Universidade Federal de Uberlândia

Faculdade de Odontologia

Programa de Pós Graduação em Odontologia – UFU

Giovanna Chaves Souza Borges

Influência De Unidades de Luz Mono e Poliwave na Dureza e Grau de Conversão de Cimentos Resinosos Fotopolimerizáveis

Influence of Monowave and Polywave Light Units on the Hardness and Degree of Conversion of Light Cured Resin Cement

Dissertação apresentada à Faculdade de Odontologia da Universidade Federal de Uberlândia, para obtenção do Título de Mestre em Odontologia na Área de Clínica Odontológica Integrada

Orientadora: Prof. Dra. Karla Zancopé

Uberlândia, 2022

Universidade Federal de Uberlândia

Faculdade de Odontologia

Programa de Pós Graduação em Odontologia – UFU

Giovanna Chaves Souza Borges

Influência De Unidades de Luz Mono e Poliwave na Dureza e Grau de Conversão de Cimentos Resinosos Fotopolimerizáveis

Influence of Monowave and Polywave Light Units on the Hardness and Degree of Conversion of Light Cured Resin Cement

Dissertação apresentada à Faculdade de Odontologia da Universidade Federal de Uberlândia, para obtenção do Título de Mestre em Odontologia na Área de Clínica Odontológica Integrada

Orientadora: Prof. Dra. Karla Zancopé

Banca Examinadora:

Prof. Dr. Carlos José Soares

Prof. Dra. Laís Rani Sales Oliveira

Uberlândia, 2022

Ficha Catalográfica Online do Sistema de Bibliotecas da UFU
com dados informados pelo(a) próprio(a) autor(a).

B732 2022

Borges, Giovanna Chaves Souza, 1996-
Influência De Unidades de Luz Mono e Poliwave na Dureza e Grau de Conversão de Cimentos Resinosos Fotopolimerizáveis [recurso eletrônico] / Giovanna Chaves Souza Borges. - 2022.

Orientadora: Karla Zancopé.
Coorientadora: Carlos José Soares.
Dissertação (Mestrado) - Universidade Federal de Uberlândia, Pós-graduação em Odontologia.
Modo de acesso: Internet.
Disponível em: http://doi.org/10.14393/ufu.di.2022.343
Inclui bibliografia.
Inclui ilustrações.

1. Odontologia. I. Zancopé, Karla ,1984-, (Orient.). II. Soares, Carlos José,1965-, (Coorient.). III. Universidade Federal de Uberlândia. Pós-graduação em Odontologia. IV. Título.

CDU: 616.314

Bibliotecários responsáveis pela estrutura de acordo com o AACR2:
Gizele Cristine Nunes do Couto - CRB6/2091
Nelson Marcos Ferreira - CRB6/3074

UNIVERSIDADE FEDERAL DE UBERLÂNDIA
Coordenação do Programa de Pós-Graduação em Odontologia
Av. Pará, 1720, Bloco 4L, Anexo B, Sala 35 - Bairro Umuarama, Uberlândia-MG, CEP 38400-902
Telefone: (34) 3225-8115/8108 - www.ppgoufu.com - copod@umuarama.ufu.br

ATA DE DEFESA - PÓS-GRADUAÇÃO

Programa de Pós-Graduação em:	Odontologia				
Defesa de:	Dissertação de Mestrado Acadêmico, nº 411, PPGODONTO				
Data:	Dezoito de Julho de Dois Mil e Vinte e Dois	Hora de início:	08:00	Hora de encerramento:	10:15
Matrícula do Discente:	12012ODO009				
Nome do Discente:	Giovanna Chaves Souza Borges				
Título do Trabalho:	Influência de unidades de luz mono e poliwave na dureza e grau de conversão de cimentos resinosos fotopolimerizáveis				
Área de concentração:	Clínica Odontológica Integrada				
Linha de pesquisa:	Propriedades Físicas e Biológicas dos materiais Odontológicos e das estruturas dentais				
Projeto de Pesquisa de vinculação:	Propriedades Físicas e Biológicas dos materiais Odontológicos e das estruturas dentais				

Reuniu-se em Web Conferência pela plataforma Zoom, em conformidade com a PORTARIA Nº 36, DE 19 DE MARÇO DE 2020 da COORDENAÇÃO DE APERFEIÇOAMENTO DE PESSOAL DE NÍVEL SUPERIOR - CAPES, pela Universidade Federal de Uberlândia, a Banca Examinadora, designada pelo Colegiado do Programa de Pós-graduação em Odontologia, assim composta: Professores Doutores: Carlos José Soares (UFU); Laís Rani Sales Oliveira (UCB); Karla Zancopé (UFU) orientador(a) do(a) candidato(a).

Iniciando os trabalhos o(a) presidente da mesa, Dr(a). Karla Zancopé, 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.

A seguir o senhor(a) presidente concedeu a palavra, pela ordem sucessivamente, aos(às) examinadores(as), que passaram a arguir o(a) candidato(a). Ultimada a arguição, que se desenvolveu dentro dos termos regimentais, a Banca, em sessão secreta, atribuiu o resultado final, considerando o(a) candidato(a):

Aprovado(a).

Esta defesa faz parte dos requisitos necessários à obtenção do título de Mestre.

O competente diploma será expedido após cumprimento dos demais requisitos, conforme as normas do Programa, a legislação pertinente e a regulamentação interna da UFU.

Nada mais havendo a tratar foram encerrados os trabalhos. Foi lavrada a presente ata que após lida e achada conforme foi assinada pela Banca Examinadora.

Documento assinado eletronicamente por **Karla Zancopé**, **Professor(a) do Magistério Superior**, em 22/07/2022, às 14:15, conforme horário oficial de Brasília, com fundamento no art. 6º, § 1º, do Decreto nº 8.539, de 8 de outubro de 2015.

Documento assinado eletronicamente por **Carlos José Soares**, **Professor(a) do Magistério Superior**, em 25/07/2022, às 08:29, conforme horário oficial de Brasília, com fundamento no art. 6º, § 1º, do Decreto nº 8.539, de 8 de outubro de 2015.

Documento assinado eletronicamente por **Lais Rani Sales Oliveira**, **Usuário Externo**, em 26/07/2022, às 22:49, conforme horário oficial de Brasília, com fundamento no art. 6º, § 1º, do Decreto nº 8.539, de 8 de outubro de 2015.

A autenticidade deste documento pode ser conferida no site https://www.sei.ufu.br/sei/controlador_externo.php?acao=documento_conferir&id_orgao_acesso_externo=0, informando o código verificador **3781462** e o código CRC **6E010396**.

DEDICATÓRIA

Começo esta dedicatória agradecendo a Deus, que me deu forças todas as vezes que eu fraquejei, todas as vezes que eu chorei temendo não conseguir mais, que sempre acalmou meu coração nos momentos de desespero e aflição. Ele, com toda a sua misericórdia e bondade colocou cada pessoa no momento certo para me ajudar a finalizar esta caminhada.

A minha mãe Christhiane, que todas as vezes que eu pensei em desistir ela me incentivou a continuar, me deu colo, amparo e sabedoria para não desistir dos meus sonhos e me tornar a mulher forte que sou hoje. Meu padrasto Marcelo, por sempre estar ao meu lado, e em todos os momentos que eu achava não ter respostas para os problemas, ele conseguia solucioná-los. Ao meu pai Patrick, e minha madrasta Danielly que sempre com todo amor e carinho torciam por mim e pela minha felicidade.

Aos meus irmãos, Ingrid, Rafael e Lívia, que em toda a minha vida, é o amor mais puro e verdadeiro que eu poderia sentir, que me move, e faz com que eu queira ser uma mulher cada vez mais forte e realizar todos os nossos sonhos. Aos meus avós, Norma, Martha e José Divino, que a cada abraço nos finais de semana, me davam forças para enfrentar um novo desafio, e vontade de orgulhá-los cada vez mais.

Ao meu noivo Lucas, que nunca me deixou sozinha, que esteve ao meu lado enxugando minhas lagrimas todos os dias, meu ponto de equilíbrio, de paz e de amor. Amo a vida que estamos construindo juntos, e esta é somente uma das nossas conquistas. Ansiosa por todas as outras virão. Te amo cada dia mais.

Esta vitória não é somente minha, e nada disso seria possível sem cada um de vocês. Isso nunca será para mim, mas sempre por vocês.

AGRADECIMENTOS

A minha orientadora, Karla Zancopé, por todo carinho e cuidado durante estes dois anos. A pandemia nos afastou presencialmente, mas saiba que nunca esquecerei toda sua dedicação e compreensão. Admiro a mulher e professora tão querida que é, e espero do fundo do meu coração que nossa história não termine aqui. Saiba que sempre terá uma orientada de portas abertas para ajudá-la. Obrigada, por tudo.

Ao meu orientador de iniciação científica, de TCC e da vida, Frederick e sua maior companheira Julia. Saibam o carinho que tenho por vocês, palavras não são suficientes para agradecer tudo que fizeram e fazem por mim todos os dias. Sem o incentivo e apoio de vocês, este mestrado seria um sonho distante para mim. Obrigada, do fundo do meu coração.

Aos meus colegas de faculdade e de mestrado Guilherme e Daniel, por todo companheirismo, por todo apoio e por todo ombro amigo durante todos estes anos.

A Bruna minha prima, que sempre foi minha melhor amiga, escutou minhas reclamações e vibrou com cada conquista.

A todas as minhas amigas e amigos, que me proporcionaram momentos de apoio e lazer e contribuíram para tornar essa jornada mais fácil.

A todos os meus colegas de pós graduação, a cada um que me ajudou (e não foram poucos) nos meus momentos de angustia e desespero no CPBIO. Vocês fizeram a diferença no meu mestrado.

Aos meus professores da pós graduação (PPGO UFU) e da graduação (UNIRV), por todos os ensinamentos e por serem degraus para que possamos chegar tão longe. A nossa formação é fruto de todo o carinho e conhecimento que vocês nos proporcionaram.

Ao grupo Nepro, que me orgulho em fazer parte e sempre contribuiu com o meu aprendizado.

Ao CPBIO, lugar que proporcionou para que eu desenvolvesse minha pesquisa com tanto conforto e qualidade.

A FAPEMIG que através da bolsa de estudo proporcionou apoio financeiro durante esse tempo

RESUMO

Objetivo: avaliar as propriedades químicas e mecânicas nas margens de cimentos resinosos fotopolimerizáveis com diferentes fotoiniciadores, utilizando duas fontes de luz (monowave e poliwave). **Materiais e métodos:** três tipos de cimentos resinosos foram utilizados, com diferentes fotoiniciadores: canforoquinona, sistema APS e Ivocerin. Trinta amostras foram confeccionadas e divididas em 6 grupos (n=5). As amostras de cimento resinoso foram feitas no formato de um incisivo central superior (dente 11) e fotoativado sob uma lâmina de cerâmica com espessura de 0,5mm. Foi utilizado um fotopolimerizador único que emite dois tipos de luz (mono e poliwave), apenas alterando a ponteira (Radii Xpert, SDI). A ponta do equipamento foi posicionada no centro da amostra, utilizando um dispositivo específico. Para avaliar o grau de conversão foi realizada a espectroscopia Raman e para dureza foi realizado teste de microdureza Knoop. Ambos avaliaram cinco regiões nas amostras: cervical, mesial, vestibular (centro), distal e incisal. **Resultados:** para o grau de conversão houve diferença significativa apenas para tipo de cimento ($p<0,001$) mostrando o cimento com fotoiniciador APS apresentando resultados satisfatórios; para dureza houve diferença significativa para tipo de cimento, novamente o cimento com sistema APS ($p<0,001$), tipo de luz monowave ($p<0,001$), região vestibular ($p<0,001$) e interação tipo de cimento X tipo de luz ($p<0,001$). **Conclusão:** a fonte de luz quando avaliada entre poliwave ou monowave pode não ser um fator determinante nos resultados de propriedades físicas dos cimentos resinosos, visto que independente da luz, os resultados serão satisfatórios. A região vestibular apresentando melhores resultados, deixa como uma alerta a necessidade de maior quantidade de fotopolimerização nas margens da cimentação. O fotoiniciador dos cimentos resinosos na maioria das vezes pode e deve ser fotoativado com um equipamento de boa qualidade, mas a quantidade de feixes de luz não irá interferir em resultados negativos no seu desempenho.

Palavras-chaves: cimento resinoso, fotoiniciador, fotopolimerizador

ABSTRACT

Objective: To evaluate the chemical and mechanical properties at the margins of light-cured resin cements with different photoinitiators, using two light sources (monowave and polywave). **Materials and methods:** Three types of resin cements were used, with different photoinitiators: camphoroquinone, APS system and Ivocerin. Thirty samples were made and divided into 6 groups (n=5). The resin cement samples were made in the shape of a maxillary central incisor (tooth 11) and photoactivated under a 0.5 mm thick ceramic sheet. A single light curing unit emitting two types of light (mono and polywave) was used, only changing the tip (Radii Xpert, SDI). The tip of the equipment was positioned in the center of the sample, using a specific device. To evaluate the degree of conversion, Raman spectroscopy was performed, and for hardness, Knoop microhardness testing was performed. Both evaluated five regions in the samples: cervical, mesial, buccal (center), distal and incisal. **Results:** for the degree of conversion there was significant difference only for the type of cement ($p<0.001$) showing the cement with APS photoinitiator presenting satisfactory results; for hardness there was significant difference for cement type, again the cement with APS system ($p<0.001$), type of monowave light ($p<0.001$), vestibular region ($p<0.001$) and interaction type of cement X type of light ($p<0.001$). **Conclusion:** The light source when evaluated between polywave or monowave may not be a determining factor in the results of physical properties of resin cements, since regardless of the light, the results will be satisfactory. The vestibular region presenting the best results, leaves as a warning the need for a greater amount of photopolymerization at the margins of the cementation. The photoinitiator of resin cements in most cases can and should be photoactivated with good quality equipment, but the quantity of light beams will not interfere in negative results in its performance.

Keywords: resin cement, photoinitiator, photopolymerizer

1. INTRODUÇÃO E REFERENCIAL TEÓRICO

Os cimentos resinosos evoluíram consideravelmente ao longo dos anos, e trouxeram para a Odontologia o avanço na cimentação de peças em cerâmica. O cimento resinoso é um material de cimentação com objetivo de unir estruturas distintas com uma característica fluida e a base de resina. (1) Para que esse material seja considerado de boa qualidade, é necessário possuir algumas características ideais, como: tempo de trabalho satisfatório, fácil remoção de excessos, baixa sensibilidade técnica ao operador, pequena espessura de película, boas propriedades físicas, baixa solubilidade e boa adesão. (1,2)

Desta forma, para um bom desempenho clínico a longo prazo deste material, um fator fundamental é o processo de fotoativação. Fotopolimerização é uma reação química em que o processo é ativado pela luz e moléculas de monômeros reagem para formar cadeias poliméricas tridimensionais. (3) O objetivo é transformar instantaneamente um monômero líquido em um polímero sólido após a exposição à luz. A exposição à luz é capaz de excitar o sistema fotoiniciador presente no material à base de resina para gerar radicais livres e, assim, iniciar a polimerização do material. (4) Um material restaurador que não obteve uma boa qualidade de polimerização, ou seja, subpolimerizado, pode resultar em falhas clínicas prematura, devido a defeitos marginais, cáries recorrentes ou até fratura de restauração. (5)

A busca pela estética de materiais resinosos, trouxe aos fabricantes e missão em desenvolver materiais que comportem de tal forma. Para materiais resinosos, que necessitam de fotoiniciador, tornou-se claro a necessidade de substituir ou no mínimo diminuir o uso, da Canforoquinona, fotoiniciador mais utilizado no mercado, mas que suas propriedades amareladas, contribuíam para a pigmentação do material, tornando assim uma estética comprometida. (6) Outros fotoiniciadores como o TPO (óxido trimetilfosfínico), Ivocerin (benzonil germânico) e PPD (fenil propanodiona) foram inseridos no mercado. Porém, alguns sistemas fotoiniciadores absorvem luz violeta, e quando esta luz não é emitida pela unidade de luz, o fotoiniciador não é efetivado de forma eficiente, reduzindo o grau de conversão do material resinoso. (7)

Com a inclusão de outros sistemas fotoiniciadores, que absorvem diferentes picos de luz, novas unidades de luz foram lançadas no mercado. Os equipamentos de fotopolimerização de diodo emissor de luz (LED) de primeira e segunda geração unidades (LCUs) mostram um pico de emissão (monowave) que corresponde ao espectro de absorção de CQ (430-500 nm) (8). O equipamento de fotopolimerização de diodo emissor deluz (LED) de terceira geração são considerados dispositivos de amplo espectro. Eles têm dois ou mais picos de emissão (poliwave) com comprimentos de onda mais estreitos; violeta para ativar fotoiniciadores alternativos e azul para ativar CQ. (9,10)

Portando, o objetivo do presente estudo foi avaliar as propriedades mecânicas de cimentos resinosos fotopolimerizáveis com diferentes fotoiniciadores, utilizando um único aparelho de fotoativação, alterando a fonte de luz entre poliwave e monowave, em cincos pontos específicos da cimentação: cervical, mesial, vestibular (centro), distal e incisal. As hipóteses nulas foram: 1) a fonte de luz mono ou poliwave não afetará as propriedades do cimento resinoso 2) a região vestibular(centro) apresentará melhores resultados de propriedades, comparado a demais regiões

<u>CAPÍTULO 1</u>

Artigo será submetido na revista Operative Dentistry "The oficial jornal of: the Academy of American Gold Foil Operators, the Academy of Operative Dentistry, and the Academy of R. V. Tucker Study Clubs"

INFLUÊNCIA DE UNIDADES DE LUZ MONO E POLIWAVE NA DUREZA E GRAU DE CONVERSÃO DE CIMENTOS RESINOSOS FOTOPOLIMERIZÁVEIS

Influence of Monowave and Polywave Light Units on the Hardness and Degree of Conversion of Light Cured Resin Cement

Giovanna Chaves Souza Borges[1], Júlia de Sousa Gonçalves[2], Rafael Resende de Miranda[3], Maria Tereza Hordones Ribeiro[3], Flávio Domingues das Neves[4], Carlos José Soares[5], Karla Zancopé[6]

[1] MS student, Department of Occlusion, Fixed Prosthesis and Dental Materials, School of Dentistry,Federal University of Uberlândia, Uberlândia, MG, Brazil

[2] Undergraduate Student, Federal University of Uberlândia, Uberlândia, MG, Brazil

[3] DDS, MS, PhD, professor, Department of Operative Dentistry and Dental Materials, School of Dentistry, Federal University of Uberlândia, Uberlândia, MG, Brazil.

[4] DDS, MS, PhD, professor, Department of Occlusion, Fixed Prosthesis and Dental Materials,School of Dentistry, Federal University of Uberlândia, Uberlândia, MG, Brazil.

[5] DDS, MS, PhD, professor, Department of Operative Dentistry and Dental Materials, School of Dentistry, Federal University of Uberlândia, Uberlândia, MG, Brazil.

[6] DDS, MS, PhD, professor, Department of Occlusion, Fixed Prosthesis and Dental Materials,School of Dentistry, Federal University of Uberlândia, Uberlândia, MG, Brazil.

Corresponding author:

Professor Karla Zancopé

Department of Occlusion, Fixed Prosthesis and Dental Materials, School of

Dentistry, Federal University of Uberlândia.

Av. Pará, 1720, Bloco 4LA sala 4LA-40, Campus

Umuarama, +55(34)3225-8105

Uberlândia, Minas Gerais, Brazil, 38405-320

Email: karlazancope@gmail.com

ACKNOWLEDGMENTS

The authors want to thank CAPES, CNPq, FAPEMIG, CPBio, NEPRO and Biaor Research Group for its contribution for this work.
The authors report no conflicts of interest related to this study.

INFLUENCE OF MONOWAVE AND POLYWAVE LIGHT UNITS ON THE HARDNESS AND DEGREE OF CONVERSION OF LIGHT CURED RESIN CEMENT

Objective: To evaluate the chemical and mechanical properties at the margins of light-cured resin cements with different photoinitiators, using two light sources (monowave and polywave). **Materials and methods:** Three types of resin cements were used, with different photoinitiators: camphoroquinone, APS system and Ivocerin. Thirty samples were made and divided into 6 groups (n=5). The resin cement samples were made in the shape of a maxillary central incisor (tooth 11) and photoactivated under a 0.5 mm thick ceramic sheet. A single light curing unit emitting two types of light (mono and polywave) was used, only changing the tip (Radii Xpert, SDI). The tip of the equipment was positioned in the center of the sample, using a specific device. To evaluate the degree of conversion, Raman spectroscopy was performed, and for hardness, Knoop microhardness testing was performed. Both evaluated five regions in the samples: cervical, mesial, buccal (center), distal and incisal. **Results:** for the degree of conversion there was significant difference only for the type of cement ($p<0.001$) showing the cement with APS photoinitiator presenting satisfactory results; for hardness there was significant difference for cement type, again the cement with APS system ($p<0.001$), type of monowave light ($p<0.001$), vestibular region ($p<0.001$) and interaction type of cement X type of light ($p<0.001$). **Conclusion:** The light source when evaluated between polywave or monowave may not be a determining factor in the results of physical properties of resin cements, since regardless of the light, the results will be satisfactory. The vestibular region presenting the best results, leaves as a warning the need for a greater amount of photopolymerization at the margins of the cementation. The photoinitiator of resin cements in most cases can and should be photoactivated with good quality equipment, but the quantity of light beams will not interfere in negative results in its performance.

Keywords: resin cement, photoinitiator, photopolymerizer

INTRODUCTION

Resin cements have evolved considerably over the years, and have brought to dentistry advances in the cementation of ceramic pieces. Resin cement is a cementation material that aims to bond distinct structures with a fluid and resin-based characteristic.(1) For this material to be considered of good quality, it must have some ideal characteristics, such as: satisfactory working time, easy removal of excess, low technical sensitivity to the operator, small film thickness, good physical properties, low solubility and good adhesion.(1,2)

Thus, for a good long-term clinical performance of this material, a fundamental factor is the photoactivation process. Photopolymerization is a chemical reaction in which the process is activated by light and monomer molecules react to form three-dimensional polymeric chains.(3) The goal is to instantly transform a liquid monomer into a solid polymer after exposure to light. Exposure to light is able to excite the photoinitiator system present in the resin-based material to generate free radicals and thus initiate polymerization of the material. (4) A restorative material that has not achieved a good quality of polymerization, underpolymerized, may result in premature clinical failure due to marginal defects, recurrent caries or even fracture of the restoration.(5)

The search for the aesthetics of resin materials, brought to the manufacturers and mission to develop materials that behave in such a way. For resin materials that require photoinitiators, it has become clear the need to replace, or at least reduce the use of camphoroquinone, the most widely used photoinitiator in the market, but its yellowish properties contributed to the pigmentation of the material, thus compromising aesthetics. (6) Other photoinitiators such as TPO (trimethylphosphinic oxide), Ivocerin (Germanic benzonyl) and PPD (phenyl propanedione) have been introduced in the market. However, some photoinitiator systems absorb violet light, and when this light is not emitted by the light unit, the photoinitiator is not effective, reducing the degree of conversion of the resin material.(7)

With the inclusion of other photoinitiator systems, which absorb different peaks of light, new light units have been launched in the market. The first and second generation light emitting diode (LED) light curing units (LCUs) show a peak emission (monowave) that corresponds to the QC absorption spectrum (430-500 nm) (8). Third generation light emitting diode (LED) photopolymerization equipment are considered to be broad spectrum devices. They have two or more emission peaks (polywave) with narrower wavelengths; violet to activate alternative photoinitiators and blue to activate CQ. (9,10)

Therefore, the aim of this study was to evaluate the mechanical properties of light-cured resin cements with different photoinitiators using a single photoactivation device, changing the light source between polywave and monowave, at five specific cementation points: cervical, mesial, vestibular (center), distal and incisal. The null hypotheses were: 1) the mono or polywave light source will not affect the properties of the resin cement. 2) the buccal (center) region will have better property results compared to the other regions.

MATERIALS AND METHODS

Study Design

Three types of photoactivated resin cements with different photoinitiators were used in the study: camphorquinone (Megalink Esthetic; Odontomega, São Paulo, Brazil); APS system (Allcem Veneer;FGM, Santa Catarina, Brazil); Ivocerin (Variolink Esthetic LC; Ivoclar Vivadent, Schaan, Liechtenstein). (Figure 1)

A lithium disilicate ceramic block (IPS e.max CAD, Ivoclar Vivadent, Schaan, Liechtenstein) HT/A1/C14 was cut to a thickness of 0.5 mm, simulating a veneer, using a precision saw (Isomet 1000, Buehler, Lake Bluff, IL, USA). The ceramic sample was then crystallized in a dental furnace (Programat EP 3010, Ivoclar Vivadent). The Radii Xpert (SDI Limited., Victoria, Australia) light curing device with two light source tips, one monowave and one polywave, the light intensity is 1500mW/cm², and was used to light cure the cements according to each experimental group. (Figure 2)

Specimen Preparation

The samples were initially developed using a template following the shape of a maxillary central incisor, tooth 11. A 3 mm thick, transparent acetate plate was used. On this plate, a maxillary central incisor was designed, taking as reference the trapezoidal shape of the tooth, 10 mm high and 9 mm wide and cut with a diamond bur n° 3122 (KG Sorensen, Cotia, SP, Brazil).

With the cut and the ideal size made on the plate, the samples were made with resin cement as follows: initially a glass plate was placed as a support, a mylar strip on top and then the acetate plate with the mold of the tooth, a portion of the resin cement, another strip of polyester and the ceramic sample with 0,5 mm of thickness were placed (figure 3), followed by light curing for 40 seconds. To photoactivate the samples, the

Radii Xpert (SDI Limited, Victoria, Australia) was used, because in a single device it is possible to place a polywave or monowave tip (Figure 4). The device was positioned on a specific support so that the equipment does not move during the photoactivation for the production of samples. Using the two tips provided by the manufacturer, the samples were photoactivated according to the pre-defined groups. After photoactivation, the cement was inserted in the acetate plate, exactly in the shape of the tooth. The samples were stored in an incubator for 24hrs until laboratory tests.

Group Distribution

A total of 30 samples were used, divided into 6 groups, and 3 types of photoactivatable resin cements, changing the light source between polywave and monowave. Within each sample, 5 different regions were evaluated, generating the following experimental groups:

Raman spectroscopy

A LabRam HR Evolution Raman spectrometer (Horiba LabRam, Villeneuve d'Ascq, France) was used to evaluate the degree of conversion of the cements. The measurements were carried out 24 hours after light curing of the resin cement samples. The samples were evaluated at the 5 pre-established regions and the parameters used at the time of the test were: Spectrum (cm-1): 1300 (centered); Acquisition time(s): 15s; Accumulation: 9 (repetitions); DuoScan dot: Off; Target: x100Vis; Grid: 600 gr/mm; ND Filter: 25%; Laser: 532 nm (100% = ~ 50 mW); Hole: 400; Range: Visible; Estimated time: 2 min 15 s (per spectrum).

The post-processing of the spectra was performed with OriginPro 2018 software (OriginLab Corporation, Northampton, MA, USA), the peaks were integrated, and the ratio was automatically given by the software. An equation based on the data obtained was used to measure the degree of conversion:

$$DC(\%) = \left(\frac{R\,(polymerized)}{R\,(non-polymerized)}\right) \times 100$$

where R is the ratio of aliphatic and aromatic peak areas at 1637 cm^{-1} and 1608 cm^{-1} in polymerized and unpolymerized resin cements. One sample of each cement, unpolymerized, underwent the test.

Microhardness test

Knoop microhardness was performed 24 hours after measuring the degree of conversion. The samples were placed in a microdurometer (MicroMet 5104, Buehler, Lake Bluff, IL, USA) and 5 measurements were taken in five different positions: cervical, mesial, buccal (center), distal and incisal. Each sample was 0,3 mm thick and a load of 50 gf was applied for 15s for a total of 3 cuts per point in the sample, totaling 15 indentations per sample with 1 mm spacing between them to obtain an average value.

Statistical Analysis

The degree of conversion and hardness data were analyzed for normal distribution and equality of variances using the Shapiro-Wilk and Levene tests, respectively. Three-way ANOVA was used to compare the main factors: type of resin cement (1), type of light (2) and region (3). Multiple comparisons were performed using Tukey's post hoc test. All tests used a significance level of $\alpha = 0.05$, and all analyses were performed using Sigma Plot 12.5 (Systat Software Inc, San Jose, CA, USA). A p value of less than 0.05 was considered to be statistically significant.

RESULTS

For the degree of conversion (Table 1), there was a significant difference only for the type of cement (Alcem Venner) ($p<0.001$). There was no difference for type of light ($p=0.594$), nor for region ($p=0.168$) nor for interaction between the three factors ($p=0.736$).

For Knoop hardness (Table 2), there was a significant difference for type of cement (Alcem Venner) ($p<0.001$), type of light (monowave) ($p<0.001$), region (buccal)($p<0.001$) and for the interaction type of cement X type of light ($p<0.001$). There was no difference for interaction between the three factors under study ($p=0.978$).

DISCUSSION

This study evaluated the properties of light-cured resin cements with different photoinitiators in five different areas using poly and monowave light sources. The null hypotheses of the study were accepted, showing that the type of mono and polywave light had no significant relevant results and the buccal region showed satisfactory results compared to the others.

For the degree of conversion, resin cement with the APS system showed better results, regardless of the light source and region. Thus, it is observed that the light source may not influence the result of the cement. According to the manufacturer, the APS system is a union of different photoinitiators, together with camphoroquinone, which is better absorbed by blue light, this justifies the indifference in the use of poly and monowave light, knowing that violet light has less penetration in this type of photoinitiator.

For hardness, the APS system continued to show better results, combined with the monowave light, and the vestibular region showed better results. We know that in a light curing system with more than one light source, the violet light has lower intensities and may have a ceramic interlayer, which got less light.

As expected, the central region showed better results, this justifies the ratio of the shadow area at the margins of a ceramic, because the diameter of the light source is smaller than the diameter of an upper central incisor. Therefore, two light cures are necessary in different regions of the cemented area.

The stabilization of the curing light is one of the primary factors for complete polymerization of the cement. The constant movement of the equipment at the time of cementation may decrease the degree of conversion and hardness of the material (11), so the best way to perform this procedure is with the equipment stabilized.

For light-cured cements, a decrease in the light energy density coinciding with a gradual increase in ceramic thickness could decrease the DC (12). Non-uniform beam profile of the equipment and its non-homogeneous light transmission through ceramic blocks result in non-uniform microhardness of the resin cement (13).

The suggested energy may differ for other cements because the polymerization pattern of resin cements varies. (14) This particular irradiance distribution may affect the activation of free radicals, which in turn affected the conversion rate and microhardness.(15) The conversion of double bonds by photopolymerization depends on a minimum energy to excite the photoinitiator and produce a sufficient number of radicals for polymerization.(16,17)

New photoinitiators are frequently launched on the market, aiming to decrease the amount of camphoroquinone use in the restorative materials, relatively decreasing the yellowing of the restorations. The photoinitiator phenylpropanedione (PPD) is highly viable in light-cured resin cement formulations, reducing or eliminating CQ that is yellowish without compromising bond strength and, moreover, both LED and QTH are effective in polymerizing cements containing either PPD or CQ. (18,7)

Other works showed that smaller marginal and internal discrepancies were found in the cervical and incisal region of ceramic veneers fabricated using the press technique.(19) For the use of lighter shaded materials, the use of polywave LEDs significantly improves the DC and KHN of materials containing TPO (trimethylbenzoyl-diphenylphosphine oxide).(20)

The thickness of the ceramic, is a factor that can influence the passage of light and thus the conversion of resin cements. The microhardness of resin cements decreased with increasing CAD-CAM block thickness, and inhomogeneous light transmission from a light polymerization unit through CAD-CAM blocks resulted in non-uniform microhardness of the resin cement.(21)

Some limitations were encountered because this was an in vitro study, such as minimum necessary cement thickness of 3 mm, so that no deformation of the samples occurred.Clinical studies may be developed to confirm the results of this laboratory study, evaluating the margins and types of cements, contributing to the clinical routine of the professional.

CONCLUSION

The light source when evaluated between polywave or monowave may not be a determining factor in the results of physical properties of resin cements, since regardless of the light, the results will be satisfactory. The vestibular region presenting the best results, leaves as a warning the need for a greater amount of photopolymerization at the margins of the cementation. The photoinitiator of resin cements in most cases can and should be photoactivated with good quality equipment, but the quantity of light beams will not interfere in negative results in its performance.

REFERENCES

1. Marinho MLVD, Suzuki TYU, Assunção WG, Moraes JCS, dos Santos PH. Degree of conversion of resin cements polymerized under different thicknesses of feldspathic porcelain. Braz Jour of Ora Sci 2019 Jan; 18: 191-250
2. Farias DCS, Gonçalves LM, Walter R, Chung Y, Blatz MB. Bond strengths of various resin cements to different ceramics. Braz Oral Res 2019 Oct; 33: 1590-1807
3. Soares CJ, Faria-E-Silva AL, Rodrigues MP, Vilela ABF, Pfeifer CS, Tantbirojn D, Versluis A. Polymerization shrinkage stress of composite resins and resin cements - What do we need to know? Braz Oral Res 2017 Aug; 31: 1807-3107
4. Marinho MLVD, Strazzi-Sayhon HB, Moraes JCS, Assunção WG, Dos Santos PH. Degree of conversion of resin cements polymerized under different ceramic systems. Gen Dent 2020 Apr; 68:44-49
5. Sinhoreti MAC, Oliveira DCRS, Rocha MG, Roulet JF. Light-curing of resin-based restorative materials: an evidence-based approach to clinical practice application. J Clin Dent Res 2018 Jan; 15:44-53
6. Miletic V, Santini A. Optimizing the concentration of 2,4,6-trimethylbenzoyldiphenylphosphine oxide initiator in composite resins in relation to monomer conversion. Dental materials journal. 2012 Jan; 31:717-23.
7. Segreto DR, Naufel FS, Brandt WC, Guiraldo RD, Correr-Sobrinho L, Sinhoreti MA. Influence of photoinitiator and light-curing source on bond strength of experimental resin cements to dentin. Braz Dent J 2016 Jan; 27:83-9
8. Contreras SCM, Jurema ALB, Claudino ES, Bresciani E, Caneppele TMF. Monowave and polywave light-curing of bulk-fill resin composites: degree of conversion and marginal adaptation following thermomechanical aging. Biomater Investig Dent 2021 Jul; 8:72-78
9. Rocha MG, Maucoski C, Roulet JF, Price RB. Depth of cure of 10 resin-based composites light-activated using a laser diode, multi-peak, and single-peak light emitting diode curing lights. Journal of dentistry. 2022, Jan; 122:104141
10. Price RB, Ferracane JL, Hickel R, Sullivan B. The light-curing unit: An essential piece of dental equipment. International dental journal. 2020, Jan;70:407-17

11. Bragança GF, Vianna AS, Neves FD, Price RB, Soares CJ. Effect of exposure time and moving the curing light on the degree of conversion and Knoop microhardness of light-cured resin cements. Dent Mater 2020 Nov; 36:340-351
12. Abate PF, Zahra VN, Macchi RL. Effect of photopolymerization variables on composite hardness. J Prosthetic Dent 2001 Dec; 86:632-5
13. Mendonça LM, Ramalho IS, Lima LASN, Pires LA, Pegoraro TA, Pegoraro LF. Influence of the composition and shades of ceramics on light transmission and degree of conversion of dual-cured resin cements. J Appl Oral Sci 2019 Jul; 27: 7757-2018
14. Meng X, Yoshida K, Atsuta M. Influence of ceramic thickness mechanical properties and polimer estructure of dual-cured resin luting agents. Dent Mater 2008 May; 24:594-9
15. Chen Y, Yao C, Huang C, Wang Y. The effect of monowave and polywave light-polymerization units on the adhesion of resin cements to zirconia. J Prosthet Dent 2019 Mar; 121:1-549
16. Koch A, Kroeger M, Hartung M, Manetsberger I, Hiller KA, Schmalz G, Friedl KH. Influence of ceramic translucency on curing efficacy of different light-curing units. J Adhes Dent 2007 Oct; 9:449-462
17. Haenel T, Hausnerová B, Steinhaus J, Price RB, Sullivan B, Moeginger B. Effect of the irradiance distribution from light curing units on the local micro-hardness of the surface of dental resins. Dent Mater 2015 Feb; 31:93-104
18. Sulaiman TA, Abdulmajeed AA, Donovan TE, Ritter AV, Lassila LV, Vallittu PK, Närhi TO. Degree of conversion of dual-polymerizing cements light polymerized through monolithic zirconia of different thicknesses and types. J Prosthet Dent 2015 Jul; 114:103-8
19. Al-Dwairi ZN, Alkhatatbeh RM, Baba NZ, Goodacre CJ. A comparison of the marginal and internal fit of porcelain laminate veneers fabricated by pressing and CAD-CAM milling and cemented with 2 different resin cements. J Prosthet Dent. 2019 Mar;121(3):470-476
20. Santini A, Miletic V, Swift MD, Bradley M. Degree of conversion and microhardness of TPO-containing resin-based composites cured by polywave and monowave LED units. J Dent. 2012 Jul;40(7):577-84

21. Go YR, Kim KM, Park SH. Influence of inhomogeneity of the polymerization light beam on the microhardness of resin cement under a CAD-CAM block. J Prosthet Dent 2022 Mar; 22: 87-7

FIGURES

Name	Manufacturer	Photoinitiator	Color
Variolink Aesthetic LC	Ivoclar Vivadent	Ivocerin	Translucent
Allcem Veneer	FGM	APS	Translucent
Megalink Esthetic	Odontomega	Camphoroquinone	Translucent

Figure 1. Resin Cements informations

Type	Manufacturer	Color
Poliwave	395 - 480nm	Violet and Blue
Monowave	440 - 480 nm	Blue

Figure 2. LCUs informations

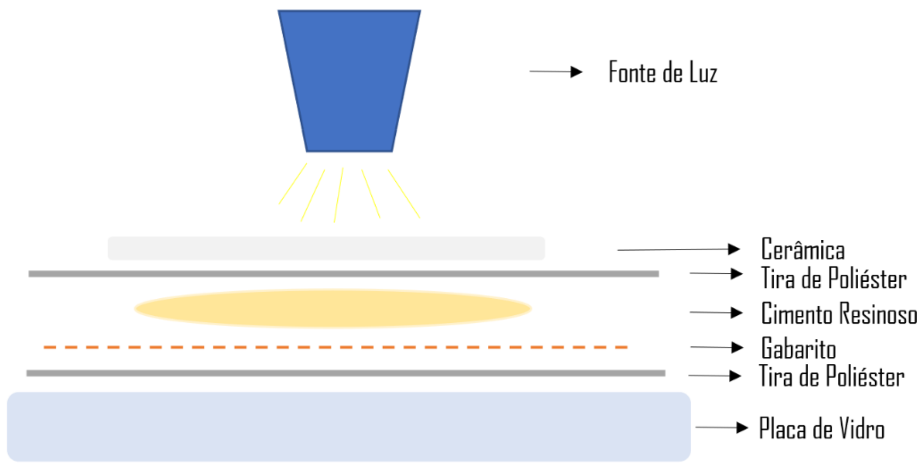

Figure 3. Order of preparation of the samples

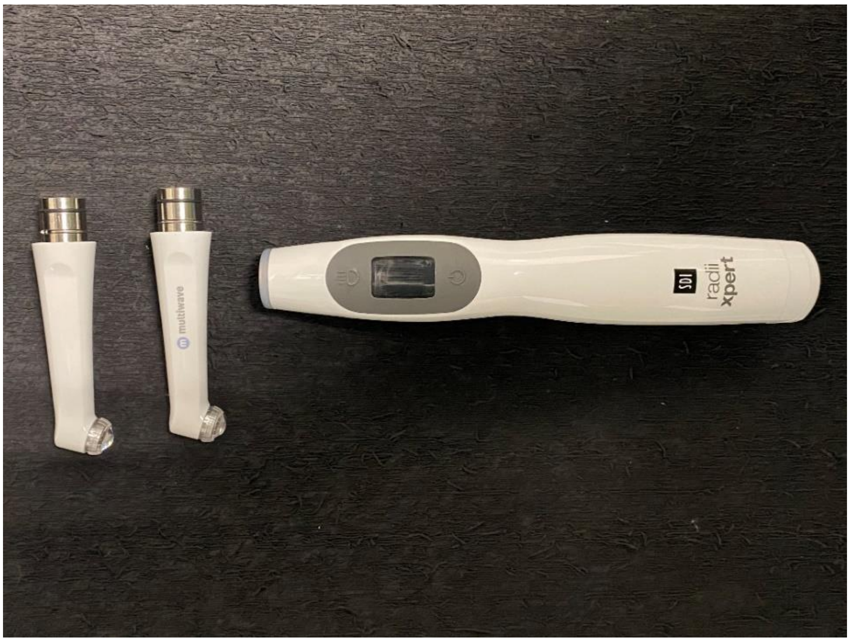

Figure 4. Light curing equipment and the two tips

TABLES

Table 1 - Mean and standard deviation (SD) of the degree of conversion (%) in the different experimental groups.

	Variolink Esthetic		Allcem Veneer		Megalink Esthetic	
	Monowave	Poliwave	Monowave	Poliwave	Monowave	Poliwave
Cervical	45.95 ± 2.92 Aa	47.36 ± 3.67 Aa	71.08 ± 1.92 Aa	69.39 ± 4.63 Aa	59.88 ± 4.41 Aa	60.37 ± 7.91 Aa
Mesial	44.86 ± 9.08 Aa	48.33 ± 1.96 Aa	70.98 ± 2.76 Aa	71.71 ± 2.66 Aa	59.19 ± 3.29 Aa	60.78 ± 2.88 Aa
Distal	44.70 ± 2.80 Aa	45.34 ± 4.41 Aa	72.51 ± 2.62 Aa	70.26 ± 3.65 Aa	56.82 ± 0.91 Aa	58.52 ± 2.90 Aa
Vestibular	50.36 ± 5.22 Aa	49.39 ± 2.81 Aa	72.51 ± 1.60 Aa	73.40 ± 2.28 Aa	60.65 ± 3.71 Aa	57.72 ± 4.57 Aa
Incisal	50.22 ± 6.91 Aa	46.26 ± 3.49 Aa	70.09 ± 0.59 Aa	70.33 ± 3.27 Aa	56.89 ± 2.43 Aa	57.81 ± 2.91 Aa

Grouped Average	47.28 ± 4.82***	71.23 ± 2.82*	58.86 ± 3.86**

Different capital letters indicate statistical difference in the columns and lower case letters in the rows.

*indicates difference between cements.

Table 2 - Mean and standard deviation (SD) of Knoop hardness in the different experimental groups.

	Variolink Esthetic		**Allcem Veneer**		**Megalink Esthetic**	
	Monowave	Poliwave	Monowave	Poliwave	Monowave	Poliwave
Cervical	13.56 ± 2.17 Aa	10.43 ± 1.75 Ab	22.28 ± 2.43 ABa	16.47 ± 5.01 ABb	5.03 ± 2.08 Ba	5.78 ± 1.43 Ba
Mesial	14.11 ± 3.67 Aa	12.33 ± 1.07 Ab	21.65 ± 6.29 ABa	18.34 ± 4.41 ABb	7.51 ± 2.67 ABa	8.01 ± 2.33 Aa
Distal	14.30 ± 2.56 Aa	10.76 ± 2.32 Ab	23.25 ± 4.06 ABa	16.14 ± 3.25 ABb	6.88 ± 2.76 ABa	7.74 ± 3.44 Aa
Vestibular	15.88 ± 2.09 Aa	13.77 ± 2.02 Ab	26.54 ± 3.92 Aa	19.24 ± 4.53 Ab	10.98 ± 1.79 Aa	10.89 ± 2.45 Aa
Incisal	14.82 ± 2.55 Aa	11.93 ± 2.28 Ab	19.36 ± 4.92 Ba	14.34 ± 4.47 Bb	4.46 ± 1.27 Ba	6.63 ± 3.11 Ba
Grouped Average	13.19 ± 2.71**		19.76 ± 5.36*		7.39 3.04***	

Different capital letters indicate statistical difference in the columns and lower case letters in the rows.

*indicates difference between cements.