IGOR OLIVEIROS CARDOSO

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Tese apresentada à Faculdade
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Orientador: Prof. Dr. Luíz Henrique Araújo Raposo
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Prof. Dr. Paulo César de Freitas Santos Filho
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Iniciando os trabalhos o(a) presidente da mesa, Dr(a). Luís Henrique Araújo Raposo, apresentou a Comissão Examinadora e o candidato(a), agradeceu a presença do público, e concedeu ao Discente a palavra para a exposição do seu trabalho. A duração da apresentação do Discente e o tempo de arguição e resposta foram conforme as normas do Programa.

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SUMÁRIO

Resumo

RESUMO

Vários fatores podem influenciar na longevidade das restaurações em resina composta: composição da resina composta, técnicas e materiais utilizados no momento da restauração. O objetivo geral desse trabalho foi avaliar os fatores que podem interferir na longevidade das restaurações em resina composta. Este estudo foi dividido em 4 capítulos de acordo com cada objetivo específico: **Capítulo 1:** Avaliar a influência de diferentes aparelhos fotoativadores com diferentes diâmetros de ponta e espectro de luz em resinas bulk-fill. **Objetivo 2:** Avaliar diferentes protocolos de fotoativação e polimento na rugosidade superficial, brilho, sorção e solubilidade de uma resina composta. **Objetivo 3:** Analisar a influência da composição de diferentes iniciadores/concetrações e espectro de luz de aparelhos fotoativadores no grau de conversão, Dureza e resistência a tração diametral em resinas compostas experimentais. Os métodos experimentais utilizados foram: grau de conversão (capítulo 1 e 3); microdureza Knoop (capítulo 1 e 3); rugosidade (capítulo 2); Brilho (capítulo 2); sorção e solubilidade (capítulo 2); resistência a tração diametral (capítulo 3). Os resultados encontrados mostram que: **1)** O aparelho fotoativador e o diâmetro da amostra afetaram significativamente a grau de conversão. O centro do espécime apresentou microdureza superior a periferia. 2) Não foram detectadas diferenças significativas na rugosidade da superfície e brilho para as diferentes aparelhos fotoativadores. Comparando os sistemas de polimento, os espécimes Sof-Lex e Opti1Step apresentaram rugosidade superficial semelhante, sendo significativamente superior ao Jiffy. 3) As resinas experimentais com presença de pelo menos 50% de BAPO apresentaram os melhores resultados de grau de conversão e resistência a tração diametral. Pode-se concluir que o tamanho da ponteira do aparelho fotoativador e o espectro de luz emitido pode influenciar nas propriedades mecânicas e ópticas da resina composta, assim como os diferentes iniciadores e suas concetrações presentes em sua consituição.

PALAVRAS-CHAVE: aparelho fotoativador, resina composta, fotoiniciador

Abstract

ABSTRACT

Several factors can influence the longevity of composite resin restorations: composite resin composition, techniques and materials used at the time of restoration. The general objective of this work was to evaluate the factors that can interfere in the longevity of composite resin restorations. This study was divided into 4 chapters according to each specific objective: **Chapter 1)** The aim of this study was to evaluate the influence of different light-curing units (LCUs) with distinct tip diameters and light spectra for activating bulk-fill resins. **Chapter 2)** The aim of this study was to evaluate different polishing protocols and light cure units (LCU) on the surface roughness, gloss, and sorption and solubility of a composite resin. **Chapter 3)** this study aimed to analyze the influence of the composition of experimental nanohybrid composite resins produced with distinct photoinitiators/concentrations and the light spectrum of different LED units on the degree of conversion, hardness and diametral tensile strength of the resulting restoratives. The experimental methods used were: degree of conversion (chapters 1 and 3); Knoop hardness (chapters 1 and 3); roughness (chapter 2); gloss (chapter 2); sorption and solubility (chapter 2); diametral tensile strength (chapter 3). The results found show that: **1)** LCUs and specimen diameter significantly affected the degree conversion. The center of the specimen exhibited superior KHN than the periphery. **2)** No significant differences were detected on the surface roughness or gloss for the different LEDs units. Comparing the polishing systems, Sof-Lex and Opti1Step specimens presented similar surface roughness, which was significantly superior to Jiffy. **3)** The experimental resins with the presence of at least 50% of BAPO showed better degree conversion and diametral tensile strength results. It can be concluded that the size of the LED tip, and the emitted light spectrum can influence the mechanical and optical properties of the composite resin, as well as the different initiators and their concentrations present in their constitution.

KEY WORDS: Light curing unit, composite resin, initiator

Introdução e referencial teórico

1. INTRODUÇÃO E REFERENCIAL TEÓRICO

As resinas compostas são amplamente utilizadas na rotina clínica, sendo indicadas para regiões anteriores e posteriores.[1] Esses materiais se destacaram por serem biocompatíveis, possuírem boas propriedades mecânicas e estabilidade de cor.[2] A evolução foi notória com o passar dos anos, aumentando a resistência, lisura superficial, capacidade de manter o polimento por mais tempo e diversas outras propriedades. Houve modificações em sua constituição, tanto nas cargas e matriz orgânica quanto na forma de ativação.[3,4]

As resinas Bulk Fill apareceram no mercado para simplificar a técnica restauradora, pela possibilidade de em um único incremento de 4 a 5mm restaurar um dente posterior.[5] A redução do tempo clínico no procedimento restaurador quando comparado a uma resina composta convencional é evidente, ao mesmo tempo em que mantém boas propriedades mecânicas, como resistência à fratura, adaptação marginal, resistência ao desgaste e longevidade.[6,7]

Para a ativação das substâncias iniciadoras, e início do processo de polimerização dos compósitos, diferentes aparelhos fotoativadores podem ser utilizados, dentre eles a luz halógena de quartzo-tungstênio, arco de plasma, laser de argônio e o diodo emissor de luz (LED). As unidades LED passaram a dominar o mercado e atualmente são os aparelhos mais utilizados na prática clínica moderna.[8] O espectro de luz emitido por estes aparelhos deve ser correspondente ao do estímulo do fotoiniciador presente no material restaurador.[9]

A Canforoquinona é o fotoiniciador mais utilizado nas resinas e apresenta como pico de absorção a luz o comprimento de onde de 468nm.[10] No entanto, fotoiniadores alternativos com diferentes picos de absorção estão sendo adicionados aos compósitos para melhorar propriedades mecânicas, profundidade de polimerização e aspecto final da cor.[11,12] A fim de irradiar luz com diferentes comprimentos de luz para ativar mais de um fotoiniciador, alguns LEDs emitem luz que possuem mais de um espectro de luz, com dois ou mais picos.[8,13]

O termo que se refere à quantidade de luz que chega à restauração é denominado irradiância.[14] O valor da irradiância é obtido pela razão da Potência pela área da ponta do aparelho fotoativador. No entanto, é um valor fácil de ser manipulado, e pode ser alterado de duas formas: aumentando a Potência, ou como é feito pela maioria dos fabricantes, diminuindo a área da ponta do LED.[15]

A irradiância não leva em consideração o tempo de exposição, é um valor momentâneo, referente à luz emitida pelo aparelho que chega ao destino, mas o tempo de exposição tem grande relevância para a polimerização dos compósitos.[14,16] A exposição por um tempo prolongado pode compensar uma irradiância menor, da mesma forma que uma exposição por menor tempo pode ser feita com um aparelho mais potente.[17,18] A melhor forma de mensurar a irradiância pelo tempo é a exposição radiante, também citada como densidade de energia, unidade de medida J/cm^2.[14] Para atingir adequados níveis de grau de conversão, as resinas requerem um total de 6 a 24J cm^2 para 2mm de profundidade, dependendo na marca e da cor.[19-21]

A Energia que chega à superfície de uma restauração pode ser alterada por diversos fatores, como características técnicas do aparelho, profundidade da cavidade, material restaurador e sua espessura, protetor de infecção utilizado nos aparelhos fotoativadores e o operador.[22,23] Fatores que são operador dependente como o tempo de fotoativação, o ângulo e a distância do aparelho fotoativador tem uma influência direta no resultado final da polimerização.[24] Com o aumento da angulação entre a ponta do aparelho fotoativador e a superfície do dente a ser restaurado a irradiância diminui significantemente.[25] As ponteiras dos aparelhos fotoativadores possuem diâmetros distintos,[26] e muitas vezes não são coincidentes com as distâncias mésio-distais dos dentes posteriores, principalmente os molares.[27] Para a técnica incremental este fator não é tão relevante, pois cada incremento deve ser polimerizado, mas para o uso de resinas Bulk Fill, em que muitas vezes é realizado apenas uma fotoativação para a resina, deve-se conhecer a distância M-D dos dentes e o diâmetro da ponteira do LED para realizar um polimerização adequada.[28,29] Quando aparelhos fotoativadores com diâmetro da ponta pequeno são utilizados para fotoativar cavidades amplas de molares, a resina não é totalmente coberta pela ponta do aparelho e pode resultar em uma polimerização inadequada.[30]

Alguns aparelhos fotoativadores devido à forma e angulação, a ponta não podem ser posicionada paralela a superfície oclusal de dentes posteriores, e consequentemente ficam inclinadas.[31] Esta inclinação aumenta a distância e a orientação dos feixes de luz da ponteira do LED à superfície a ser polimerizada. Com o aumento da distância entre a fonte de luz e a restauração, menos irradiância chega à superfície e algumas regiões podem não ser ativadas adequadamente.[25]

Objetivos

3.1 Objetivo Geral

O objetivo desse trabalho foi avaliar fatores que interferem na longevidade de restaurações em resina composta, analisando diferentes aparelhos fotoativadores, constituição das resinas compostas e desenvolvimento de uma resina composta experimental.

3.2 Objetivos específicos

Objetivo específico 1: O objetivo deste estudo foi avaliar a influência de diferentes aparelhos fotoativadores com diferentes diâmetros de ponta e espectro de luz em resinas bulk-fill.

Objetivo específico 2: O objetivo deste estudo foi avaliar diferentes protocolos de fotoativação e polimento na rugosidade superficial, brilho, sorção e solubilidade de uma resina composta.

Objetivo específico 3: O objetivo deste estudo foi analisar a influência da composição de diferentes iniciadores/concetrações e espectro de luz de aparelhos fotoativadores no grau de conversão, Dureza e resistência a tração diametral em resinas compostas experimentais.

Capítulos

Essa Tese foi dividida em 4 capítulos:

4.1- Capítulo 1- Artigo publicado no periódico European Journal of Dentistry: Influence of tip diameter and light spectrum of light curing units on the properties of bulk-fill resins.

4.2- Capítulo 2- Artigo em revisão para publicação no periódico Operative Dentistry: Influence of light curing units and polishing protocols on the surface roughness, gloss, and sorption and solubility of a composite resin.

4.3- Capítulo 3- Artigo em revisão para publicação no periódico Dental Materials: Effect of different initiators/concentrations on the mechanical properties of experimental composite resins.

4.4- Capítulo 4- Artigo em revisão para publicação no periódico ROBRAC. Fatores de sucesso em restaurações diretas de dentes anteriores com resina composta: série de casos.

Capítulo 1

Title: Influence of tip diameter and light spectrum of light curing units on the properties of bulk-fill resins

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Title: Influence of tip diameter and light spectrum of curing units on the properties of bulk-fill resin composites

Abstract

Objective: The aim of this study was to evaluate the influence of different light-curing units (LCUs) with distinct tip diameters and light spectra for activating bulk-fill resins.

Materials and methods: The specimens (n=10) were made from a conventional composite (Amaris, VOCO) and bulk-fill resins (Aura Bulk Fill, SDI; Filtek One, 3M ESPE; Tetric Bulk Fill, Ivoclar Vivadent) with two diameters, 7 or 10 mm, x 2 mm thickness. Following 24 h of specimen preparation, the degree of conversion (DC) was evaluated using the FTIR unit. Knoop microhardness (KHN) readings were performed on the center and periphery of the specimens. Data were assessed for homoscedasticity and submitted to 1-way and 3-way analysis of variance followed by the Tukey and Dunnett tests, depending on the analysis performed ($\alpha=0.05$).

Results: LCUs and specimen diameter significantly affected the DC. The *Tetric Bulk Fill* provided increased DC results when light-cured with *Valo* (54.8 and 53.5%, for 7 and 10 mm, respectively) compared to *Radii Xpert* (52.1 and 52.9%, for 7 and 10 mm, respectively). No significant differences in KHN results were noted for the conventional resin composite (*Amaris*) compared with LCUs ($p=0.213$) or disc diameters ($p=0.587$), but the center of the specimen exhibited superior KHN ($p\leq0.001$) than the periphery.

Conclusion: The light spectrum of the multipeak LCU (*Valo*) significantly increased the DC and KHN of the bulk-fill resin composite with additional initiator to CQ (*Tetric Bulk Fill*) compared to the monowave LCU (*Radii Xpert*). The tip size of the LCUs influenced the performance of some of the resin composites tested.

Keywords: composite resins, curing lights dental, polymerization

Introduction

Resin-based composites (RBCs) are widely used materials for Class I and II restorations with failure rates of 1.8% after 5 years and 2.4% after 10 years.[1] Although conventional RBCs exhibit good mechanical properties, they also present undesirable characteristics, such as polymerization shrinkage.[2] This shrinkage results in residual stress in the tooth-restoration interface. If not controlled or reduced either by the operator or material, the shrinkage stress is related to marginal staining, enamel cracks and postoperative sensitivity.[2] According to the World Dental Federation, direct restorations can fail based on aesthetic, functional or biological aspects.[3] Shrinkage stress may be related with all these criteria regardless of whether manifested early or in late stages, leading to failures.[3] Some measures can be taken to reduce the influence of polymerization shrinkage; for example, the use of incremental insertion techniques or bulk-fill composite materials would be beneficial for the final restoration.[4] Beyond decreasing the clinical time of the restorative procedure, bulk-fill resin composites are used in single increments of up to 4 or 5 mm thickness because they present lower polymerization shrinkage and consequently lower residual shrinkage stress.[5]

For RBCs restorations to be successful and acquire adequate mechanical and optical properties, proper polymerization is require.[6] Some relevant properties for the success of a restoration, such as the degree of conversion and hardness, are influenced by irradiance and the light spectrum.[6,7] The degree of conversion, namely, monomers converting to polymers, is directly related to hardness, a property that expresses the mechanical and wear resistance of resin-based composites.[5,7] The light-curing unit (LCU) provides the light that will allow the activation of initiators present in the composites to trigger the polymerization process.[7] Currently, the most widely used LCUs include light emitting diodes (LED) that can present different spectra, and these devices are classified into monowave and multipeak units.[8] Monowave LED units present a light spectrum between 450 and 490 nm. This light spectrum is effective in activating the camphorquinone (CQ) initiator, which has its peak action at 468 nm and is the most commonly used agent in resin-based materials.[9] Multipeak LED units present violet light in addition to blue light with emission of wavelengths below 420 nm, allowing the activation of different initiators.[9]

The light tips of the LCUs have different diameters,[10] and their sizes often do not coincide with the mesio-distal distances of the posterior teeth, which ranges from 6.74 to 7.16 mm in premolars and from 9.72 to 11.03 mm in molars.[11] For the incremental technique, this factor may not be relevant given that each increment must be individually activated by light. However, for the use of bulk-fill resins, only one light-activation cycle is typically performed. Under these circumstances, the mesio-distal distance from the teeth and the diameter of the LED tip must be known to perform proper light-curing to the whole restoration and consequently allow for sufficient polymerization.[12] LCUs with small tip diameter used to activate large molar restorations may not completely cover the resin composite, potentially resulting in insufficient polymerization.[7]

Thus, the aim of this study was to evaluate the influence of different LED-based LCUs with different tip diameters and light spectra for activating bulk-fill RBCs. The null-hypothesis generated was that LCUs with different tip sizes and light spectra would not influence the degree of conversion and Knoop hardness of different bulk-fill RBCs.

Methods and materials

Irradiance Measurement

The curing units, Valo (Ultradent, Salt Lake City, UT, USA) and Radii Xpert (SDI, Bayswater, Australia) were fully charged as recommended by the manufacturer. The higher power (mW) of the cordless LED units during the cycle was individually checked for 5 light cycles of 20s using a power meter (Nova, Ophir Spiricon, Logan, UT, USA), then the average of the 5 cycles was divided by the tip area (cm^2), calculated from the optical diameter, as measured with a digital caliper (CD6CS, Mitutoyo, Kanagawa, Japan), to obtain the irradiance (mW/cm2) (Table 1).[13]

Specimen preparation

To simulate the diameter of average occlusal cavities in premolars and molars, 2-mm thick resin cylinders with 7 mm and 10 mm diameter, respectively, were made from the conventional and bulk-fill composites as described in Table 2. For this, circular aluminum matrixes were positioned over glass plates, and specimens were obtained by inserting the RBCs in a single increment. Then, a Mylar strip and a glass plate were placed over the resin and slightly compressed to regularize the top surface of the specimens.

For light curing the specimens, the tip of the LCU (Table 3) was positioned parallel and in close contact to the top glass plate, and light-curing was performed for 20s, as recommended by each composite manufacturer, using a standardized position. The position of each specimen in relation to the LCU tip was noted in the top of the discs with permanent marker to allow the same position to be determined during the tests. After this, the specimens were stored under dry conditions in identified light-proof containers.

Degree of conversion (DC)

Twenty-four h after preparation, the DC was evaluated at the center of the top surface of the specimens (n=10) using a Fourier-transform infrared spectroscopy (FTIR) unit (Tensor 27, Bruker, Ettlingen, Germany). To determine the number of carbon bonds remaining, a percentage was obtained between the aliphatic C=C (vinyl) (1638 cm^{-1}) and aromatic C=C absorption (1608 cm^{-1}) chains for both cured and uncured specimens. The spectra of cured and uncured specimens were obtained using 32 scans at 4 cm^{-1} resolution within 1000 to 6000 cm^{-1} range. The spectra were subtracted from the background spectra using the FTIR unit provided software (OMNIC 6.1, Nicolet 138 Instrument Corp, Madison, WI, USA). The DC was calculated with the following equation: DC (%) = [1- (cured aliphatic / aromatic ratio) / (uncured aliphatic / 144 aromatic ratio)] x 100.[6]

Knoop microhardness (KHN)

KHN specimens were included in polyester resin to allow for better handling during polishing and hardness tests. Then, the specimens were submitted to sequential wet polishing using sandpapers (#100, 600, 1200, 2000 and 3000 grit; 3M, Sumaré, SP, Brazil) in an automatized polisher for 1 min in each polisher. Sequentially, the specimens received final polishing using felt discs associated with 1 µm and 0.25 µm metallographic diamond pastes (Arotec, Cotia, SP, Brazil) for 1 min in each polisher. The specimens were then washed with deionized water.

After air-drying, the specimens were submitted to KHN tests (HMV-2; Shimadzu, Kyoto, Japan), which were performed on the top surface by applying a load of 100 g for 10 s. Fifteen indentations were performed in each specimen at five different areas with 3 indentations in the central area and 12 in the periphery with 3 in each extremity: superior, inferior, left and right, 1 mm away from the margin of the disc. The KHN corresponding to each indentation was determined by measuring the dimensions of the indentation using the following formula: *KHN = 14.2 (F=d/d2)*, where *F* is the test load in Kg, and *d* is the longer diagonal length of an indentation in mm. Then, the KHN value was determined by obtaining the arithmetic mean of indentations made in the center and peripheries.[5]

Statistical analysis

The data collected for DC and KHN were assessed for homoscedasticity and submitted to 3-way ANOVA. Multiple comparisons were made using the Tukey test within the experimental groups. One-way ANOVA followed by Dunnett test was used for comparisons between control and experimental groups. All the tests were conducted at a $\alpha = 0.05$ significance level. The analyses were performed using a statistical software (SigmaPlot 12.0, Systat Software, San Jose, CA, USA).

Results

Degree of conversion (DC)

The DC results are shown in Tables 4 and 5. *Tetric Bulk Fill* exhibited increased DC compared to conventional resin composite for both diameters and

LCUs evaluated. For *Filtek One*, significant differences from the control group were only observed for 10-mm specimens light-cured with *Radii Xpert*, which presented increased DC. *Aura Bulk Fill* exhibited increased DC compared with the control group in almost conditions. However, no significant differences were verified for 10-mm specimens light-cured with *Valo*. None of the bulk-fill RBCs exhibited significantly reduced DC results compared to the control group. In most situations, bulk-fill RBCs exhibited superior or statistically similar DC results (Table 4).

LCUs and specimen diameter significantly affected DC results compared with bulk-fill RBCs (Table 5). The *Tetric Bulk Fill* showed increased DC results (54.8 and 53.5% for 7 mm and 10 mm, respectively) when light cured with *Valo* compared to *Radii Xpert* (52.1 and 52.9%, respectively). When using *Valo*, *Tetric Bulk Fill* also presented superior DC results compared with the other bulk-fill RBCs evaluated. The *Tetric Bulk Fill* and *Aura Bulk Fill* presented superior DC results compared with *Filtek One* when light curing with *Radii Xpert*. Significant differences were observed for DC results for the different specimen diameters in the *Filtek One* group.

Knoop Microhardness (KHN)

The KHN results are described in Tables 6 and 7. No significant differences were noted in KHN results for the conventional resin composite (*Amaris*) when comparing LCUs (p=0.213) or disc diameters (p=0.587), but the center of the specimen exhibited superior KHN (p≤0.001) compared with periphery. KHN results for *Aura Bulk Fill* were not influenced by LCUs (p=0.049), specimen diameter (p=0.468) or region of analysis (p=0.083). For *Filtek One*, similar KHN results were verified for the different LCUs (p=0.276), but 7-mm diameter specimens exhibited greater KHN than 10 mm (p=0.002), and the center region exhibited superior results compared to periphery (p=0.038). For *Tetric Bulk Fill*, light curing with *Valo* resulted in superior KHN compared to *Radii Xpert* (p≤0.001), and 7-mm specimens also presented increased KHN compared with 10-mm diameter specimens (p=0.015), but no significant differences were observed for the region of analysis.

None of the experimental groups showed significantly reduced KHN results compared to the control group (Amaris). The 7-mm *Aura Bulk Fill* specimens photoactivated with *Valo* were not statistically different compared with *Amaris* (control group). All other groups presented significantly superior KHN results compared with the control group (Table 6).

Discussion

The LCUs tested in the present study present different tip diameters and light spectra and have influenced the degree of conversion and Knoop hardness of the bulk-fill RBCs tested. Thus, the null hypothesis tested was rejected.

The use of bulk-fill RBCs have increased substantially in recent years, and adequate light curing is essential to achieve the best mechanical properties with these materials.[7] The polymerization process of light-cured composites is completely dependent on the technical characteristics of the LCU, such as irradiance, wave length range, diameter of the tip, and others.[14] Different LCUs can result in distinct physical properties for the same material given that the degree of conversion and hardness of RBCs may be affected as demonstrated by the results of this investigation and previous studies.[15,16] ENREF 21

Different mechanisms can be used to allow deeper polymerization and reduced stress for bulk-fill composites. Some manufacturers achieve deeper polymerization by using additional or different photoinitiators, such as diphenyl phosphine oxide (Lucerin – TPO) or bis-(4-methoxybenzoyl)diethyl-germane (Ivocerin).[17] The properties of bulk-fill resins may also be improved when increased light transmission through the composite is possible, which its commonly achieved by changing the filler content. The presence of pigments and refractive index mismatch between the organic matrix and fillers are the main factors causing reduction in light transmission.[18]

In the present study, no bulk-fill RBCs presented lower DC values than the conventional composite (control group). The LCU factor was only relevant for *Tetric N-Ceram Bulk Fill*, and this may be explained by the fact that this material has an additional initiator to CQ, Ivocerin, which is most reactive at 408 nm but remains sensitive to wavelengths between 400-430 nm.[19] This spectrum of light is present in *Multipeak* LCUs with wavelength peaks at 405 nm, 440 nm and 460 nm but not in the *Monowave* LCUs, which commonly present a wavelength peak approximately 460 nm.[20] For the other bulk-fill RBCs in which the manufacturer does not mention the initiator used or only CQ is present, the light spectrum emitted from the *Monowave* LCU was sufficient to achieve similar DC to that obtained with the *Multipeak* LCU. The manufacturers of the bulk-fill RBCs used in this study do not completely indicate the specific initiators and the number of initiators used in these materials.

The hardness of dental materials is an important aspect for the selection of different restorative approaches on posterior teeth.[5] In the present study, no bulk-fill RBCs presented lower KHN values than the convectional composite tested. Only *Aura Bulk Fill* 7-mm specimens light-cured by *Valo* exhibited similar KHN results to the control group, and the other experimental groups exhibited superior KHN in all conditions evaluated. *Filtek One* exhibited higher KHN results compared with the other RBCs, and a possible explanation may be the different monomers and filler composition present in this material (Table 1). Regarding the degree of conversion, LCU was the only relevant factor for the *Tetric N-Ceram Bulk Fill* groups.

There is a high demand for Class II restorations, which have an annual failure rate of 1.68% over 12 years.[21] Conventional and bulk-fill RBCs are suitable materials for these restorations.[14,15] Clinically, several LCUs present smaller tips compared with the restorative area that needs to be reached by light (10). Mesio-occluso-distal (MOD) cavities, such as those noted in first maxillary molars with a 10.31-mm mean mesio-distal distance (MD-D); second maxillary molars (9.79 mm MD-D), and first (6.98 mm MD-D) or second maxillary premolars (6.74 mm MD-D) may present superior dimensions compared with the LCU tip.[11] Thus, the specimens in this study exhibited two different diameters: 7 mm (equivalent to maxillary premolars MD-D) and 10 mm (equivalent to maxillary molars MD-D).

The conventional composite *Amaris* and the *Filtek One* bulk-fill exhibited variations in KHN, which were verified at the central and peripheric regions of the specimens. KHN measurements were performed at the top of the specimens given that the main objective was to verify the influence of the LCU tip diameter and not the polymerization depth. The central region of the *Amaris* and *Filtek One* specimens exhibited increased KHN values compared with the periphery. These results are consistent with previous studies that reported similar findings.[7,22] The *Tetric N-Ceram* and *Aura* bulk-fill RBCs presented similar hardness values at the center and periphery. This fact can be justified by the composition of the organic matrix in these composites that allows greater dispersion of light or the presence of additional initiators that may consequently lead to favorable physical properties in the periphery.[23]

The *Valo* LCU has 4 LEDs positioned in the different quarters of the tip diameter, which results in a nonuniform wavelength light beam emission because 3 LEDs emits blue light (2 with peak emission at 460 nm and 1 with at 440 nm) and 1 LED emits violet light (peak emission at 405 nm) (20). Despite this fact, no differences in KHN were assessed in the center or periphery of the specimens for the bulk-fill resin composite with the additional initiator (Ivocerin). This finding indicates that the rotation angle of the light tip from multipeak LCUs may not affect the properties of RBCs with different photoinitiators from CQ.

LCUs with small-diameter tips should not be an issue if an incremental filling technique is used.[7] However, reduced light tips may become a problem when a bulk technique is used for extensive MOD restorations. Additional light exposure in the peripheric regions of MOD and larger cavities in posterior teeth is subsequently recommended.[22] Thus, clinicians can assure that all bulk fill-resins receive proper light irradiance, even when using LCUs with small tips. To minimize this problem, additional light exposure in the mesial and distal regions is suggested. LCUs with wide tips and longer exposure times are preferred when light-curing MOD or other large restorations.[22]

Despite the limitations of mechanical laboratory tests, they can provide better understanding of fragile materials that are more likely to fail early as RBCs.[24] The light beam profile provides information on the irradiance distribution from LCUs,[8] and the light emitted from LCUs influences the polymerization of light-cured RBCs and consequently its properties.[6] Several LCUs present very irregular beam profiles with very high irradiance values at the center of the tip and low values or even no irradiance at the periphery. Thus, the effective light-curing area can be even smaller than the tip of the device.[8,22] Despite this, the mold and the diameter used for preparing the specimens can influence the degree of conversion of the composites. As one of the factors analyzed in this study was the restoration dimension (specimen diameter), it was not possible to standardize the diameter between specimens.[25]

The distance from the tip of the LCU to the restoration can also influence the irradiance reaching the material and consequently its physical properties.[26] In this study, tests were performed with the LCU in close contact to the RBCs. This condition represent the ideal condition, but there are clinical situations in which it is not possible to place the LCU tip in close contact to the restoration, such as in deep cavities larger than 5 mm and proximal regions with adjacent teeth.[27] In addition LCUs are generally poorly maintained in dental offices and can deliver inadequate light output.[6] This is a limitation of the present study, as light was always delivered from a favorable position and the LCUs were maintained in ideal conditions.

Therefore, clinicians should be aware that the properties of the restoration are material dependent, and bulk-fill RBCs available on the market may present very distinct physical properties. In addition, is also important to distinguish the initiators present in the resin composites that are used in routine practice and the emission spectrum of the LCU given that these aspects are important to achieve adequate mechanical properties for RBCs. Unfortunately, some manufacturers do not provide this information. Studies are necessary to further investigate the relationship between the tip diameter of LCUs and the properties of RBCs.

Conclusion

Within the limitations of the present study, it was possible to observe that the light spectrum of the multipeak LCU significantly increased the DC and KHN of a bulk-fill resin composite with additional initiator to CQ, compared to the monowave LCU. LCU tip size influenced the performance of some RBCs tested. The influence of LCU on the properties of RBCs is material dependent.

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Tables

Table 1 – Specifications of the tested RBCs.

Resin composite	Manufacturer	Color	Type	Organic Matrix	Filler	Amount of load (wt%/vol %)	Batch #
Amaris	Voco, Cuxhaven, Germany	TN	Conventional Nanohybrid	Bis-GMA, UDMA, TEGDMA	Inorganics fillers in a methacrylate matrix	80/-	1829623
Filtek One Bulk Fill	3M ESPE, St. Paul, MN, USA	A2	Bulk fill	AFM, AUDMA, UDMA and 1,2-dodecano-DMA (DDMA)	Ytterbium trifluoride, non-aggregated silica, non-aggregated zirconia, zirconia/silica clusters	76,5/58	N974887
Aura Bulk Fill	SDI, Bayswater, Victoria, Australia	BKF	Bulk fill	Bis-GMA, UDMA, Bis-EMA, TEGDMA	Silica, signaled barium and glass particles	74,2/65	180143
Tetric N-Ceram Bulk Fill	Ivoclar Vivadent, Schaan, Liechtenstein	IVA	Bulk fill	Bis-GMA, BisEMA and UDMA	Barium aluminum silicate glass, an “Isofiller”, ytterbium fluoride and spherical mixed oxide	75-77/55	94624

Table 2 – Specifications of the light-curing (LCU) units tested.

LCU	Manufacturer	Irradiance	Wavelength emission	Tip diameter (mm) [18]
Radii Xpert	SDI, Bayswater, Victoria, Australia	1200 mW/cm² (Standard)	Monowave	7.8
Valo	Ultradent, Salt Lake City, Utah, USA	1000 mW/cm² (Standard)	Multipeak	9.5

Table 3 - Mean degree of conversion values (DC%) and standard deviation (±) for control and experimental groups according to LCU and specimen diameter.

Group	Diameter	LCU	DC%	P-value	LCU	DC%	P-value
Amaris (CG)	*7 mm*	***Valo***	47.2±3.6	-	***Radii Xpert***	45.9±3.4	-
	10 mm		48.6±3.6	-		44.9±3.0	-
Aura Bulk Fill	*7 mm*		51.2±1.9*	=0.004		51.7±3.0*	<0.001
	10 mm		50.4±2.3	=0.344		52.9±2.9*	<0.001
Filtek One	*7 mm*		49.7±2.7	=0.099		47.0±2.0	=0.753
	10 mm		49.6±2.8	=0.741		52.4±2.2*	<0.001
Tetric Bulk Fill	*7 mm*		54.8±1.7*	<0.001		52.1±3.1*	<0.001
	10 mm		53.5±1.5*	<0.001		52.9±2.4*	<0.001

* Indicates significant difference from control group (CG); ANOVA one-way and Dunnett test ($p > 0.05$).

Table 4 - Mean degree of conversion (DC%) and standard deviation (±) for bulk-fill RBCs according to LCU and specimen diameter.

Group	**Valo**		**Radii Xpert**	
	7 mm	***10 mm***	***7 mm***	***10 mm***
Aura Bulk Fill	51.2±1.9	50.4±2.3	51.7±3.0	52.9±2.9
	Ab€	Ab€	Aa€	Aa€
Filtek One	49.7±2.7	49.6±2.8	47.0±2.0	52.4±2.2
	Ab£	Ab€	Ab£	Ab€
Tetric Bulk Fill	54.8±1.7	53.5±1.5	52.1±3.1	52.9±2.4
	Aa€	Aa€	Ba€	Ba€

* Capital letters indicate significant differences among LCUs (rows: vertical direction). Lowercase letters indicate significant differences among bulk-fill RBCs (columns: horizontal direction), and symbols indicate significant differences between diameters for the same LCU (rows: vertical direction). Tukey test ($p<0.05$).

Table 5 – Mean Knoop hardness (KHN) values and standard deviation (±) for control and experimental groups according to LCU, specimen diameter and region of analysis.

Group	Diameter	Region	LCU	KHN	P-value	LCU	KHN	P-value
Amaris (CG)	*7 mm*	*Center*	**Valo**	53.0±4.4	-	**Radii Xpert**	51.3±1.0	-
		Periphery		51.8±3.7	-		48.8±0.8	-
	10 mm	*Center*		53.2±1.8	-		54.3±1.7	-
		Periphery		57.6±1.6	-		49.4±1.4	-
Aura Bulk Fill	*7 mm*	*Center*		57.6±2.5*	=0.032		58.8±2.3*	<0.001
		Periphery		55.3±2.2	=0.067		57.0±1.9*	<0.001
	10 mm	*Center*		58.3±2.1*	<0.001		57.5±1.7*	<0.001
		Periphery		57.6±1.6*	<0.001		57.4±3.0*	<0.001
Filtek One	*7 mm*	*Center*		70.5±0.8*	<0.001		69.9±1.7*	<0.001
		Periphery		69.4±1.1*	<0.001		69.7±0.8*	<0.001
	10 mm	*Center*		68.9±2.1*	<0.001		69.0±1.1*	<0.001
		Periphery		68.5±2.0*	<0.001		66.8±1.0*	<0.001
Tetric Bulk Fill	*7 mm*	*Center*		62.1±0.9*	<0.001		59.7±1.7*	<0.001
		Periphery		61.7±0.7*	<0.001		58.6±1.2*	<0.001
	10 mm	*Center*		60.6±1.0*	<0.001		58.1±2.6*	<0.001
		Periphery		60.0±0.8*	<0.001		57.4±1.9*	<0.001

* Indicates significant difference from control group (CG). ANOVA One-way and Dunnett test ($p > 0.05$).

Table 6 – Mean Knoop Hardness (KHN) and standard deviation (±) for bulk-fill RBCs according to LCU, specimen diameter and region of analysis.

Group	**Diameter**	**Valo**		**Radii Xpert**	
		Center	***Periphery***	***Center***	***Periphery***
Amaris	*7 mm*	53.0±4.4 Aa£	51.8±3.7 Ba£	51.3±1.0 Aa£	48.8±0.8 Ba£
	10 mm	53.2±1.8 Aa£	49.6±1.5 Ba£	54.3±1.7 Aa£	49.4±1.4 Ba£
Aura Bulk	*7 mm*	57.6±2.5 Aa£	55.3±2.2 Aa£	58.8±2.3 Aa£	57.0±1.9 Aa£
	10 mm	58.3±2.1 Aa£	57.6±1.6 Aa£	57.5±1.7 Aa£	57.4±3.0 Aa£
Filtek One	*7 mm*	70.5±0.8 Aa£	69.4±1.1 Ba£	69.9±1.7 Aa£	69.7±0.8 Aa£
	10 mm	68.9±2.1 Ab£	68.5±2.0 Bb£	69.0±1.1 Ab£	66.8±1.0 Ab£
Tetric Bulk	*7 mm*	62.1±0.9 Aa£	61.7±0.7 Aa£	59.7±1.7 Aa€	58.6±1.2 Aa€
	10 mm	60.6±1.0 Ab£	60.0±0.8 Ab£	58.1±2.6 Ab€	57.4±1.9 Ab€

* Capital letters indicate significant differences between center and periphery regions (rows: vertical direction). Lowercase letters indicate significant differences between disc diameters (columns: horizontal direction), and symbols indicate significant differences between LCUs for the same region (rows: vertical direction). Tukey test ($p<0.05$).

Capítulo 2

TITLE: Influence of light curing units and polishing protocols on the surface roughness, gloss, and

sorption and solubility of a composite resin.

RUNNING TITLE: Different finishing and polishing and light curing units on the properties of a composite resin.

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TITLE: Influence of light curing units and polishing protocols on the surface roughness, gloss, and sorption and solubility of a composite resin.

RUNNING TITLE: Different finishing and polishing and light curing units on the properties of a composite resin.

Abstract

The aim of this study was to evaluate different polishing protocols and light cure units (LCU) on the surface roughness, gloss, and sorption and solubility of a composite resin. The surface roughness and gloss of specimens (n=8) from a nanohybrid composite resin (E1, VOCO) lightcured with different light-emitting diode (LED) devices: Valo (Ultradent), Valo Grand (Ultradent), Bluephase 20i (Ivoclar Vivadent), Elipar DeepCure-L (3M-ESPE), Emitter D (Schuster) and Radii Xpert (SDI) were read; and after polishing the specimens with three different systems: Sof-Lex Diamond Polishing System (3M-ESPE), Jiffy Original Composite System (Ultradent) and Opti1Step (Kerr), surface roughness and gloss were verified again. No significant differences were detected on the surface roughness (P=0.935) or gloss (P=0.012) for the different LEDs units. Comparing the polishing systems, Sof-Lex and Opti1Step specimens presented similar surface roughness, which was significantly superior to Jiffy. For the surface gloss, Sof-Lex and Opti1Step presented superior results to Jiffy. On sorption (P=0.474) and solubility (P=0.531), no significant differences were seen among the specimens from the different LEDs and polishing protocols. The LCUs have shown null influence on the surface roughness and gloss of the composite resin tested; while these parameters were affected by the polishing protocols evaluated.

Clinical relevance: Composite resin restorations are routinely placed in dental practice. The influence of the light cure unit and the finishing and polishing protocols on the surface of composite resins is still not well established.

Key word: Composite resin, finishing and polishing, Light Emitted Diode, Light Cure Unit

Introduction

Over the years, several studies were performed to evaluate the longevity of resin based composite (RBCs) restorations over time.[1-3] The survival rates varies between 93% (91% - 95%) in four years to 86% (82% - 89%) in twelve years.[4] The most common reasons noticed for failures are caries,[5] bruxing patients,[6] fractured or lost restoration, fractured tooth, and endodontic complications.[4]

Some of the major failure risks can be prevented during the restorative procedure.[5] Low strength and susceptibility to degradation can be caused by an insufficient radiant exposure taking to short composite longevity.[7] A properly curing technique must be applied to light activated composites, paying special attention to the light exposure time [7] and distance between the light tip of the curing unit and the restorative material, trying to set it to 0 mm.[5] The total irradiance that reaches the material depends on the light distance of the tip and exposure time to restoration.[8] Thus, if the light irradiance is increased, the degree of cure of RBCs will also enhance and the physical and mechanical properties of the material will be improved.[9]

As essential as satisfactory light curing, an adequate finishing and polishing of RBCs is required to reach out good results and prevent future problems such as secondary caries and surface or marginal discoloration.[10] While finishing is perfomed to achieve desired anatomy and a gross contouring of RBCs, polishing reduces roughness and removes scores created during finishing.[11] To perform this step a diversity of instruments such as tungsten carbide and fine-grained diamond burs, stones, rubber burs, and abrasive latex are commonly used in finishing procedures.[12] Abrasive diamond-impregnated rubber cups and points, aluminum oxide-coated abrasive disks, abrasive strips, and polishing pastes are then used for the final polishing process.[13]

The polishing step of RBCs can influence some of the physical properties, such as surface gloss and roughness. Gloss by definition is an optical phenomenon related to the light reflection on the material's surface when light rays hit the surface in the same angle.[14, 15] Surface roughness is a measurement of surface texture. It is defined as a vertical deviation of a real surface from its ideally smooth form.[16] Therefore, the relationship between the photoactivation delivered by the LCU and the finishing and polishing procedures is uncertain.

It is known that no better LCU or finishing and polishing protocol have been defined yet. Thus, the aim of this study was to evaluate if different LCU and polishing protocols can affect the surface roughness, gloss and sorption and solubility of a nanohybrid composite resin. The null hypotheses were that the surface roughness, gloss and sorption and solubility of the nanohybrid composite resin tested would not be influenced by: 1) the different LCUs and; 2) the distinct polishing protocols.

Materials and methods

Specimen preparation

A nanohybrid resin-based composite was selected for the tests (Amaris, E1, VOCO Cuxhaven, Hamburg, Germany). The specimens (n=8) were made using a circular metallic mold with 2.0 mm deep and 4.0 mm diameter in a room with yellow light. A glass plate placed below the mold and then, the RBC material was inserted into the matrix with a resin spatula. After, a Mylar strip was placed on the top of the matrix over the RBC, which was used to properly condensate the material into the mold and to avoid direct contact between the resin and the light source, once the unit tip was directly positioned on the surface of the strip. All the light curing units were statically hold by operator with both hands, centering the tip on the top of the specimen and performing 20 s activation cycle. The six different light curing units used are detailed on Table 1.

Table 1 – Information provided by manufacturers about the light curing units (LCU).

LCU	Manufacturer	Irradiance (mW/cm^2)	External tip diameter (mm)	Emission spectrum (nm)
Valo	Ultradent, Salt Lake City, Utah, EUA	1000	10	395–480
Valo Grand	Ultradent, Salt Lake City, Utah, EUA	1000	12	395–480
Bluephase 20i	Ivoclar, Schaan, Liechtenstein	1200	10	385–515
Elipar DeepCure-L	3M ESPE, St Paul, MN, USA	1470	10	430–480
Emitter D	Schuster, Hyannis, MA, USA	1250	8.2	420-480
Radii Xpert	SDI Bayswater, Vistoria, Australia	1500 (+ 5 %, - 15 %)	8	440-480

After light-curing, the specimens were detached from molds, and excess material was removed. The finishing was performed with an electric motor and handpiece (Synea-1:1/EM-12L, W&H Dentalwerk, Burmoos, Austria) at 10.000 RPM, using aluminum-oxide discs (OptiDisc, Kerr, Orange, CA, USA), in different grit levels (coarse and fine) for 1 minute on each surface. Thereafter, three different polishing protocols were performed according to the groups: SL- Sof-Lex Diamond Polishing System (Beige: pre-polishing + Pink: polishing; 3M ESPE, St Paul, MN, USA); JI- Jiffy Original Composite System (Yellow: medium + White (fine); Ultradent, Salt Lake City, UT, USA); and O1- Opti1Step (Kerr, Orange, CA, USA). A custom-made device with a holding arm for the handpiece was used to standardize the pressure during the polishing steps. Each polishing step was performed for 60 s according to each system, always associated to water irrigation.

Surface Roughness Measurement

The surface roughness (Ra) values were obtained using a surface roughness tester (SJ-310, Mitutoyo, Kawasaki, Japan) at the top surfaces of the specimens in three distinct locations. Roughness values (Ra) were measured for each specimen operating with a 2 µm diamond stylus and roughness measurements were recorded as it moved at a constant speed of 0.5 mm / s with a 0.7 mN force.

Surface Gloss Analysis

The evaluation of surface gloss was performed with a gloss meter (CS300, CHN Spec, Hangzhou City, China). After calibrating the equipment according to manufacturer's instructions, all specimens were submitted to light incidence at a 60-degree angle.

The gloss measurements are known as gloss units (GU), and determines that a surface that does not reflect brightness has zero GU and a glass surface with a refractive index of 1567 has 100 GU.[17]

Sorption and solubility

The sorption and solubility test were performed, first storing the specimens (n= 8) in a desiccator with silica gel at 37°C for 24 h. After that, the specimens were weighted on an analytical balance with 0.01 mg accuracy (AG200, Gehaka, SP, Brazil) in intervals of 24 h until reaching constant weight, named *m1*. The next step was to place the specimens into individual plastic vials with artificial saliva fully covering it, followed by storage at 37ºC. The specimens were weighted at intervals of 24, 48 and 72 h, allowing to progressively scan the water sorption until stabilization. Then, the specimens were gently dried, taking out the excess of liquid, and weighted one more time to obtain *m2.* Next, the specimens were stored again in desiccator with silica gel at 37°C to eliminate the absorbed liquid of the artificial saliva. After that, specimens were weighted until their mass was constant, achieving *m3.*

The thickness and diameters of the specimens were measured at four different points using a digital caliper (CD6 CS, Mitutoyo) after *m1* was determined to obtain the volume (V). The sorption (Sor) and solubility (Sol) rates were then calculated, based on the following formula: Sor = (m2 – m3)/V and Sol = (m1 – m3)/V, in which:

m1 = is the mass of the specimen (lg) before storage in saliva.

m2 = is the mass of the specimen (lg) after storage in saliva.

m3 = is the mass of the specimens (lg) after desiccation until reach constant mass.

V = is the volume of the specimen (mm^3).[18]

Statistical Analysis

Surface roughness, gloss, and sorption and solubility data were analyzed by two-way ANOVA with Tukey's post-hoc test for multiple comparisons. A statistical software package (SigmaPlot 12.0, Systat Software, San, Jose, CA, USA) was used to perform the tests, with significance level set at 95%.

Results

The results for surface roughness, gloss and water sorption and solubility are presented in Tables 2, 3, 4 and 5, respectively. No significant differences were observed for surface roughness (p=0.012), gloss (p=0.935) and water sorption (p=0.474) and solubility (p=0.531), when comparing the different LCUs tested.

The distinct polishing protocols (p≤0.001) showed significant differences for the surface roughness. The SL and O1 groups presented similar roughness results (0.160 and 0.164 Ra, respectively), which were significantly lower than those presented by JI group (0.224 Ra) (Table 2).

Significant differences were also observed in the gloss test results when comparing the polishing protocols ($p \leq 0.001$). Groups SL and O1 presented similar gloss results (34.34 and 31.47 GU, respectively), which were significantly superior compared to those presented by JI (20.93 GU) (Table 3).

The sorption and solubility was not affected by the different LCUs or by the distinct polishing protocols, as it can be seen on table 4 and 5.

Table 2- Mean surface roughness (Ra) and standard deviation (±) of a nanohybrid composite resin according to different LCUs and distinct polishing protocols (n = 8)

	Valo	**Grand Valo**	**Elipar DeepCure-L**	**Radii Xpert**	**Bluephase 20i**	**Emitter D**	*Mean*
O1	0.19 ± 0.06	0.12 ± 0.04	0.12 ± 0.04	0.14 ± 0.04	0.18 ± 0.06	0.20 ± 0.05	0.16 ± 0.05 **A**
JI	0.22 ± 0.07	0.21 ± 0.08	0.22 ± 0.04	0.25 ± 0.06	0.20 ± 0.03	0.25 ± 0.06	0.22 ± 0.06 **B**
SL	0.14 ± 0.03	0.17 ± 0.03	0.19 ± 0.03	0.22 ± 0.03	0.12 ± 0.03	0.16 ± 0.05	0.16 ± 0.04 **A**

Table 3- Mean surface gloss (GU) and standard deviation (±) of a nanohybrid composite resin according to different LCUs and distinct polishing protocols (n = 8)

	Valo	**Grand Valo**	**Elipar DeepCure-L**	**Radii Xpert**	**Bluephase**	**Emitter D**	*Mean*
O1	31.58 ± 8.23	37.21 ± 8.3	30.82 ±8.85	36.62 ± 9.48	36.10 ± 6.43	33.75 ± 9.51	34.34 ± 8.46 **A**
JI	22.1 ±3.1	20.3 ± 5.6	21.0 ± 6.2	19.8 ± 5.4	19.5 ± 4.2	22.9 ± 8	20.93± 5.4 **B**
SL	31.76 ±10.71	29.97 ± 5.35	31.6 ± 10.29	31.01 ± 7.74	30.61 ± 9.90	33.90 ± 5.62	31.47± 8.26 **A**

Table 4- Mean water sorption (µg) and standard deviation (±) of a nanohybrid composite resin according to different LCUs and distinct polishing protocols (n = 8)

	Valo	**Grand Valo**	**Elipar DeepCure-L**	**Radii Xpert**	**Bluephase**	**Emitter D**
O1	42.2 ± 18.6 Aa	38.0 ± 8.8 Aa	42.1 ± 15.1 Aa	34.3 ± 15.2 Aa	43.6 ± 24.8 Aa	55.7 ± 14.4 Aa
JI	49.7 ± 10.5 Aa	42.1 ± 17.3 Aa	31.0 ± 15.3 Aa	41.8 ± 8.32 Aa	58.1 ± 15.1 Aa	45.0 ± 12.4 Aa
SL	49.9 ± 10.8 Aa	42.6 ± 17.3 Aa	41.1 ± 27.6 Aa	44.3 ± 13.7 Aa	47.7 ± 19.7 Aa	47.3 ± 19.1 Aa

Table 5- Mean water solubility (µg) and standard deviation (±) of a nanohybrid composite resin according to different LCUs and distinct polishing protocols (n = 8)

	Valo	**Grand Valo**	**Elipar DeepCure-L**	**Radii Xpert**	**Bluephase**	**Emitter D**
O1	3.69 ± 1.24 Aa	4.10 ± 1.41 Aa	4.03 ± 2.45 Aa	4.03 ± 1.62 Aa	3.96 ± 1.60 Aa	3.84 ± 1.24 Aa
JI	3.98 ± 1.72 Aa	4.37 ± 1.34 Aa	3.98 ± 1.13 Aa	4.20 ± 1.80 Aa	3.81 ± 1.03 Aa	3.98 ± 1.02 Aa
SL	2.80 ± 0.94 Aa	4.52 ± 1.11 Aa	3.73 ± 1.83 Aa	3.61 ± 1.58 Aa	4.40 ± 1.08 Aa	4.06 ± 1.31 Aa

Discussion

The null hypotheses that different LCUs and distinct polishing systems would not influence the surface roughness, gloss and water sorption and solubility of a nanohybrid resin composite was rejected. Despite the LCUs have not affected none of the tested parameters; the polishing protocols used influenced the surface roughness and gloss, but not the water sorption or solubility of the nanohybrid resin composite tested.

Finishing and polishing procedures are directly related to the longevity and maintenance of aesthetics in resin composite restorations.[18-20] These steps can produce improved mechanical and physical properties on the surface of resin composite restorations, such as minimizing wear, reducing roughness and increasing gloss.[21-23] Although it is observed that surface roughness and gloss can be negatively correlated during the finishing and polishing, presenting a non-proportional relationship in most of the cases.[24]

Different LCUs can activate the polymerization of a given resin composite in distinct depths and generate different degree of conversion (DC) results.[25] The DC is directly related to the physical and chemical properties of resin composites.[26] In the present study the surface roughness and gloss of the resin composite tested was not significantly influenced by the different LCUs.

Some studies showed the surface roughness of Amaris resin composite ranging between 0.16 Ra [27] to 0.23 Ra.[28] In the present study, the results were similar to previous investigations, but varied mostly according to the polishing protocol used. SL and O1 groups performed similarly on all tests; however, both presented significantly better results comparing to JI group. The SL and O1 groups presented surface roughness results close to that described on the literature, [26,27] raging between 0.123 and 0.216 Ra. By its turn, JI group showed superior surface roughness than other groups, ranging between 0.197 and 0.248 Ra. This finding can be possibly explained by the type and distribution of abrasive particles present in the different polishing systems, since the polishers from JI group are impregnated with aluminum oxide as O1 and SL pre-polishing, probably the distribution resulted in higher surface roughness values for the resin composite tested.

Differences were also observed between the polishing procedures on the gloss test results. The results found for the nanohybrid resin composite tested ranged between 19.5 and 37.21 GU according to the polishers. The SL group presented higher gloss results and this occurred probably due to the wheels of this polishing system that has 2 parallel rows of 15 individually radiating elastomeric bristles, uniformly impregnated with abrasives that can nearly polish every surface of a restoration.[29] Also, studies showed that flexible aluminum oxide discs can create a smooth and glossy surface.[19, 30, 31] The polisher from O1 group applied to the resin composite produced a glossy surface similar to that obtained with SL polishers; JI polishers resulted in lower gloss comparing to the other groups. This result may be explained by the shape, hardness, disposition and type of particles and matrix used in the polishers.[19]

Polishing can improve surface gloss and decrease roughness constantly during the procedure.[24] However, this is not always a direct relationship, also depending on the properties of the resin composite, such as filler particles type/size and matrix composition.[32] So, great variation may exist on the results of different polishing procedures, which can bring up different surface roughness, gloss and other properties according to the resin composite and polishers used. By this way, a given polisher could deliver different results depending on the resin composite composition.

As described on literature, light curing is an vital step and have highly impact on the water sorption and solubility properties of light-cure resin composites.[33] It is important to highlight that specimen dimensions, a correct light curing technique delivering appropriated energy dose may influence on the results of the water sorption and solubility tests.[34] This fact probably explains why no statistical differences were seen on the results obtained on these tests by the present study.

This study present intrinsic limitations. It was carried out on controlled laboratory situations that cannot be fully transported to clinical situations. An example is the capability to access all restored faces with the light curing tip or to equally polish all regions with polishers and handpieces of different sizes. The limitation about light curing that was performed with close contact to the resin composite disc without any movement and distancing of the LED tip may not be realistic for all clinical situations. This is not something that is always possible to do on patients due to mouth opening limitation, cavity depth or the LED tip shape/size.

Conclusion

The LCUs have not affected the surface roughness, gloss, and water sorption and solubility of the resin composite evaluated. The different poshing systems resulted in distinct surface characteristics, with Opti1Step and Sof-Lex polishers showing lower surface roughness and higher gloss for the nanohybrid composite tested.

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Capítulo 3

Title: Effect of initiators/concentrations and different light-curing units on the mechanical properties of experimental composite resins.

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Title: Effect of initiators/concentrations and different light-curing units on the mechanical properties of experimental composite resins.

Abstract: The purpose of this study was to investigate the influence of the composition of experimental nanohybrid composite resins produced with distinct photoinitiators/concentrations and the light spectrum of different LED units on the degree of conversion, hardness and diametral tensile strength of the resulting restoratives. The experimental composite resins were designed into 9 groups: CR1 (100% CQ), CR2 (100% TPO), CR3 (100% BAPO), CR4 (50%CQ/50%TPO), CR5(50%CQ/BAPO), CR6 (50%BAPO/50%TPO), CR7 (70%CQ/30%TPO), CR8 (70%CQ/30%BAPO), CR9 (70%BAPO/30%TPO); resin composite discs (2x4mm) were photoactivated by 2 light curing units (LCUs), monowave (Elipar, 3M ESPE) and multipeak (Valo, Ultradent). The degree conversion (DC) and Knoop Hardness (KHN) were tested in the top and bottom surfaces of the discs, and then, the diametral tensile strength (DTS) of the specimens were tested (n=10). Data were checked for homoscedasticity and submitted to 2-way ANOVA for DTS, and 3-way ANOVA for DC and KHN ($\alpha<0.05$). Higher DC values were observed for the CR3 group (100% BAPO). For the multipeak LCU, groups CR3 (100% BAPO), CR5 (50% CQ/50% BAPO) and CR6 (50% BAPO/50% TPO) presented the highest KHN values in the top surface. The highest DTS values were found for CR6 group (50%BAPO/ 50%TPO). The light spectrum of LCU and type/concentration of photoinitiator influenced the properties of the experimental resin composites tested. Improved mechanical properties were observed for the composite resins with at least 50% of BAPO photoinitiator.

Introduction

Dental composite resins are an excellent choice as restorative material and have been commonly used due to its good attributes, such as relative color stability, adhesive capability, adequate mechanical properties and relative good adaptation to dental structures, in addition to the versatility of handling and low cost.(1, 2) Furthermore, composite resins are suitable for use in both, anterior and posterior restorations, proving its versatility.(3) Regardless all the positive aspects involving composite resins, the material present some intrinsic limitations, which can impact the longevity of resin-based restorations, mainly when direct use is performed in the clinical practice. (1,2)

Despite being highly discussed in recent years, light-cure composite resins were initially developed in the 1970s, as filler-reinforced epoxy resins exhibited negative properties such as low polymerization speed and easy color variation.(4) Over the years, research, developing and changes in the composition of light-curing composite resins have provided a broad indication of this material in the clinical dental practice.(4) Composite resins are composed of an organic phase (matrix) consisting of dimethacrylates, and the most common are diglycidyl bisphenol dimethacrylate A (Bis-GMA), the ethoxylated version of dimethacrylate (BisEMA), triethylene glycol dimethacrylate (TEGDMA) and urethane dimethacrylate (UDMA) (5); and inorganic phase (filler particles), which is commonly composed by materials such as quartz, colloidal silica, glass containing barium, strontium and zirconia; a binding agent, which in the case of composite resins is silane (6) and also initiator agent(s) presents in organic matrix, which are responsible for starting de polymerization process(7).

It is important that a balance exists between the components of the resin, so that it has strength, favorable aesthetics and is possible to work with. The polymerization reaction of dimethacrylates occurs through the activation of photoinitiators contained in the composite resin, which are responsible for the formation of free radicals that will initiate this process,(8) called addition (chain-growth) polymerization, in which monomers will react to form a polymer without generating by-products.(8) One of the photoinitiators most used to date in light-cure composite resins is the camphorquinone, which has its absorption peak at 400-500nm, when exposed to visible light, and through the production of free radicals, initiates the polymerization process.(9) However, camphorquinone has some limitations, such as its yellowish color, which can mainly influence esthetic restorations, and also the presence of the alpha-diketone group, which has an absorption peak in the range of ambient light (fluorescent lamps and overhead lights), reducing its working time.(10) In view of these factors, alternative photoinitiators have been proposed to overcome the CQ limitations, showing higher degree of conversion when compared to the previous system. One of the most used alternative photoinitiators is Lucirin TPO, which has a less yellowish color, being useful for composite resins for teeth with great translucency or bleached elements.(11) Its absorption spectrum ranges between 380nm and 425nm, which is beyond the wavelength of the blue LED equipment.(12, 13) The phenylbis (2,4,6-trimethylbenzoyl)-phosphine oxide (BAPO) is a photoinitiator presenting absorption in the visible spectrum between 365 and 416nm and has shown advantages such as white coloration that could help in the light penetration and at the same time increase the polymerization depth through the composite resin, as it has high reactivity, and because, it is unnecessary to use an amine as a co-initiator in this system.(14)

The start of the reaction from the initiator molecules present in composite resins, occurs by the light activation provided by light curing units (LCUs). Currently, the most common LCUs are based on light emitting diodes (LEDs) with different spectrums, classified as second or third generation, or even in monowave or multipeak.(15) Monowave LEDs are devices that present a spectrum between 450 and 490nm, being duly effective in activating the camphorquinone, which has its absorption peak at 468nm.(15) Multipeak (broadwave, polywave) light sources have, in addition to blue light, violet, in order to reach other lower spectra, from 420nm onwards, to reach the peak absorption of alternative photoinitiators that are now currently used.(16) After the polymerization process, the final outcomes of a composite resin restoration depend on some factors, including the degree of conversion, which is directly related to the mechanical properties of the resins. Lower degree of conversion can result in reduced mechanical properties such as wear resistance, hardness, and diametral tensile strength in addition to decreased color stability, also leading to increased water sorption/solubility and secondary caries formation.(17, 18)

Thus, both the composition of the composite resins and the equipment used to activate light polymerization can influence the resistance and aesthetic factors of the composite resin, consequently affecting longevity.

Considering the aforementioned aspects of photoinitiator systems and the use of different LCUs to composite resins, this study aimed to analyze the influence of the composition of experimental nanohybrid composite resins produced with distinct photoinitiators/concentrations and the light spectrum of different LED units on the degree of conversion, hardness and diametral tensile strength of the resulting restoratives. Therefore, the null hypothesis generated was that distinct photoinitiators/concentrations and different light spectra from LCUs would not influence the proprieties of nanohybrid experimental composite resins.

Materials and Methods

Composite Resin

The experimental composite resins used in the study were produced by a specialized company (XX) and have the same constitution regarding the organic matrix, filler particles and all other elements, except for the photoinitiators, which were modified according to the types and proportions. The resulting experimental composite resins were designed into 9 groups as detailed in Table 1. For the study, the composite resins were prepared by the company, sent blindly to the researchers, and were only revealed after the statistical analysis. All tests and statistical analysis were also performed blindly.

Table 1 - Experimental composite resins, photoinitiator type and proportions (%).

Experimental group	Photoinitiator/Proportion (%)
CR1	Camphorquinone (CQ) (100%)
CR2	TPO (100%)
CR3	BAPO (100%)
CR4	CQ (50%)/TPO (50%)
CR5	CQ (50%) /BAPO (50%)
CR6	BAPO (50%)/TPO (50%)
CR7	CQ (70%)/TPO (30%)
CR8	CQ (70%)/BAPO (30%)
CR9	BAPO (70%)/TPO (30%)

Specimen preparation

The composite resin specimens were obtained from silicone matrixes with internal dimensions of 2 mm in depth and 4 mm in diameter. The matrixes were placed over glass plates and sufficient composite resin was inserted in a single increment. Then, a Mylar strip was positioned over the matrix filled with the composite resin, and another glass plate was used to apply slight pressure to remove any bubbles, making the specimen uniform. Photoactivation of the specimens was performed for 20s according to the LCUs (Table 2). The Valo LCU was used in the standard mode, while Elipar LCU was used in the single operationmode available. Next, the specimens were removed from the silicone matrixes and stored in individual, properly identified, light-sheltered containers. The steps necessary for obtaining the specimens were performed in a temperature-controlled room (23ºC), under yellow light and the resulting discs were stored in 100% relative humidity at 37 ºC.

Table 2- Specifications of the LCU tested(19).

LCU	Manufacturer	Irradiance	Wavelength emission	Internal tip diameter (mm)
Valo	Ultradent, Salt Lake City, Utah, USA	933 mW/cm² (Standard)	Multipeak	9.0
Elipar	3M ESPE, St. Paul, Minesota, USA	1350 mW/cm²	Monwave	9.0

Degree of conversion

The degree of conversion (DC) of the resin specimens was obtained 24 h after completing the preparation (n=10). The DC evaluation was performed in the top and bottom central regions of the specimens, using a Fourier Transform Infrared Transmission Spectroscope (FTIR; Tensor 27, Bruker, Ettlingen, Germany). To determine the number of carbon bonds remaining, a percentage between the C = C (vinyl) (1638 cm-1) and C = C aromatic (1608 cm-1) absorption chains was obtained for polymerized and non-polymerized specimens of each experimental material. The spectra of polymerized and unpolymerized specimens were obtained using 32 scans with a resolution of 4 cm-1 within the range of 1000 to 6000 cm-1. Spectra were subtracted from background spectra using software provided by the FTIR unit (OMNIC 6.1, Nicolet 138 Instrument Corp, Madison, WI, USA). The GC was calculated with the following equation: DC (%) = [1- (cured aliphatic/aromatic ratio) / (uncured aliphatic/aromatic ratio 144)] x 100.

Knoop Hardness

Knoop hardness (KHN) measurements were also performed on both top and bottom surfaces of the specimens (n=10). Three subsequent indentations were performed in the central region of the two surfaces analyzed, using 500gF for 10 s with the microhardness tester (HMV-2; Shimadzu, Kyoto, Japan). The KHN value was determined by measuring the dimensions of each indentation performed using the following formula: KHN= 14.2 ($F= d/d^2$), where F represents the test load in kg and d represents the largest diagonal length of the indentation in mm. Then the arithmetic mean of the KHN values from the 3 indentations was calculated for obtaining the final KHN value per specimen.(20)

Diametral Tensile Strength

The disc specimens previously analyzed for the DC and KHN measurements were used for performing diametral tensile strength (DTS) tests (n=10), in a universal testing machine (DL 2000, EMIC, São José dos Pinhais, PR, Brazil). The specimens were positioned on the testing machine between a flat stainless steel tip and base; Thus, compressive loading was applied vertically on the lateral portion of the cylinder at 0.5 mm/min, producing tensile stresses perpendicular to the vertical plane through the center of the specimen, until failure. The fracture load (F) was recorded in Newtons (N), and the diametral tensile strength (rt) was calculated (MPa) as follows: $\sigma t = 2F/\pi dh$ where, d is the diameter (4 mm), h the height (2 mm) of specimens, and the constant p is 3.1416.(17)

Statistical Analysis

After data passed homoscedasticity test (Kolmogorov-Smirnov), 2-way analysis of variance (ANOVA) was used for the diametral tensile strength and 3-way ANOVA for the Knoop hardness and degree of conversion. To assess the differences between the means, the Scott-Knott test was used with 5%

significance level. The tests were performed using the SISVAR software (5.6, UFLA, Lavras, MG, Brazil).

Results

Degree of conversion

The pooled mean for the degree of conversion values (DC%) and standard deviation (±) verified in the top and bottom surfaces of the specimens are described in Table 3. The top surface showed significantly higher degree of conversion when compared to the bottom surface when taking all the experimental groups into account.

Table 3- Pooled means for degree of conversion (DC%) and standard deviation (±) considering all the experimental resin composites and light curing units (LCUs) in the different specimen surfaces.

Surface	Pooled Mean (DC%)
Top	55.91±15.24 A
Botton	47.54±17.76 B

* Distinct capital letters indicate significant difference between the specimen surfaces in columns; Scott-Knott test (α=0.05).

The mean degree of conversion values (DC%) and standard deviation (±) verified in the surfaces of the specimens for the experimental composite resins activated with the different LCUs, are presented in Table 4. When analyzing the experimental composites, irrespective of the surfaces and LCUs, higher DC values were observed for the CR3 group (100%BAPO); while lower DC values were presented by the CR6 (50% BAPO/50% TPO) and CR8 (70% CQ/30% BAPO) groups. The other experimental composites presented intermediate, similar DC results.

Considering the LCUs and top surfaces of the specimens, higher DC values were observed for the Valo LCU in the top surface for CR2 (100% TPO), CR3 (100% BAPO), CR4 (50% CQ/50% TPO), and CR6 (50%BAPO/50%TPO) groups. No significant differences were found between Valo and Elipar LCUs in the top surface for the CR1 (100% CQ), CR5 (50% CQ/50% BAPO), CR7 (70% CQ/30% TPO), CR8 (70% CQ/30% BAPO) and CR9 (70% BAPO/30% TPO) groups. On the other hand, the DC values were higher for the Elipar LCU when assessing the bottom surface for the CR6 (50%BAPO/50%TPO) and CR9 (70% BAPO/30% TPO) groups. The other experimental composites showed no significant differences among them, irrespective of the LCU or specimen surface (Table 4).

Table 4- Mean degree of conversion (DC%) and standard deviation (±) according to the experimental composite resins, light curing units (LCUs) and specimen surfaces.

Surface	LCU	**DC% - Experimental composite resin**								
		CR1	**CR2**	**CR3**	**CR4**	**CR5**	**CR6**	**CR7**	**CR8**	**CR9**
Top	*Elipar*	65.5±3.4 Aa€	43.4±2.1 Bc€	68.0±2.4 Ba€	60.3±3.3 Bb€	66.4±2.2 Aa€	25.9±3.5 Be€	58.3±3.3 Ab€	29.7±4.1 Ad€	65.7±2.7 Aa€
	Valo	66.7±3.4 Ab€	52.2±3.9 Ad€	71.6±3.2 Aa€	69.4±2.7 Aa€	67.8±2.8 Ab€	39.5±2.6 Ae€	59.3±5.0 Ac€	30.4±2.5 Af€	65.6±2.2 Ab€
Bottom	*Elipar*	56.3±2.0 Ac£	---	64.6±2.1 Aa£	54.5±3.4 Ac£	59.5±1.2 Ab£	19.9±2.8 Ae£	50.9±1.6 Ad£	19.1±3.0 Ae£	60.9±1.6 Ab£
	Valo	56.8±1.9 Ab£	---	63.6±0.8 Aa£	54.9±0.9 Ab£	60.5±2.0 Aa£	13.4±1.3 Bd£	51.7±3.0 Ab£	19.2±1.7 Ac£	55.1±1.0 Bb£
Pooled Mean		61.32±5.5 c	---	67.16±4.2 a	59.75±6.7 c	63.54±4.2 b	24.68±10.4 f	55.02±5.0 d	24.59±6.4 f	61.79±4.8 c

* Distinct capital letters indicate difference between LCUs in columns; distinct small letters indicate difference between composite resins in rows; and distinct symbols indicate difference between the specimen surfaces in rows; Scott-Knott test (α=0.05); "---", means that the composite resin has not polymerized on the base.

Knoop Hardness (KHN)

The mean Knoop Hardness values (KHN) and standard deviation (±) verified in the surfaces of the specimens for the experimental composite resins activated with the different LCUs, are presented in Tables 5 and 6. Considering the pooled means, the top surface showed significantly higher KHN values when compared to the bottom surface when taking all the experimental groups into account, irrespective of the LCU. Additionally, the Valo LCU resulted in higher KHN values for the top surfaces of the specimens; while in the bottom surfaces, higher KHN values were observed for the Elipar LCU.

Table 5- Pooled means for Knoop hardness (KHN) and standard deviation (±) considering all the experimental resin composites in the different specimen surfaces and light curing units (LCUs) conditions.

	Pooled Means		
Top	53.33±7.61 A	*Elipar*	50.99±9.24 b
		Valo	55.66±4.55 a
Bottom	38.99±5.71 B	*Elipar*	40.61±6.34 a
		Valo	37.37±4.53 b

* Distinct capital letters indicate significant difference between the specimen surfaces in columns; distinct small letters indicate difference between LCUs in columns; Scott-Knott test (α=0.05).

When analyzing the experimental composites, higher KHN values were observed for the CR1 (100%CQ), CR3 (100%BAPO) and CR5 (50% CQ/50% BAPO) groups, irrespective of the specimen surfaces and LCUs; while the CR2 group (100%TPO) presented the lowest KHN values. The other experimental composites presented intermediate KHN values, with similar results among them.

Considering the LCUs and specimen surfaces, CR1 group (100% CQ) presented higher KHN values in the top surface when using Elipar LCU; followed by the CR6 (50%BAPO/ 50% TPO), CR3 (BAPO) e CR5(50% CQ/ 50% BAPO) groups when using Valo LCU. No significant differences were observed for the CR3 (100% BAPO), CR5 (50% CQ/50% BAPO), CR8 (70% CQ/30 %BAPO) and CR9 (70% BAPO/30% CQ) groups in the top surface, irrespective of the LCU. Significant differences were verified for the CR1 (100% CQ) and CR3 (100% BAPO) groups in the bottom surface, with higher KHN values when using the Elipar LCU. The other experimental composite resins presented similar KHN results.

Table 6- Mean Knoop hardness (KHN) and standard deviation (±) according to the experimental composite resins, light curing units (LCUs) and specimen surfaces.

		CR1	CR2	CR3	CR4	CR5	CR6	CR7	CR8	CR9
Top surface	*Elipar*	61.4±5.3 Aa€	31.6±5.0 Bd€	58.0±3.8 Aa€	43.9±1.8 Bc€	53.0±2.0 Ab€	55.4±2.6 Bb€	46.3±2.4 Bc€	53.6±1.5 Ab€	55.3±5.0 Ab€
	Valo	48.5±4.2 Bb€	54.9±1.3 Ab€	59.9±1.2 Aa€	55.0±4.6 Ab€	57.8±1.6 Aa€	62.1±3.1 Aa€	53.8±2.6 Ab€	54.2±2.5 Ab€	54.7±2.8 Ab€
Lower surface	*Elipar*	50.6±1.7 Aa£	---	44.6±3.9 Ab£	29.5±1.8 Ad£	43.8±1.4 Ab£	40.2±2.9 Ab£	36.3±1.5 Ac£	41.1±2.3 Ab£	38.8±3.5 Ac£
	Valo	42.9±3.1 Ba£	---	37.2±2.4 Bb£	32.5±2.6 Ab£	42.0±2.5 Aa£	34.8±2.1 Ab£	35.8±1.4 Ab£	39.6±0.8 Aa£	34.0±1.1 Ab£
Pooled Mean		50.8±7.8 a	---	50.0±10.1 a	40.2±10.8 d	49.2±6.8 a	48.1±11.7 b	43.0±7.9 c	47.1±7.3 b	45.7±10.2 b

* Distinct capital letters indicate difference between LCUs in columns; distinct small letters indicate difference between composite resins in rows; and distinct symbols indicate difference between the specimen surfaces in rows; Scott-Knott test (α=0.05); "---", means that the composite resin has not polymerized on the base.

Diametral Tensile Strength

The mean diametral tensile strength (DTS) values (MPa) and standard deviation (±) assessed for each of the experimental composite resins activated with the different LCUs, are presented in Table 7.

Table 7- Mean diametral tensile strength (MPa) and standard deviation (±) according to the experimental composite resins and light curing units (LCUs).

	DTS (MPa) – Experimental composite resin									
LCU	**CR1**	**CR2**	**CR3**	**CR4**	**CR5**	**CR6**	**CR7**	**CR8**	**CR9**	**Pooled mean**
Elipar	38.8±3.7 Ab	25.4±3.0 Bc	38.5±3.4 Ab	36.0±4.5 Bb	47.7±3.8 Aa	45.7±3.9 Ba	43.1±5.2 Aa	44.7±2.6 Aa	44.0±5.1 Aa	40.4±7.5 B
Valo	42.6±4.4 Ac	31.0±3.3 Ae	38.1±3.5 Ad	48.9±5.4 Ab	45.6±4.8 Ac	53.9±4.6 Aa	41.4±3.0 Ac	43.8±5.1 Ac	44.1±3.5 Ac	43.3±7.3 A
Pooled Mean	40.69±4.4 d	28.21±4.2 e	38.32±3.3 d	42.47±8.2 c	46.62±4.4 b	49.82±5.9 a	42.22±4.2 c	44.29±3.9 c	44.04±4.2 c	

* Distinct capital letters indicate difference between LCUs in columns; distinct small letters indicate difference between composite resins in rows; Scott-Knott test (α=0.05).

When considering the pooled means for DTS of the experimental composites, higher diametral strength values were observed for the specimens light-activated with the Valo LCU as compared to those light-activated using the Elipar LCU. While considering the pooled means for DTS for both LCUs, higher diametral tensile strength values were verified for the CR6 (50% BAPO/ 50%TPO) group, followed by CR5 (50% CQ/50% BAPO) group; and lower DTS values were presented by the CR1 (100% CQ), CR3 (100% BAPO) groups, followed by CR2 (100% TPO) presenting the lowest values. The other experimental composite resins presented intermediate, similar DTS results.

Higher diametral tensile strength values were observed for the specimens from CR2 (100% TPO), CR4 (50% CQ/ 50%TPO) and CR6 (50%BAPO/5A%TPO) groups when light-activated with the Valo LCU; while higher DTS values were observed for the specimens from CR5 (50% CQ/50% BAPO), CR6 (50% BAPO/50% TPO), CR7 (70% CQ/30% TPO), CR8 (70% CQ/30% BAPO), and CR 9(70% BAPO/30% TPO) groups when light-activated with the Elipar LCU. No significant differences were detected for CR1 (100% CQ), CR3 (100% BAPO) and CR4 (50% CQ/ 50%TPO) groups, irrespective of the LCU; However, CR2 (100% TPO) group presented the lowest DTS values, for both the LCUs.

Discussion

The experimental composite resins formulated with the different photoinitiators and concentrations were influenced by the distinct light-curing units (monowave and multipeak LCUs) in this investigation, which have different light spectra, and resulted in contrasting properties for the tested materials. The distinct experimental composite resins also presented different degree of conversion, hardness and tensile strength with the same LCU; As different properties were found for the experimental composites, while using the distinct LCUs, the null hypothesis tested in the study was rejected.

There are many variables that could impact the longevity of composite resins, depending on the operator skills, restorative technique, patient habits, maintenance protocols and constitution of the restoring material. A systematic review showed a survival rate of 86.2% for direct composite resin restorations with 55 months of follow-up. (21) Also, a clinical study with a 33-year follow-up of direct composite resin restorations placed in posterior teeth, presented a survival rate of 48% for this restorative material. (22) Despite the acceptable survival rates and functional/aesthetic outcomes, resin composites are considered reliable restorative materials for anterior and posterior applications. (23) Even though, several modifications had been proposed on the composition of resin composites trying to overcome the intrinsic limitations of this material. (24) Thus, studies on how to modify the constitution and activation techniques are necessary in an attempt to improve the longevity of composite resin restorations.

The polymerization process of light-cured composite-based materials is dependent upon the technical characteristics of the LCU, such as light- irradiance and spectra.(25) Different LCUs can result in distinct physical properties for the same material given that the degree of conversion, hardness and diametral tensile strength of composite resins may be affected as demonstrated by the results of this investigation; and this fact is also in accordance to previous studies.(26, 27) The broad-spectrum presented by certain LCUs may influence the properties of some particular composite resins, which have alternative photoinitiators, other than camphorquinone (CQ).(28, 29) This fact was observed in the present study for the experimental composite resins, since CRs 4 and 6 that were formulated using CQ associated to other photoinitiators, showed better polymerization at the top when light-activation was performed with Valo LCU. This light-curing unit has broader spectrum of light and was able to stimulate all initiators present on the aforementioned composites, when compared to the Elipar LCU, which emits light only in the blue spectrum.

As seen, the properties from composite resins can be influenced by multiple factors, such as the type of methacrylate monomers, the light absorption range of the photoinitiator(s) on the region of the emitted spectrum, light intensity used for irradiation, and the type and concentration of the initiation system.(30) Photoinitiation systems used for radical polymerization of methacrylate-based materials are classified based on the mechanism of formation of free radicals after light absorption: Type I systems generate radicals by fragmentation of the photoinitiator molecule; and Type II photoinitiators in their excited state need to interact with a co-initiator, donor of electrons and protons, so the radicals can be generated.(31) TPO and bisacylphosphine oxide (BAPO) are examples of Type I photoinitiators; CQ is a Type II photoinitiator and the co-initiators commonly used are aromatic tertiary amines or aliphatic amines.(32)

The hardness of composites is an important aspect for the selection of different restorative materials.(20) In the present study, the KHN values assessed in the top surface of the specimens were higher when compared to those verified in the bottom region (Table 5), what is in disagreement with some studies in which composite resin specimens up to 2mm thickness showed no difference in the properties from top and bottom surfaces.(33,34) This finding can be explained by the lack of polymerization depth when little or no CQ photoinitiator was present in the experimental composites; and also because the Valo LCU has lower irradiance and part of the light does not correspond to the CQ spectrum. When using Valo LCU, higher hardness values were obtained at the top surface only for specimens from CR 2, 4, 6 and 7 experimental composites, in which, additional initiator was added to CQ or without CQ.

In the present study, the specimens from experimental composites groups CR6 and CR8 presented the lowest degree of conversion results, irrespective of the LCU. For the CR2 group, the composite resin has not even polymerized at the base, remaining viscous in this region, preventing the degree of conversion analysis to be performed. This fact can be explained since this experimental composite (CR2) has only TPO as initiator, which depends on violet light for its activation; and the broad-spectrum LCU (Valo) violet light has not sufficient intensity to penetrate more than 1 mm in the specimen or is absent in the monowave LCU (Elipar).(28,29) Additionally, CR2 showed the lowest average values for diametral tensile strength, and this can be also explained by using only TPO as initiator, in which, despite achieving an adequate degree of conversion in the top surface, the base surface was not well polymerized. The experimental resins CR 5, 6, 7, 8 and 9, used different compositions of photoinitiators, and showed statistically similar results, which were superior to all the other groups.

This study demonstrated that not only the type of initiator but the amount of each of these components can affect the properties of experimental composite resins. The presence of at least 50% of BAPO improved the properties of the composite resins analyzed. The highest top hardness values were observed for groups CR6 (50% BAPO/50%TPO), CR3 (BAPO) and CR5 (50%CQ/ 50%TPO); while the highest diametral tensile strength was for CR6 (50% BAPO/50% TPO); and the highest degree of conversion was achieved by the CR3 group.

Despite the limitations of mechanical laboratory tests, they can provide better understanding of fragile materials that are more likely to fail early as composite resin.[35] This study presents intrinsic limitations such as preparation of specimens and tests in a controlled environment with a trained operator. The specimens have not undergone thermomechanical aging as it occurs with composite restorations in the oral environment and only a few among hundreds of possible combinations between types and concentration of initiators for producing the experimental resin composites have been evaluated. Further laboratory and clinical investigations on this topic would be of benefit.

Conclusion

Within the limitations of this study, the following conclusions were drawn:

1- The type and concentration of photoinitiator(s) influenced the properties from the experimental resin composites tested. The experimental composite resins with at least 50% of BAPO showed the best results in terms of degree of conversion, Knoop hardness and diametral tensile strength.

2- The multipeak LCU obtained better or similar results than the monowave LCU for the experimental composite resins with other initiators than the CQ.

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Capítulo 4

Fatores de sucesso em restaurações diretas de dentes anteriores com resina composta: série de casos.

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Fatores de sucesso em restaurações diretas de dentes anteriores com resina composta: série de casos.

Resumo

As alterações estéticas do sorriso têm sido uma demanda constante apresentada pelos pacientes na rotina clínica. Dentre as possibilidades permitidas pela resina composta, destaca-se a capacidade clínica de realizar procedimentos restauradores mais conservadores, além de permitir reparos das restaurações que possuem defeitos localizados, contribuindo então para uma maior preservação da estrutura dentária. O objetivo deste trabalho foi apresentar uma série de casos clínicos, nos quais restaurações em resinas compostas foram utilizadas em dentes anteriores, seguindo protocolos criteriosos e embasados cientificamente na execução, para se obter maior previsibilidade estética, funcional e de longevidade, demonstrando a aplicabilidade e versatilidade deste material restaurador em situações clínicas distintas. Foram apresentados 4 casos clínicos de fechamento de diastema e facetas. Foram aplicadas técnicas de isolamento, adesão, fotoativação e polimento baseado em pesquisas recentes. As restaurações atingiram os objetivos estéticos e funcionais. Os pacientes relataram alto índices de satisfação. Com base na série de caso e na literatura consultada conclui-se que restaurações estéticas em dentes anteriores em resina composta é uma excelente opção de tratamento para alterações estéticas do sorriso.

Palavras-chave: resina composta, facetas, diastema

Introdução

As alterações estéticas do sorriso têm sido uma demanda constante apresentada pelos pacientes na rotina clínica. O aumento da valorização da estética pela sociedade resultou em uma maior busca por melhoras na autoimagem e aceitação social, por meio de tratamentos odontológicos que possibilitem a resolução de problemas dentais como alterações de cor, forma e/ou tamanho.[1] As alterações estéticas em dentes anteriores podem ser ocasionadas por cáries, fraturas, má formações, mal posicionamento e/ou diastemas. No entanto, nem todas as alterações de formatos e diastemas devem ser vistas como dependentes de correção pelos profissionais. O paciente deve relatar suas queixas, necessidades e expectativas de forma espontânea, devendo estas serem consideradas no processo de planejamento do tratamento, favorecendo maior satisfação do mesmo com os resultados.[2]

As técnicas restauradoras diretas e indiretas empregando restaurações em resina composta figuram como opções de tratamento viáveis para a alteração do formato e cor dos dentes. Dentre as possibilidades permitidas pela resina composta, destaca-se a capacidade clínica de realizar procedimentos restauradores mais conservadores,[3,4] além de permitir reparos das restaurações que possuem defeitos localizados, contribuindo então para uma maior preservação da estrutura dentária.[5] Além disso, as resinas compostas possibilitam a recuperação do comportamento biomecânico semelhante ao da estrutura dentária perdida,[6,7] e têm demonstrando baixas taxas de falhas anuais para dentes anteriores, variando de 0 a 4,1%.[8]

A melhoria das técnicas restauradoras diretas associado com o aprimoramento nas tecnologias adesivas, favorece maior resistência e capacidade de polimento dos materiais, permitindo que as resinas compostas possam ser indicadas/utilizadas em regiões de alto esforço mastigatório e de alta exigência estética.[9] No entanto, o entendimento da técnica e o embasamento científico que valida cada etapa clínica são fundamentais para a previsibilidade do procedimento. Etapas como a fotoativação e polimento são determinantes para longevidade das restaurações diretas e indiretas que empreguem materiais resinosos, e devem ser feitas de forma criteriosa.[10,11]

O objetivo deste trabalho é apresentar uma série de casos clínicos, nos quais restaurações em resinas compostas foram utilizadas em dentes anteriores, seguindo protocolos criteriosos e embasados cientificamente na execução, para se obter maior previsibilidade estética, funcional e de longevidade, demonstrando a aplicabilidade e versatilidade deste material restaurador em situações clínicas distintas.

Relato de caso

Caso Clínico 1

Paciente do gênero masculino, 28 anos, compareceu à clínica, tendo como queixa principal o espaço presente entre os incisivos centrais superiores (Figura 1). Foram realizados anamnese, exame clínico e radiográfico. Durante a avaliação clínica, constatou-se a presença de diastema entre os dentes 11 e 21. O paciente relatou insatisfação quanto ao diastema presente entre os incisivos que se tornava muito evidente quando sorria. Após a realização dos exames iniciais, nenhuma alteração radiográfica e clínica significativa foi diagnosticada (Figura 2), sendo proposto para o paciente fechamento de diastema dos dentes 11 e 21 com o uso de restaurações diretas em resina composta, realizadas em sessão única.

Figura 1 – Aspecto inicial do sorriso do paciente

Figura 2- Aspecto inicial intraoral do paciente.

Inicialmente foi realizado profilaxia com pedra pomes e água nos dentes 11 e 21 (Figura 3). Com a própria resina composta a ser utilizada, colocando-se pequenas porções sobre a face vestibular e polimerizando-as foi selecionada a cor da restauração. Assim, a única resina selecionada foi a A1 Palfique (Tokoyama Dental, Tóquio, Japão). Em seguida feito um isolamento relativo e inserção do fio afastador #000 Ultrapak (Ultradent, Indaiatuba, SP, Brasil) com espátula de fischer® (Ultradent) (Figura 3).

Figura 3 – Profilaxia realizada com pedra pomes e água nos dentes 11 e 21.

Condicionamento ácido (Figura 4) foi realizado por 30 segundos com ácido fosfórico gel a 35% (Ultradent), seguido de lavagem abundante por cerca de 20 segundos. Inserção do fio afastador #000 Ultrapak (Ultradent). Aplicação de adesivo (Figura 6) Single Bond 2 (3M ESPE, St.Paul, MN, EUA) com um micro aplicador KG Brush (KG Sorensen, Cotia, SP, Brasil) em duas camadas consecutivas, com breve jato de ar e fotoativação 40 s Valo (Ultradent).

Figura 4 – Condicionamento com ácido fosfórico 35% (Ultradent) por 30 segundos.

Figura 5- Inserção do fio afastador #000 Ultrapak (Ultradent).

Figura 6- Aplicação de adesivo convencional Single Bond 2 (3M ESPE), St. Paul, MN, EUA) com o micro aplicador (KG Sorensen).

Foi utilizado matriz de poliéster para adaptar e resina composta, definir o ponto de contato e evitar adesão entre as resinas compostas do dente 11 e 21 (Figura 6).

Figura 6- Matriz de poliéster posicionada entre os dentes 11 e 21.

A resina foi aplicada e fotoativada por 40 segundos Valo (Ultradent). A ponta que emite luz do Valo cobrindo toda a área do dente a ser fotoativada (Figura 7).

Figura 7- Fotoativação da resina composta por 40s. Observar que a ponta ativa do aparelho é maior que a área a ser fotoativada.

Em seguida a etapa restauradora, iniciou-se o acabamento e polimento das restaurações. Foi utilizado tira serrilhada (KG Sorensen) para remoção de excessos proximais e a mesma tira, porém na região diamantada, para o acabamento proximal (Figura 8). Utilizou-se no o acabamento inicial o disco abrasivo grosso/médio OptiDisc (Kerr, Orange, CA, EUA), para definição de ameias incisais, arestas mesiais e distais, área de espelho e área de sombra (Figura 9). Para remoção de excessos cervicais foi utilizado a ponta diamantada #1190FF (KG Sorensen). Utilizou-se os discos abrasivos fino e extra-fino OptiDisc (Kerr) para o refinamento do acabamento (Figura 10). Para o polimento foi usado a taça de borracha Opti1Step® (Kerr) (Figura 11). A fim de facilitar o polimento em regiões proximais e cervicais foi realizado polimento com uma mini escova de Robinson e pasta para polimento KG Gloss (KG Sorensen), (Figura 12).

Figura 8 – Lixa serrilhada para remoção de excessos na proximal e diamantada para acabamento (KG Sorensen).

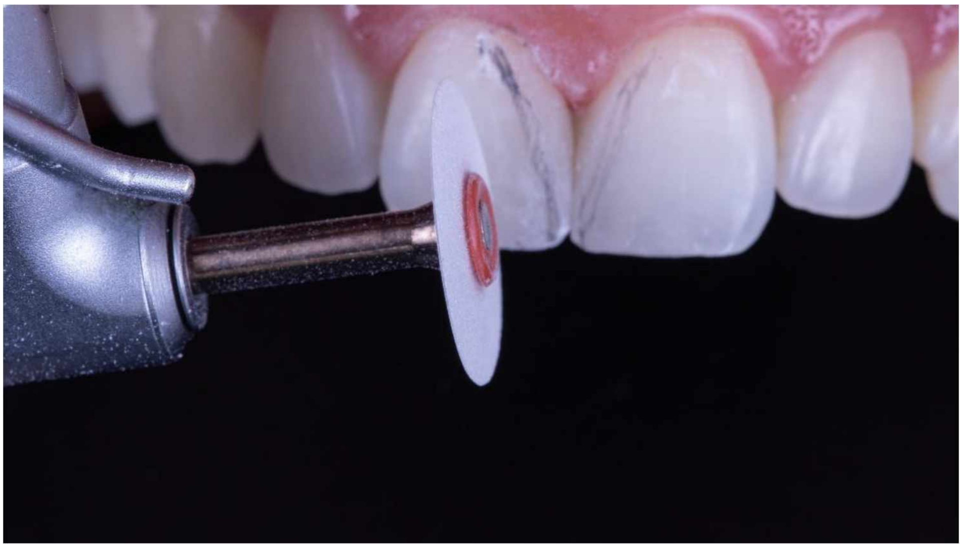

Figura 9- Disco abrasivo médio/grosso (Kerr) para acabamento inicial.

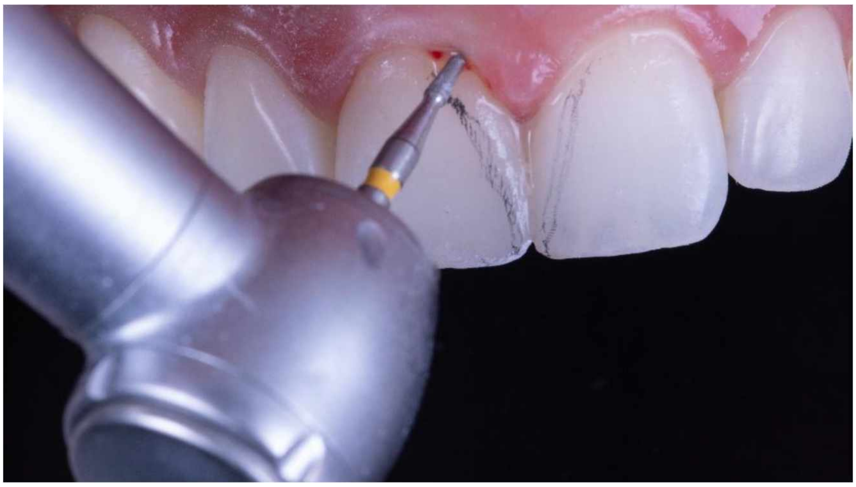

Figura 10- Ponta diamantada #1190FF (KG Sorensen) para acabamento cervical.

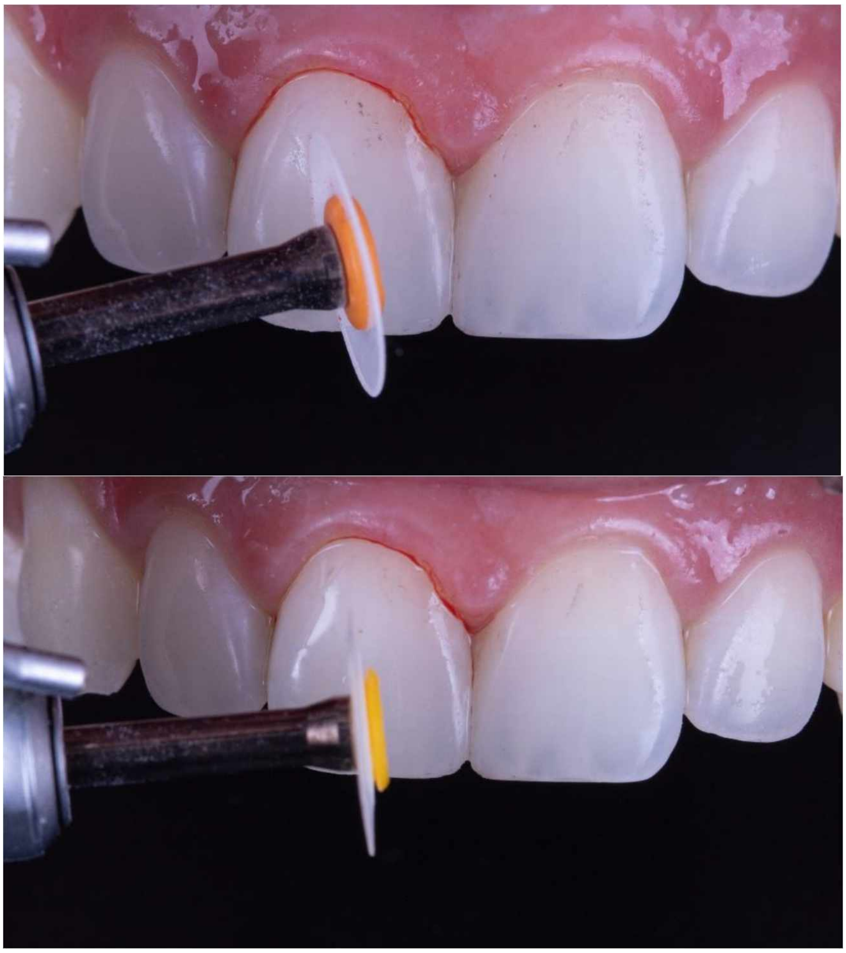

Figura 11- Discos Abrasivos fino e extra-fino para refinamento do acabamento.

Figura 12- Borracha polidora Opiti1Step (Kerr) utilizada para polimento.

Figura 13- Mini escova de Robinson e pasta KG Gloss (KG Sorensen) para polimento final.

Figura 14- Aspecto intraoral final do paciente

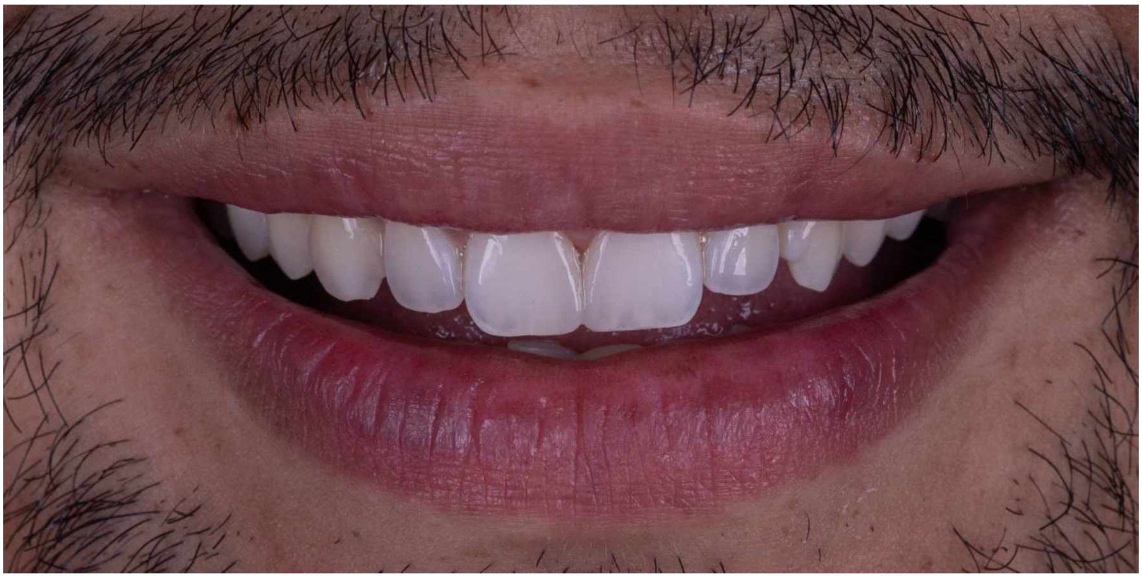

Figura 15- Aspecto do sorriso final do paciente

Paciente relatou satisfação com resultado final. O grande desafio deste caso foi fotoativar e polir bem nas regiões proximais e cervicais, exatamente onde falha mais essas restaurações a médio e longo prazo.

Caso clínico 2

Paciente do gênero feminino, 45 anos, compareceu à clínica, tendo como queixa principal o formato do dente 22 e espaço gerado após finalização ortodôntica (Figura 16). Foi realizado anamnese, exame clínico e radiográfico. Durante a avaliação clínica, constatou-se o dente 22 com formato conóide e espaço entre os dentes 22 e 23. Após a realização dos exames iniciais, nenhuma alteração radiográfica e clínica significativa foi diagnosticada, sendo proposto para o paciente fechamento do espaço e alteração morfológica do dente 22 com o uso de restauração direta em resina composta, realizada em uma única sessão (Figura 17). As técnicas utilizadas e materiais foram os mesmos descritos no caso clínico 1, com a cor de resina utilizada sendo a A3 (Palfique A3, Tokoyama Dental, Tóquio, Japão).

Figura 16- Vista do sorriso, antes e após a restauração em resina composta dos dentes 22 e 23.

Figura 17- Vista intraoral, antes e após a restauração em resina composta dos dentes 22 e 23.

Paciente relatou satisfação com resultado. O grande desafio deste caso foi fotoativar e polir bem nas regiões proximais e cervicais, exatamente onde falha mais essas restaurações a médio e longo prazo.

Caso clínico 3

Paciente do gênero masculino, 23 anos, compareceu à clínica, tendo como queixa principal a coloração amarelada dos dentes mesmo após realização de clareamento dental (Figura 18). Foi realizado anamnese, exame clínico e radiográfico. Durante a avaliação clínica, constatou-se a presença de restaurações opacas e sem brilho nos dentes 22, 21, 12 e 22 (Figura 19). Após a realização dos exames iniciais, nenhuma alteração radiográfica e clínica significativa foi diagnosticada, sendo proposto para o paciente facetas em resina composta dos dentes 13, 12, 11, 21, 22 e 23, realizadas de forma direta em duas sessões (Figuras 20 e 21). As técnicas utilizadas e materiais foram os mesmos descritos no caso clínico 1, com a cor de resina utilizada sendo a B1 (Palfique B1, Tokoyama Dental, Tóquio, Japão).

Figura 18- Aspecto inicial do sorriso do paciente.

Figura 19 – Aspecto intraoral inicial do paciente.

Figura 20- Aspecto intraoral final do paciente.

Figura 21- Aspecto final do sorriso do paciente.

O paciente relatou satisfação com o resultado final das facetas. O maior desafio do caso foi manter as dimensões que o paciente já demonstrava satisfação. Foi otimizado o formato, cor e leve efeito incisal.

Caso Clínico 4

Paciente do gênero masculino, 35 anos, compareceu à clínica, tendo como queixa principal diastemas e tamanho dos dentes (Figuras 22 e 23). Foi realizado anamnese, exame clínico e radiográfico. Durante a avaliação clínica, constatou-se a presença de espaços entre os incisivos superiores e largura do dente similar à sua altura, com aspecto de dentes mais quadrados. Após a realização dos exames iniciais, nenhuma alteração radiográfica e clínica significativa foi diagnosticada, sendo proposto para o paciente facetas em resina composta dos dentes 14, 13, 12, 11, 21, 22, 23 e 24, realizadas de forma direta em duas sessões (Figuras 24 e 25). As técnicas utilizadas e materiais foram os mesmos descritos no caso clínico 1, com a cor de resina utilizada sendo a A1 (Palfique A1, Tokoyama Dental, Tóquio, Japão).

Figura 22- Aspecto inicial do sorriso do paciente.

Figura 23- Aspecto inicial intraoral do paciente.

Figura 24- Aspecto final do sorriso do paciente.

Figura 25- Aspecto final intraoral do paciente.

O paciente relatou satisfação com o resultado final das facetas. O maior desafio do caso foi definir as dimensões pelo aumento de largura consequente do fechamento dos espaços e o aumento de altura para manter a proporção adequada.

Discussão

É comum que a presença de diastemas, má formações dentárias e mal posicionamento dos dentes gerem desconforto estético. Diferentes abordagens clínicas podem ser utilizadas para corrigir essas falhas, podendo o profissional optar pela movimentação ortodôntica ou pela execução de restaurações diretas e indiretas. Em alguns casos, a associação de movimentações, acréscimos e desgastes pode se fazer necessária na correção desses casos. Para escolher a melhor técnica e/ou materiais, vários fatores devem ser analisados, desde as relações maxilo-mandibulares até questões econômicas e sociais relacionadas ao paciente.[12] O correto diagnóstico e adequado planejamento são elementos fundamentais para a obtenção do sucesso clínico e longevidade das restaurações.[13]

Restaurações indiretas geralmente exigem preparo dental mais extenso, com desgaste adicional de tecido.[14] Já a técnica restauradora direta apresenta vantagens como custo reduzido, preservação de estrutura dental sadia, velocidade de execução e maior facilidade para alguma eventual necessidade de correção, o que fez com que esta técnica fosse escolhida para a série de casos clínicos em questão.[15] Para qualquer situação clínica é importante que o profissional opte por uma abordagem conservadora de tratamento, que possa garantir a maior preservação possível de estrutura dental sadia associada a longevidade.

Está estabelecido que a boa adesão ao esmalte e aceitável à dentina podem ser alcançadas com sistemas adesivos convencionais e também com os autocondicionantes.[16,17] No entanto, a técnica que emprega condicionamento com ácido fosfórico definitivamente ainda é a abordagem mais eficaz para se obter adesão mais estável e eficiente em esmalte. Nesta técnica, o ataque ácido individualmente expõe cristais de hidroxiapatita e *tags* de resina são criados entre estes cristais expostos devido à polimerização *in situ* da resina.[18] A adesão micromecânica por travamento com os *tags* de resina ainda é considerada o padrão ouro onde até 40 MPa é alcançado em estudos laboratoriais, às vezes até superando a força coesiva do próprio esmalte.[19,20] Como as resinas compostas diretas nestes casos foram realizados em superfícies de esmalte não danificadas, a estratégia adesiva utilizada foi por sistema de adesivo com condicionamento por ácido fosfórico em esmalte a fim de se obter uma adesão mais estável e eficiente.

Fatores como película de saliva, umidade, detritos orgânicos, sangue e óleo de compressores de ar e de peças de mão são potenciais contaminantes de superfícies dentais que podem levar à redução da resistência de união.[21] Profilaxia prévia deve ser realizada antes dos procedimentos adesivos a fim de evitar possíveis contaminações e aumentar a previsibilidade da adesão.[22] A profilaxia realizada nos casos clínicos apresentados foram feitas com pedra pomes e água, que além do baixo custo é efetiva para limpeza superficial do esmalte.[23]

Para conseguir o máximo de adesão e as melhores propriedades da resina, durante o procedimento restaurador não deve haver contaminação no campo operatório por saliva, fluído crevicular, óleo, umidade ou sangue.[24,25] Um isolamento relativo realizado com fio afastador, rolete de algodão, e um auxiliar realizando um bom controle de umidade possui resultados similares à realização de isolamento absoluto em restaurações envolvendo a região cervical, desde que o profissionais tenha boa experiência clínica.[26] As restaurações apresentadas nessa série de caso foram realizadas com isolamento relativo de forma criteriosa.

É importante que a polimerização dos materiais resinosos seja eficiente de forma a se obter propriedades adequadas para os mesmos.[27] A fotoativação deve ser realizada o mais próximo possível da restauração. O afastamento de menos de 1,0 cm pode reduzir mais de 65% da irradiância que chega à restauração.[28] O tamanho da ponteira deve ser condizente com a área a ser fotoativada, ou polimerizações adicionais devem ser realizadas nas áreas que a ponteira não consegue atingir.[29] Nos casos apresentados foi utilizado o Valo que apresenta 9.6mm[30] de diâmetro da ponta e foi suficiente para polimerizar todas as áreas desejadas.

O entendimento da composição da resina composta empregada nos procedimentos restauradores se faz necessária para obter as melhores propriedades do compósito. O iniciador presente deve ser compatível com a luz utilizada no aparelho fotoativador. O uso de iniciadores adicionais a canforoquinona (CQ) demonstraram que podem melhorar o grau de conversão, dureza Knoop e resistência a tração diametral das resinas compostas, desde que utilizado um aparelho multipico (polywave).[31] Nos casos apresentados foi utilizado o aparelho fotoativador Valo (Ultradent), multipico, entretando as resinas utilizadas não apresentam fotoiniciador adicional em sua composição, apenas a luz azul é suficiente para atingir alto grau de conversão de monômeros em polímeros.

Com o acabamento e polimento realizados de forma efetiva é possível diminuir as rugosidades superficiais, corrigir as margens inadequadas, delimitar forma e contorno, dar brilho e textura às restaurações e evidenciar as propriedades óticas e biomecânicas.[32] Com a técnica correta, evita-se o acúmulo de biofilme, recidiva de cárie secundária, manchamento das margens e inflamação gengival, promovendo então maior longevidade às restaurações, deixando o tecido de proteção periodontal saudável e livre de irritações.[33]

O polimento está relacionado com duas propriedades da resina composta, a rugosidade superficial e o brilho.[34] A rugosidade da superfície de uma restauração resina composta depende de vários fatores, incluindo o tamanho, forma e quantidade de partículas de carga; tipo de monômero; grau de conversão; e a adesão eficiente da carga à matriz orgânica.[35] O brilho (registrado como unidades de brilho [GU]) normalmente é usado para quantificar o brilho de uma superfície e é baseado na refletância especular medida com um medidor de brilho em um ângulo específico através de uma abertura. O brilho é um fenômeno complexo que é difícil de avaliar objetivamente porque é afetado pela percepção do observador.[36] Na odontologia restauradora, o objetivo é atingir um nível de brilho que seja comparável ao esmalte, 40 a 60 GU, sendo identificado como brilho desejado típico com base em observações de 1 profissional experiente.[37]O polimento da superfície depende muito do técnica clínica, podendo ser afetado pela pressão aplicada, movimento de polimento e tempo total de polimento.[34,38]

Os pacientes devem ser orientados quanto aos cuidados relacionados à higienização, dieta, presença de distúrbios parafuncionais e a necessidade de acompanhamento odontológico para a preservação das características satisfatórias da restauração.[39] Diante disso, as restaurações anteriores em resina composta realizadas de forma direta são capazes de apresentar longevidade, sendo versáteis e clinicamente satisfatórias na adequação de forma, função e estética em situações distintas.

Conclusão

Nesta série de casos, as restaurações anteriores realizadas de forma direta em resina composta geraram bons resultados estéticos e funcionais, atingindo as expectativas dos pacientes. Entretanto, passo a passo técnico criterioso e bem embasado deve ser realizado para que não sejam obtidos apenas resultados imediatos e que os procedimentos restauraores apresentem boa longevidade.

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