.9%) stated that, although they did not wear eye protection, they tried to look away from the light, however, such behavior does not prevent the exposure to light. Seven polymerization cycles are sufficient to exceed the maximum recommended daily exposure to blue light when looking at the light for one second before looking away (Price, 2017). Professionals should know that such exposure may be avoided using orange goggles, which filter 99% of blue light (Price, 2017). This equipment allows the operator to verify light-curing unit positioning during light-curing, improving the amount of light supplied to the restoration (Scott, Felix & Price, 2004; Price, 2017; Rueggeberg et al., 2017).

Safety barriers during light-curing are essential. This study showed that more than half of the students have done it frequently. No standardization is available on the best use of safety barriers, but this practice prevents cross-contamination and material adherence to the device tip, avoiding damage from autoclaving. These barriers prevent contamination and are inexpensive (McAndrew et al., 2011).

Alternatives such as using PVC film are appealing, because they allow very thin protection juxtaposed to the device tip. The barrier should cover the entire tip and body of the light-

curing unit and be adequately juxtaposed to minimize irradiance reduction and the adverse effects on polymerization. Seam lines, wrinkles, or folds in the barrier should not be in the light-emitting area, as they are thicker and cause more light-curing reduction (Soares, Braga, Ribeiro & Price, 2020).

A small percentage of students did not use the safety barrier because they believed it could interfere with light emission (5.2%) or restoration quality (1.7%), showing the need for further explanation. Some barriers, including latex-based ones, decrease irradiance by up to 40% (Sword, Do, Chang & Rueggeberg, 2016) and should therefore be avoided (Price, 2017). Barriers need to be transparent and adequately fitted over the light-curing unit light tip to minimally interfere with light emission (Scott et al., 2004; Sword et al., 2016; Price, 2017).

The literature must discuss the cleaning of light-curing unit light tips. Most of the participants in the present study always cleaned the light tip of the device after using it. It should be noted that, over time, disinfectant sprays degrade the plastic of the light-curing unit body and the light source, consequently reducing light emission (Price, 2017). Thus, a dental radiometer should be used to assess and record emissions from routine curing lights. If the device allows, the tip should be removed frequently to clean and check them for possible damage (Price et al., 2020).

The applied questionnaire was probably a limitation of this study, as the consulted literature did not provide a validated questionnaire to allow comparisons with other studies. In order to minimize these limitations, an objective questionnaire was constructed, with questions addressing the use and maintenance of light-curing units, internally validated with the participation of graduate students and teachers in "Operative Dentistry and Dental Materials".

As for future perspectives, it is hoped to develop training courses or include more seminars or classes on the subject in undergraduate courses, since it seems like a compelling strategy. Despite the similarity of curriculum structures in undergraduate dental schools in Brazil and Mercosur countries, further research evaluating the pedagogical proposals of these courses for addressing the content or professors' knowledge (Angar et al., 2021) will also provide complementary answers on the knowledge acquired by future professionals.

CONCLUSION

Undergraduate dental students from the schools included in this study have a good understanding of biosafety care with the use of light-curing units. However, further knowledge is required about the technical aspects related to device irradiance and clinical care for adequate light-curing.

COMPETING INTERESTS

The authors declare that there are no conflicts of interest.

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AUTHOR CONTRIBUTIONS

Conceptualization: A. C. C. M. R. *Data curation*: R. S. S. T. *Formal analysis*: E. M. P. C. *Investigation*: E. M. P. C., A. C. C. M. R., J. C. N., F. M. T., C. H. N., D. E. P., R. S. S. T. *Methodology*: E. M. P. C., A. C. C. M. R., R. S. S. T. *Project administration*: C. H. N. *Resources*: D. E. P. *Software*: J. C. N., F. M. T. *Supervision*: R. S. S. T. *Validation*: J. C. N., E. M. P. C., A. C. C. M. R. Visualization: D. E. P. *Writing the initial draft*: E. M. P. C. *Revision and editing of writing*: A. C. C. M. R., R. S. S. T.

PEER REVIEW

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