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AVALIAÇÃO DA INTERFACE FACETA-CIMENTO-ESMALTE COM TOMOGRAFIA POR COERÊNCIA ÓPTICA

RECIFE- PE
2017

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AVALIAÇÃO DA INTERFACE FACETA-CIMENTO-ESMALTE POR TOMOGRAFIA POR COERÊNCIA ÓPTICA

Dissertação apresentada à banca da Pós-Graduação em Clínica Integrada do Centro de Ciências da Saúde da Universidade Federal de Pernambuco, como requisito para obtenção do grau de mestre em Clínica Odontológica Integrada.

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Co-Orientadora: Prof Dra Cláudia Cristina Brainer de Oliveira Mota

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TEREZA JANUÁRIA COSTA DIAS

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" AVALIAÇÃO DA INTERFACE FACETA-CIMENTO-ESMALTE TOMOGRAFIA POR COERÊNCIA ÓPTICA "

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“Nada do que foi será de novo do jeito que já foi um dia!”

Lulu Santos

RESUMO

O objetivo deste trabalho foi a avaliação da interface de cimentação de micro laminados cerâmicos por tomografia por coerência óptica (OCT), cimentados com diferentes cimentos resinoso (RBC), através da técnica convencional cimentação ou utilizando o dispositivo de vibração sônica (SV) antes da reação de cura do cimento.
Os laminados foram preparados à base de IPS e.max (Ivoclar-Vivadent), onde blocos de esmalte bovino foram preparados e divididos aleatoriamente em seis grupos (n = 5) de acordo com os RBC utilizados: All Cem Veneer (FGM Dentscare), ACC/ ACSV; NX3 (Kerr), NX3C/ NX3SV; and RelyX Veneer (3M ESPE), RVC/ RVSV. Os grupos ACC / NX3C / RVC foi submetido à cimentação convencional (C), enquanto que o ACSV / NX3SV / RVSV recebeu o Smart Sonic Device (SSD, FGM Denstcare) operando a 170 Hz antes da reação de cura. A análise de OCT foi realizada antes da aplicação de RBC, 48h após a cimentação e 48h após a ciclagem térmica. O sistema OCT (Ganymede SD-OCT, Thorlabs) opera a 930 nm de comprimento de onda central, taxa de varredura axial de 29 kHz, resolução lateral de 8 μm e resolução axial de 5,8 μm / 4,4 μm no ar / água, respectivamente. Um algoritmo foi desenvolvido em MATLAB para redução de ruído e extraídos o A-scan das imagens filtradas para análise. Histogramas foram extraídos de amostras através do software Image J, onde os tons de cinza foram avaliados. As falhas foram visualizadas em imagens bidimensionais de OCT e confirmadas pelos A-scans. Os testes T-student e Anova foram utilizados quando os casos de normalidade foram indicados. Mann-Whitney e Kruskall-Wallis, quando a normalidade não foi observada. As falhas foram claramente visualizadas em imagens OCT e confirmadas por A-scans. Não houve diferença estatística entre a técnica convencional e o uso da técnica SVD para evitar falhas. Além disso, após o ciclo térmico, apenas RVSV apresentou resultados estatisticamente diferentes em relação aos outros grupos.

Palavras-chave: Tomografia de Coerência Óptica. Laminados Dentários. Cerâmica.

ABSTRACT

To evaluate using optical coherence tomography (OCT) ceramic veneers interface with different resin-based cements (RBC), through conventional technique or using sonic vibration device (SV) before RBC cure reaction.

IPS e.max (Ivoclar-Vivadent) veneers were prepared for bovine enamel, and randomly divided into six groups (n=5) according to the RBC used: ACC/ACSV, All Cem Veneer (FGM Dentscare); NX3C/NX3SV, NX3 (Kerr); and RVC/RVSV, RelyX Veneer (3M ESPE). ACC/NX3C/RVC underwent conventional technique cementation (C), whilst ACSV/NX3SV/RVSV received the Smart Sonic Device (SSD, FGM Denstcare) operating at 170 Hz before RBC cure reaction. OCT analysis was performed before the RBC application, 48h after cementation and 48h after thermal cycling. The OCT system (Ganymede SD-OCT, Thorlabs) operates at 930 nm central wavelength, 29 kHz axial scan rate, 8 µm lateral resolution and 5.8 µm/ 4.4 µm axial resolution in air/water, respectively. An algorithm developed in MATLAB to noise reduction and A-scan analysis to filtered images. Histograms were extracted from samples through Image J software Failures were visualized in OCT images and confirmed by A-scans. T-student and Anova were used when the cases of normality were indicated. Mann-Whitney and Kruskall-Wallis, when normality were not. The faults were clearly visualized in OCT images and confirmed by A-scans. There was no statistical difference between the conventional technique and the use of the SVD technique to avoid failures. In addition, after the thermal cycle, only RVSV presented statistically different results in relation to the other groups.

Keywords: Optical Coherence Tomography. Lithium Disilicate. Ceramic.

SUMÁRIO

1 INTRODUÇÃO

Esta dissertação compreende uma revisão de literatura sobre técnicas de cimentação de microlaminados cerâmicos, sua interface de adesão ao substrato dentário, os materiais para cimentação e a Tomografia por Coerência Ótica (OCT), que foi o método de análise utilizado. Segue como parte integrante da dissertação o artigo a ser submetido ao periódico Dental Materials (IF 3.931 e Qualis Capes A1 Odontologia), contendo metodologia, resultados e discussão acerca do tema, para obtenção do grau de mestre.

O apelo estético em relação à forma e coloração do sorriso tem aumentado em larga escala nos últimos anos, como decorrência da exposição contínua da imagem das pessoas. A evolução dos materiais restauradores adesivos, assim como o progresso das cerâmicas odontológicas, no que tange à capacidade adesiva, possibilita novas alternativas de intervenções estéticas mais duradouras e com maior mimetismo à estética natural do sorriso. As cerâmicas enquanto materiais restauradores estéticos apresentam algumas características que se destacam: capacidade de mimetizar a estrutura dentária opticamente e anatomicamente; excelente polimento superficial; conservação de coloração; e, em cerâmicas com camadas vítreas, são passíveis de condicionamento ácido, o que potencializa a adesão à estrutura dentária. (DE ANDRADE et al., 2013)

Em restaurações cerâmicas de alta performance estética, a excelente qualidade na cimentação da restauração se faz imprescindível, uma vez que a camada de cimento resinoso subjacente exercerá fortes influências na beleza e na longevidade do tratamento. Insucessos neste tipo de intervenção estão intimamente relacionados a falhas desta interface. Tais falhas podem estar relacionadas a problemas na interferência da coloração do cimento resinoso, presença de bolhas e defeitos na camada de cimento, que podem ocasionar infiltração marginal, pigmentação, cáries secundárias, descolamento da restauração, sensibilidade pós-operatória, e propiciar pontos de tensão para fratura da porcelana subjacente (de ANDRADE BORGES et al., 2015). O tipo, a cor e a espessura de cerâmica também interferem no grau de conversão da camada de cimento resinoso e a maneira como o material é cimentado (ÖZTÜRK et al., 2013;FERRACANE; HILTON, 2016).

Para atender a esta demanda, tecnologias específicas têm sido desenvolvidas pela indústria odontológica, visando proporcionar maior previsão e durabilidade ao tratamento. Novas técnicas de cimentação estão sendo testadas para que tal interface apresente a menor quantidade possível de falhas (SAMPAIO et al., 2016).

Este trabalho tem como objetivo avaliar, através de tomografia por coerência óptica, a interface do conjunto microlaminado cerâmico - cimento resinoso - dente, com relação a diferentes técnicas de cimentação e consequente aparecimento de falhas, como bolhas e gaps nesta interface, bem como o comportamento desses defeitos após a ciclagem térmica. É importante destacar que a técnica de OCT é, no momento, a única alternativa para avaliação não destrutiva e não invasiva *in vitro* (BORGES et al., 2015) e *in vivo* (FERNANDES et al., 2016) de facetas. *In vivo*, a inspeção visual é a alternativa atualmente utilizada, o que naturalmente não permite a observações de possíveis falhas no interior na amostra.

2 REVISÃO DE LITERATURA

2.1 Microlaminados Cerâmicos

Nos últimos anos laminados cerâmicos medindo entre 0,2 a 0,7 mm de espessura, popularmente denominados de lentes de contato, vêm conquistando espaço no mercado por possibilitar menor ou nenhum desgaste à estrutura dental, obedecendo os padrões atuais de procedimentos minimamente invasivos. Isso se tornou possível graças ao desenvolvimento de pesquisas que tiveram como intuito aperfeiçoar os sistemas cerâmicos, resultando em cerâmicas amplamente utilizadas ao redor do mundo devido à elevada estética e maior resistência mecânica. O sistema cerâmico utlizado nessa pesquisa foi criado através do acréscimo de cristais de dissilicato de lítio à formulação das porcelanas feldspáticas, favorecendo, assim, as propriedades mecânicas sem prejuízo à estética, como ocorre em outras modalidades de cerâmicas odontológicas. Essa adição de novos cristais possibilitou a decadência das infraestruturas metálicas que são associadas às porcelanas feldspáticas para intensificar a sua resistência mecânica. Outra característica de extrema importância associada à cerâmica de Dissilicato de Lítio, foi a potencialização das forças de adesão às estruturas dentais (AMOROSO, 2012; SUNDFELD et al., 2016; MORITA et al., 2016; GUARDA; CORRER; GONC, 2013), além de melhorar os protocolos de cimentação (SCOTTI et al., 2016). Pode-se citar também fatores como a melhora do coeficiente de expansão térmica linear, o tamanho e a distribuição das partículas – produzindo restaurações cerâmicas com melhor polimento superficial – e maior resistência à fratura – resultando em um melhor prognóstico –, além de estabilidade química e baixa condutividade térmica (GHAVAM et al, 2010; GUARDA et al, 2013; LIN et al., 2014). Como aspectos negativos, as restaurações com laminados cerâmicos exigem alto investimento financeiro, além de maior tempo clínico e laboratorial em sua confecção (DE ANDRADE et al., 2013).

2.2 Cimentos Resinosos

Em tratando-se das características da interface de cimentação, o material responsável por esta área deve proporcionar alta retenção, prevenir microinfiltrações para que não ocorra colonização por micro-organismos, além de aumentar a resistência à fratura das peças cerâmicas. A camada de cimento tem como uma das principais funções dissipar as forças exercidas nos laminaos afim de evitar a propagação de trincas e microtrincas (GHAVAM; AMANI-TEHRAN; SAFFARPOUR, 2010). Outro fator de fundamental importância é que o cimento resinoso deve ser capaz de amortecer os impactos das forças mastigatórias (BLATZ; SADAN; KERN, 2003). O grau de conversão refere-se à quantidade de cadeias poliméricas formadas no interior da amostra, de modo a reduzir a quantidade de monômero residual após a reação de cura do material resinoso. Uma reação de cura inadequada do material causa um decréscimo das propriedades físicas e, por consequência, aumenta a solubilidade e a sorção de água pelo mesmo. Peculiaridades como propriedades ópticas, modo de ativação do cimento e espessura do material podem inferir no grau de conversão (SCOTTI et al., 2016; PEREIRA et al., 2016).

Os cimentos resinosos são resinas compostas cuja fase orgânica é preparada à base de BISGMA (bisfenolglicidil metacrilato), UDMA (uretano dimetacrilato) e/ou TEGDMA (dimetacrilato de trietileno glicol), e a fase inorgânica possui menor quantidade de carga, visando o aumento da fluidez necessária para cimentação (LIN et al., 2014; SUNDFELD et al., 2016). Os cimentos podem ser classificados quanto ao tipo de polimerização em:

a) quimicamente ativados, onde há a mistura de pasta base e pasta catalisadora que, através de uma reação peróxido-amina, iniciam a polimerização;

b) fotoativados, que possuem iniciadores como a canforoquinona que, na presença de luz na faixa de comprimento de onda em torno de 470 nm, iniciam a cura do material; e

c) duais, que consistem na combinação dos dois métodos anteriores.

Deve-se ressaltar que os materiais que sofrem dupla polimerização apresentam níveis mais elevados de grau de conversão, otimizando suas propriedades mecânicas - isso se deve à ação do sistema fotoativador. Como desvantagem pode-se citar a presença do iniciador químico, a amina terciária, peróxido de benzoíla, que pode alterar a coloração do cimento ao longo do tempo (BRAZ et al., 2009; DENTSCARE, 2013; CUADROZ-SANCHEZ, 2014; BORGES et al, 2015).

Os cimentos resinosos fotopolimerizáveis foram desenvolvidos para cimentação dos microlaminados, capazes de proporcionar maior estabilidade de cor, decorrente da ausência das aminas terciárias presentes nos cimentos de cura dual, que provocam manchas e aumento da opacidade na superfície, além de proporcionarem maior tempo de trabalho (BRAZ et al., 2009; DIKSHIT; GROVER, 2015).

Tais cimentos ainda são subdivididos de acordo com a forma de condicionamento do substrato em:

a) “Etch and rinse” ou condicione e lave: são os sistemas convencionais onde há o condicionamento com ácido fosfórico a 37% para remoção da lama dentinária, ou smear layer, e logo após a lavagem do substrato dental e aplicação do adesivo;

b) Self-Etch ou autocondiconantes: o cimento é acompanhado de adesivo autocondicionante, onde elimina-se a necessidade do condicionamento prévio com ácido fosfórico a 37%;

c) Autoadesivo ou auto-aderentes: o próprio cimento possui a função de condicionar e promover a adesão à superfície (LOGUERCIO, 2007; SOUZA, FILHO, BEATRICE, 2011; CALIXTO; MASSING, 2013).

Deve-se atentar que facetas com espessura de 0,5 mm, por si só, possibilitam uma maior passagem de luz para fotoativação do cimento, porém não neutralizam a coloração do substrato dental sozinhas, sendo necessária também intervenção da coloração da camada de cimento (CALIXTO et al., 2012). Cimentos de coloração mais translúcida, ou seja, menos opaca, propiciam uma maior profundidade de penetração de luz e, assim, um provável grau de conversão mais elevado após a reação de cura (ÖZTÜRK et al., 2013).

A contração de polimerização sofrida pelos cimentos resinosos, pode levar ao rompimento da união entre a faceta indireta e o substrato dentário, e consequente aumento da susceptibilidade à infiltração de fluidos bucais, bactérias e demais substâncias, o que acarreta em sensibilidade dentinária tardia e manchas na restauração (BADINI, TAVARES, GUERRA, 2008). Ainda sobre contração de polimerização dos materiais resinosos, a redução do volume que ocorre deve ser considerada, uma vez que tal característica pode levar a formação de gaps e desajustes no interior da interface cimentada. Em uma cimentação ideal, o cimento resinoso não deveria sofrer contração de polimerização e a inserção deveria ser adjacente às estruturas que propõe-se a unir, para que não haja incorporação de falhas e não absorva água com o tempo (FERRACANE; HILTON, 2016). Além deste trabalho, o único artigo científico encontrado que que avalia a interface de cimentação de laminados é o de SAMPAIO et al (2016). Todavia este artigo apresenta diferenças metodológicas nos matériais utilizados nos substratos, nos matériais de cimentação (utilizou cimentos resinosos e resina composta pré aquecida) e a técnica diagnóstica foi a micro Tomografia Computadorizada (µCT).

2.3 Vibração Sônica

A utilização de vibração sônica constitui uma possível técnica de redução da incorporação e eliminação de bolhas que possam vir a ser incluídas no ato da cimentação. O dispositivo sônico pode ser acoplado ao conjunto laminado/cimento, previamente à fotoativação, no ato da inserção da faceta no dente e através de vibrações expelir bolhas incorporadas. (CUADROS-SANCHEZ et al., 2014).

Tais dispositivos agem por cavitação, promovendo liberação de energia por vibração ou por transmissão acústica, que pode provocar aquecimento da solução, porém tais mecanismos podem ser afetados pela configuração da ponteira de inserção, frequência de vibração aplicada e o meio no qual se encontra (MENA-SERRANO et al., 2014).

O Smart Sonic Device – SSD (FGM Dentscare Ltda, Joinville, SC, Brazil) é um aparelho que produz oscilação vibratória em 5 diferentes frequências: 144.5, 150, 167.5, 170 e 223.5 Hz através de suas ponteiras. Foi primeiramente desenvolvido para aplicação de camada de adesivo em cimentação de pinos intra radiculares. O mecanismo de vibração proporcionou aumento no tamanho dos tags e microtags dentinários, com consequente aumento da retenção dos sistemas adesivos testados. O aparelho apresenta ponteiras que, quando acopladas pode-se encaixar microbrush e uma ponteira própria em silicone (Figura 1) para posicionamento em superfícies com o intuito de proporcionar vibração e, assim, melhorar o assentamento da peça, segundo o fabricante. Quando em contato com essas superfícies, a frequência oscilatória irá variar de acordo com a pressão inserida. Para evitar grandes oscilações de vibração o dispositivo deve ser aplicado com leve pressão pelo operador (CUADROS-SANCHEZ et al., 2014). Nesta dissertação, metade dos grupos das amostras estudadas utilizam um SSD como técnica alternativa de mitigação de falhas na interface devido ao processo de cimentação.

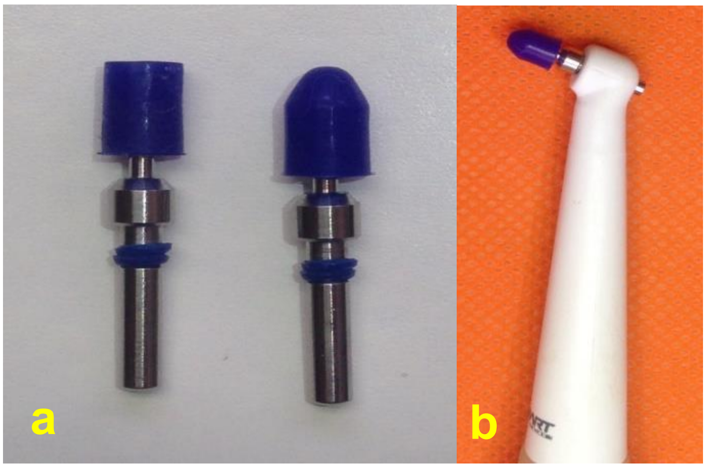

Figura 1: (a) Ponteiras em silicone para acoplamento no SSD. (b) ponteira acoplada no aparelho (Fonte: Arquivo pessoal)

2.4 Tomografia por Coerência Ótica (OCT)

A Tomografia por Coerência Óptica constitui o método utilizado neste estudo para obtenção de imagens e investigação da integridade da porcelana e da interface da cimentação do microlaminado-cimento-dente. Estudos prévios realizaram avaliações de OCT e microscopia eletrônica de varredura (MEV), e visualizaram áreas de degradação e descontinuidade nessa região (Figura 2), além de bolhas presentes na linha de cimentação antes e após a ciclagem térmica. Tais regiões consistem de pontos de tensão que podem provocar a fratura do laminado (PETRESCU et al., 2011; BAKHSH et al., 2011 ; NAZARI et al., 2013; BORGES et al., 2015).

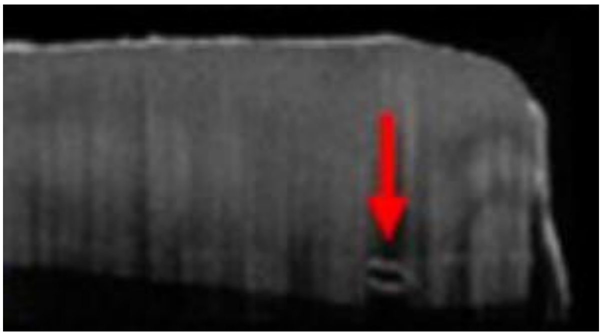

Figura 2. Evidenciação de bolha em linha de cimentação de faceta (BORGES et al., 2015).

A tomografia por coerência óptica, consiste em um método eficiente e não ionizante de avaliação de materiais translúcidos, que permite a análise não invasiva e não destrutiva de microestruturas biológicas, com imagens geradas em tempo real e com alta resolução (< 10 μm), bi- ou tridimensionais, baseadas na emissão de espectro de luz na faixa do infravermelho, a partir de uma fonte determinada, e refletidas ou retroespalhadas pelas estruturas em avaliação. Os atuais sistemas de OCT são baseados no Domínio de Fourier, que proporciona alta velocidade de aquisição de dados e superioridade de sensibilidade à luz que, ao ser refletida pela amostra, é decodificada por um Interferômetro (Interferômetro de Michelson) e um fotodetector associado a um processamento eletrônico e digital (GUPTA, DHADED, SHALINIBN, 2014; TURKISTANI et al., 2014).

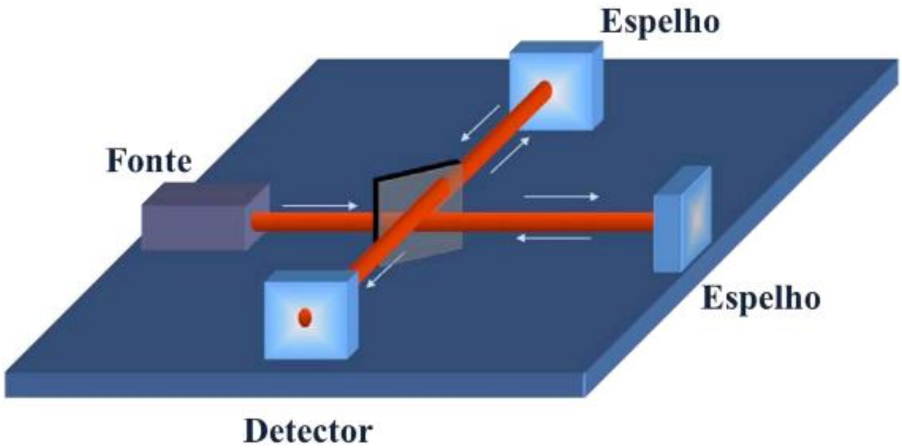

Figura 3: Desenho esquemático do interferômetro de Michelson. (fonte: arquivo Labfoton)

O escaneamento das amostras é realizado da seguinte forma:

a) Escaneamento Axial ou A-Scan:

Dados de varredura unidimensional no qual obtém-se a decodificação, ou seja, o espectro matemático da imagem a partir de um único ponto da amostra, onde o feixe de luz penetra e é refletido/retroespalhado (Figura 4a). A figura 4b mostra um interferograma típico obtido a partir do A-scan.

b) B-Scan:

Agrupamento de dados A-scan ao longo de uma linha, que resultam na formação de uma imagem bidimensional. Aspectos de profundidade e largura do material em análise são observados (Figura 4a).

c) C-Scan:

Conjunção de imagens B-Scan que constituem uma varredura tridimensional (DIKSHIT, GROVER, 2015).

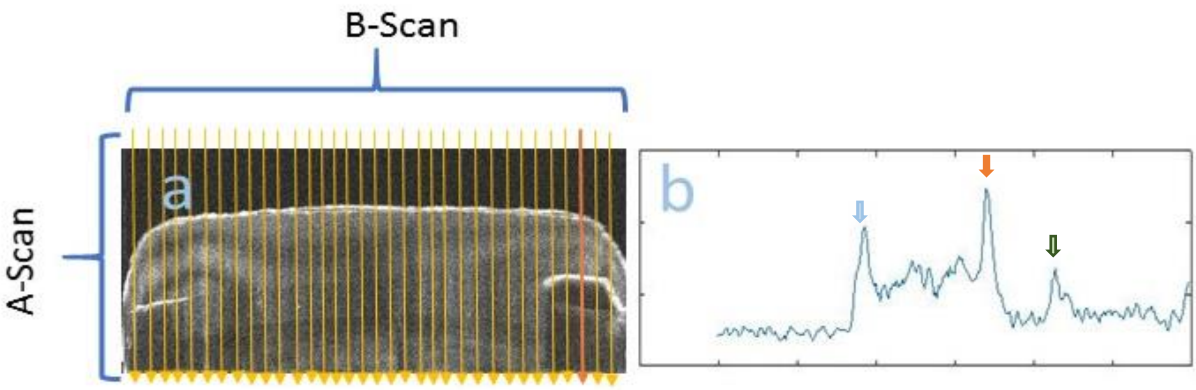

Figura 4: a) Esquema representativo do A-Scan, representado pelas setas amarelas e seu agrupamento formando a imagem do B-scan; b) A-scan representativo da coluna correspondente à seta laranja na Figura 4a. Seta azul: pico que representa a porcelana; seta Laranja, representa parte superior da bolha; seta verde, parte inferior da bolha. (Fonte: Arquivo Pessoal).

Por tais características, o OCT pode ser considerado o padrão-ouro para avaliação da integridade de laminados e da interface de cimentação de facetas, principalmente pela ausência de outra alternativa viável clinicamente, onde podem ser observadas possíveis falhas de adesão como bolhas e gaps, tanto *in vitro* (GUPTA, DHADED, 2014; TURKISTANI et al., 2014; BORGES et al., 2015), *como in vivo* (FERNANDES et al., 2016).

3 METODOLOGIA

Os materiais utilizados neste estudo estão descritos na tabela 1 e consistem em três cimentos resinosos e seus respectivos sistemas de silano e adesivo. Observe que existem dois sistemas adesivos convencionais de duas etapas, que requerem ataque ácido prévio e um sistema adesivo autocondicionante. As cores dos cimentos resinosos foram as mais claras de cada fabricante, sendo elas: translúcida, clara e A1 para All Cem Veneer, NX3 e Rely-X Veneer, respectivamente.

Materiais	**Fabricante (número do lote)**	**Composição**	**Instruções de uso para dente e laminados cerâmicos**
IPS e.max Ceram	Ivolcar Vivadent, Schann, Liechtenstein (U37422)	Silicon Dioxide, Aluminium Oxide, Sodium Oxide, Potassium Oxide, Zinc Oxide, Calcium Oxide, Phosphorus pentoxide, Fluorine, 1,3 Butanediol, other oxides, pigments, glycerine	1. Ataque com ácido Fluorídrico a 10% por 90s 2. Lavagem e secagem 3. Ataque com ácido fosfórico a 37% por 20s 4. Lavagem e secagem 5. Aplicaçao do Silano por 60s (o silano do respective fabricante) 6. Aplicação do adesivo (adesivo do respective fabricante 7. Aplicação do cimento do respective fabricante 8. A) Grupo da técnica convencional: Posicionamento da faceta sobre o dente, leve pressão e fotopolimerização. B) Grupo d Vibração Sônica: Posicionamento da faceta sobre o dente; posicionamento do Smart Sonic Device (FGM) sobre a faceta; remoção dos excessos de cimento com microbrush; Fotopolimerização.
Condac	FGM Dentscare Ltda Joinville, SC, Brazil (120815)	Orto Phosphoric acid at 37%	
Condac Porcelain	FGM Dentscare Ltda Joinville, SC, Brazil (120815)	Fluoride acid at 10%,	
Bonding Agent Silane Prosil	FGM Dentscare Ltda, Joinville, SC, Brazil (030815)	3-Metacriloxipropiltrimetoxisilano Ethanol	
Relyx Ceramic Primer	3M ESPE, Saint Paul, MN, USA (N764840)	Ethyl Alcohol, Water, Methacryloxypropyl Trimethoxysilane	
Silane Primer	Kerr, Orange, CA, USA (5797399)	Ethanol, Organosilane ester	

All Cem Veneer	FGM, Dentscare Ltda, Joinville, SC, Brazil (210415)	Glass of Boron Barium, BIS(EMA), Diuretano, TEGDMA, Silane treated silica, Ethyl 4-dimethylaminobenzo, Camphorquinone	Preparo do dente: 1. Ataque com ácido fosfórico a 37% por 30s 2. Lavagem e secagem com jatos livres de óleo 3. Aplicação do adesivo com microbrush
Ambar Adhesive System	FGM Dentscare Ltda, Joinville, SC, Brazil (020615)	UDMA, HEMA, Etil 4-dimetilaminobenzoato, Ethanol, Camphorquinone, Silanized silicon dioxide, Hydrophilic methacrylate monomers, Methacrylated acid monomers	
Rely-X Veneer	3M ESPE, Saint Paul, MN, USA (N776873)	Silane treated ceramic, TEGDMA, BISGMA, Silane treated silica, Reacted polycaprolactone polymer, Titanium dioxide, EDMAB, Benzotriazol, Diphenyliodonium hexafluorophosphate	Preparo do dente: **1.** Ataque com ácido fosfórico a 37% por 30s **2.** Lavagem e secagem com jatos livres de óleo **3.** Aplicação do adesivo com microbrush
Adper Single Bond 2	3M ESPE, Saint Paul, MN, USA (N763602)	Ethyl alcohol, BISGMA, Silane treated silica (nanofiller), HEMA, Copolymer of acrylic and itaconic acids, Glycerol 1,3-dimethacrylate, Water, UDMA, Diphenyliodonium hexafluorophosphate, EDMAB	
NX3 Nexus Third Generation	Kerr, Orange, CA, USA (5797394)	Poly(oxy-1,2-ethanediyl), α,α'-[(1-methylethylidene)di-4,1-phenylene]bis[ω-[(2-methyl-1-oxo-2-propen-1-yl)oxy]-7,7,9 (or 7,9,9)-trimethyl-4,13-dioxo-3,14-dioxa-5,12-diazahexadecane-1,16-diyl, Bismethacrylate, 2,2'-ethylenedioxydiethyl dimethacrylate, 2-hydroxyethyl methacrylate, 3-trimethoxysilylpropyl methacrylate	Preparo do dente: 1. Aplicação do adesivo com microbrush
Optibond All in One Adhesive System	Kerr, Orange, CA, USA (5732932)	GPDM, camphorquinone, water acethone, ethanol 2-hydroxyethyl methacrylate, acethone, propan-2-one, propanone	

Tabela 1. Composição, fabricante, número de lote e instruções de uso dos materiais estudados. (Fonte: Arquivo Pessoal)

3.1 Aspectos Éticos e Seleção da Amostra

Este estudo *ex vivo* foi aprovado pelo Comitê de Ética em Experimentação Animal (Centro de Ciências Biológicas, Universidade Federal de Pernambuco, protocolo número 23076.018892 / 2015-10).

Foram selecionados 30 incisivos bovinos extraídos recentemente de um matadouro local. Os dentes selecionados não apresentavam variações significativas em relação à tonalidade do substrato dentário, nem rugosidade muito divergentes, os quais foram critérios de seleção. Os dentes foram imersos em cloramina-T 0,5% (Sigma-Aldrich, St. Louis, MO) solução para desinfecção, polidos com pedra-pomes e água, com auxílio de escova Robinson acoplado em peça de mão e armazenados em água destilada.

3.2 Preparos de amostras

3.2.1 Preparação dos dentes

Para a preparação das amostras, os dentes foram ligeiramente polidos com lixa de carboneto de silício com granulações de 600, 800 e 1200 para regularização da superfície. Em seguida, foram seccionados com discos diamantado de dupla face 7016 (KG Sorensen, Cotia, São Paulo, Brasil) acoplados em peça de mão sob refrigeração, visando obter fragmentos de 5 mm x 5 mm de formato quadrado a partir da área plana da superfície vestibular e incluídos em resina acrílica quimicamente ativada (JET, São Paulo, SP, Brasil). Posteriormente, os fragmentos de dentes foram analisados por OCT, a fim de evitar possíveis rugosidades na superfície dos dentes.

3.2.2 Preparação Cerâmica

No prepare das porcelanas, os microlaminados foram padronizados por cor (A1), matiz e valor, com dimensões de aproximadamente 5 mm x 5 mm de largura e altura, e 0,5 mm de espessura em cerâmica dissilicato de lítio (e.max, Ivoclar Vivadent). Foi escolhido um bloco de alta translucidez de dissilicato de lítio, afim de proporcionar uma melhor transmissão de luz através da cerâmica e aumentar o grau de conversão dos cimentos à base de resina [19; 20]. As amostras de cerâmica foram submetidas à análise de OCT, para evitar possíveis defeitos de cerâmica.

Para os microlaminados cerâmicos, o tratamento prévio à cimentação da superfície interna consistiu de ácido fluorídrico a 10% (FGM) por 90 segundos e lavagem com jatos de ar / água durante 10 segundos; Em seguida utilizou-se o ácido fosfórico à 37% (FGM) na mesma superfície por 20 segundos, seguido de outra lavagem com ar / água. Posteriormente, aplicou-se uma camada de silano durante 60 segundos e secou-se com um jato de ar livre de óleo por 10 segundos. Finalmente, aplicou-se o adesivo correspondente a cada cimento resinoso.

3.2.3 Cimentação

As amostras foram divididas aleatoriamente em seis grupos (n = 5), de acordo com a técnica de cimentação e o cimento, conforme tabela 2.

O dispositivo sônico empregado é um Smart Sonic Device (FGM Dentscare Ltda, Joinville, SC), capaz de gerar oscilações em 5 freqüências diferentes: 144,5, 150, 167,5, 170, 223,5 Hz. Este estudo empregou frequência de 170 Hz. Quando em contato com superfícies rígidas, a frequência oscilatória varia de acordo com a pressão aplicada. Para evitar grandes oscilações de vibração, o operador deve posicionar o dispositivo com leve pressão. As amostras foram cimentadas por técnica convecional e técnica SSD pela mesma pessoa calibrada [21].

Grupo (n=5)	Cimento resinoso	Técnica de cimentação
ACC	All Cem Veneer	Técnica Convencional
ACSV	All Cem Veneer	Emprego do Smart Sonic Device[a]
NX3C	Nexus Third Generation – NX3	Técnica Convencional
NX3SV	Nexus Third Generation – NX3	Emprego do Smart Sonic Device[a]
RVC	Rely-X Veneer	Técnica Convencional
RVSV	Rely-X Veneer	Emprego do Smart Sonic Device[a]

[a]FGM Dentscare Ltda (Joinville, SC, Brazil).

Tabela 2. Grupos Experimentais, de acordo com o cimento resinoso e a técnica de cimentação. (Fonte: Pessoal)

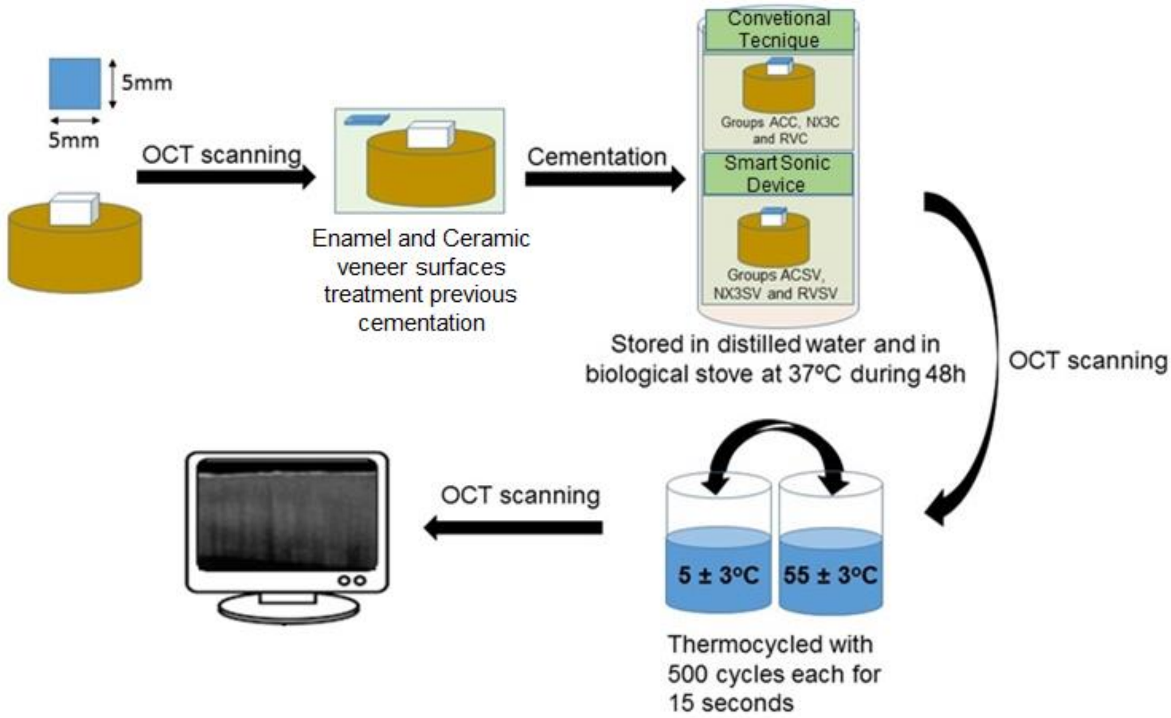

Figura 1: Sequência de prepare das amostras e escaneamento por Tomografia de Coerência Óptica. (Fonte: Arquivo Pessoal)

Para a cimentação, o cimento resinoso foi aplicado sobre os microlaminados que, em seguida, foram posicionados sobre a superfície do esmalte. Após leve pressão, o excesso de material foi removido por um pincel. Os grupos ACC, NX3C e RVC foram fotoativados imediatamente após este momento, de acordo com as respectivas instruções do fabricante. Para os grupos ACSV, NX3SV e RVSV, a ponta do Smart Sonic Device foi acoplada sobre os folheados com leve pressão, sendo o aparelho calibrado com 170 Hz, visando promover o escoamento do cimento e a remoção de excessos previamente à fotoativação, de acordo com as respectivas instruções do fabricante. Todas as amostras foram fotoativadas por 20 segundos com Radii-cal (SDI, Victoria, Austrália), emitindo uma densidade de potência de 1200 mW / cm2.

Após a fixação, as amostras foram armazenadas em água destilada e mantidas em estufa biológica (Fanem, São Paulo, SP) a 37ºC por 48h. Em seguida, os espécimes foram submetidos a leitura pelo OCT, anterior a ciclagem térmica. O sistema e o princípio de funcionamento do OCT estão detalhados na secção 2.2.

As amostras foram termocicladas com banho alternado de 5 ± 3ºC e 55 ± 3ºC, aplicadas a 500 ciclos cada uma por 15 segundos (Nova Ética, Vargem Grande

Paulista, SP), simulando alterações térmicas na cavidade bucal [21]. Os espécimes seguintes foram armazenados novamente em água destilada em estufa biológica a 37ºC por 48h antes da última análise de OCT.

3.3 Tomografia por Coerência Óptica

Previamente à cimentação, todos os dentes e superfícies cerâmicas internas foram submetidos à análise individual pelo OCT, para verificar a presença de qualquer irregularidade. Após esta análise, o OCT foi realizada em dois momentos: 48h após cimentação e 48h após o ciclo térmico.

O sistema de Tomografia de Coerência Óptica empregado foi o Ganymede Spectral Domain OCT (Thorlabs Inc, Newton, Nova Jersey, EUA), operando a 930 nm de comprimento de onda central, taxa de varredura axial de 29 kHz, profundidade de imagem máxima de 2,7 mm, resolução lateral de 8 μm e 5,8 μm / 4,4 mm de resolução axial em ar / água, respectivamente.

Os sistemas OCT de domínio espectral (SD-OCT) operam no domínio de Fourier para determinar as propriedades físicas das amostras analisando a luz reflectida e retroespalhada a partir da amostra. A fonte de luz de banda larga emite um feixe que percorre o interferómetro de Michelson até atingir perpendicularmente a amostra. A luz de espalhamento dispersa viaja para o espectrómetro onde é detectado o atraso de fase único para cada comprimento de onda. A informação da profundidade é adquirida usando uma Transformação Rápida de Fourier (FFT). Este perfil de profundidade de um único ponto na amostra é referido como A-scan. Através de um espelho Galvo, é possível emitir e coletar luz de vários pontos da amostra ao longo de uma linha, conhecida como B-scan, a imagem bidimensional criada (Figura 2).

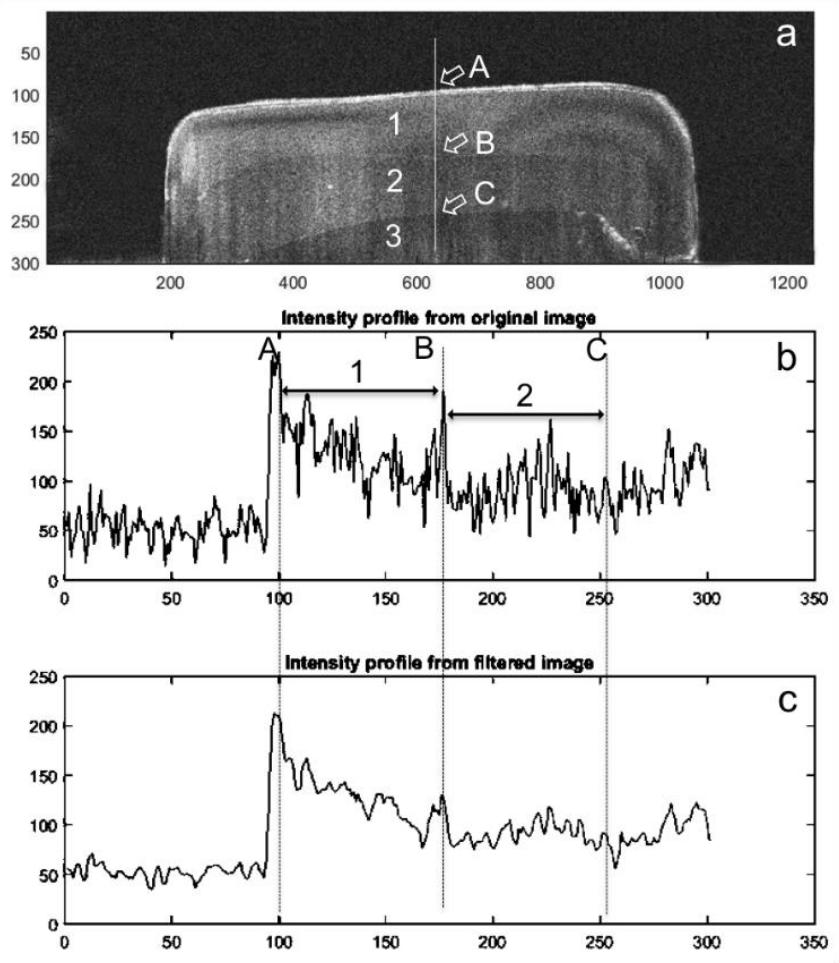

Figura 2. (a) Imagem OCT gerada a partir de uma amostra. (B) A-scan obtido a partir da coluna correspondente à linha tracejada na figura (a). (C) O mesmo A-scan filtrado através de MATLAB. Na imagem A-scan é possível identificar três picos, correspondendo às seguintes interfaces: A - ar e microlaminado cerâmico; B – microaminado cerâmico e cimento à base de resina; C - cimento à base de resina e substrato de esmalte. A distância do intervalo entre cada pico corresponde à distância, em pixels, entre as estruturas citadas. Desta forma, 1 - microlaminado cerâmico; 2 - cimento resinoso; 3 -esmalte. (Fonte: Arquivo Pessoal)

Um dispositivo à base de teflon foi confeccionado para assegurar que as imagens OCT realizadas antes e após a termociclagem fossem obtidas das mesmas regiões nas amostras. O índice de refração considerado para os microlaminados cerâmicos foi de 1,45 [13; 22].

3.4 Dados de Processamento de Imagem

Um algoritmo foi desenvolvido pelo programa MATLAB (Mathworks Inc, Natick, Massachusetts, EUA) para obter os A-scans a partir de imagens OCT. Em geral, as imagens OCT apresentam ruído e faz-se necessário filtrar a imagem para obter-se uma imagem de melhor qualidade. Foi utilizado um filtro “low passa” (filtro médio, 3x3) (Figura 2b). Em seguida, analisou-se uma única coluna para obter qualitativamente informação sobre uma região seleccionada em amostras de imagens (A-Scan de OCT), como mostrado nas figuras 2b e 2c. Depois de as imagens serem processadas no Matlab, a espessura de cimentação foi avaliada no programa ImageJ (Imaging Processing and Analysis em Java, National Institutes of Health, Bethesda, MD, EUA) que quantificou os tons de cinza em pixel para verificar a presença de falhas. Cada interface de cimentação medida foi transformada de pixels para mm. Para análise estatística, as informações dos histogramas da extração da Imagem J foram preconizadas de acordo com o número de pixels (intensidade) e os tons de cinza de cada grupo.

3.5 Análise Estatística

Para os casos em que a normalidade foi indicada, o teste T-student foi utilizado para comparar as medidas entre dois grupos de interesse, e o teste ANOVA foi utilizado para comparar três ou mais grupos de interesse. Nos casos em que a normalidade não foi indicada, o teste de Mann-Whitney foi aplicado para comparação de medidas entre os dois grupos de interesse e o teste de Kruskall-Wallis para comparação entre três ou mais grupos de interesse.

Para avaliar a influência do uso ou não da vibração sônica, foi aplicado o teste Qui-quadrado para amostras independentes, e se as suposições não foram confirmadas, foi aplicado o teste Exato de Fisher. Todas as conclusões foram realizadas considerando o nível de significância de 5%.

4 RESULTADOS

Os resultados desta pesquisa encontram-se relacionados em forma de artigo científico que é apresentado no Apêndice desta dissertação.

REFERÊNCIAS

AMOROSO, A. INDICAÇÕES E CONSIDERAÇÕES CLÍNICAS. **Revista Odontológica de Araçatuba**, v. 33, p. 19–25, 2012.

BADINI, TAVARES, GUERRA, D. E V. Cimentação adesiva – Revisão de literatura Adhesive strengthen – Literature review. **Revista Odonto**, v. 16, n. 32, p. 105–115, 2008.

BAKHSH, T. A. et al. Non-invasive quantification of resin-dentin interfacial gaps using optical coherence tomography: Validation against confocal microscopy. **Dental Materials**, v. 27, n. 9, p. 915–925, 2011.

BLATZ, M. B.; SADAN, A.; KERN, M. Resin-ceramic bonding: A review of the literature. **Journal of Prosthetic Dentistry**, v. 89, n. 3, p. 268–274, 2003.

BRAZ, A. K. S. et al. Evaluation of crack propagation in dental composites by optical coherence tomography. **Dental Materials**, v. 25, n. 1, p. 74–79, 2009.

CALIXTO, L. R. et al. Reabilitação Estética Multidisciplinar : Parte 3 – Preparo para Facetas , Confecção de Provisórios , Prova e Cimentação dos Laminados Cerâmicos. **Clínica- nternacional JOurnal of Brazilian Dentistry**, v. 8, p. 412–421, 2012.

CALIXTO, R.; MASSING, N. Restaurações Cerâmicas em Dentes Anteriores: Cimentação- Parte 2. **Revista Dental Press Estética**, v. 10, n. 4, p. 14–26, 2013.

CUADROS-SANCHEZ, J. et al. Effects of sonic application of adhesive systems on bonding fiber posts to root canals. **Journal of Endodontics**, v. 40, n. 8, p. 1201–1205, 2014.

DE ANDRADE, O. S. et al. Ultimate Ceramic Veneers: A Laboratory-Guided Preparation Technique for Minimally Invasive Restorations. **The American Journal of Esthetic Dentistry**, v. 3, n. 1, p. 8–22, 2013.

DE ANDRADE BORGES, E. et al. Study of lumineers' interfaces by means of optical coherence tomography. **SPIE Biophotonics South America**, v. 9531, p. 953147, 2015a.

DIKSHIT, GROVER, B. AND S. Optical Coherence Tomography-A Boon for Dental Diagnostics. **BRITISH BIOMEDICAL BULLETIN**, v. 3, n. 2, p. 239–252, 2015.

FERNANDES, L. O. et al. *In vivo* assessment of periodontal structures and measurement of gingival sulcus with Optical Coherence Tomography: a pilot study. **Journal of Biophotonics**, v. 8, p. 1–8, 2016.

FERRACANE, J. L.; HILTON, T. J. Polymerization stress--is it clinically meaningful? **Dental materials : official publication of the Academy of Dental Materials**, v. 32, n. 1, p. 1–10, 2016.

GHAVAM, M.; AMANI-TEHRAN, M.; SAFFARPOUR, M. Effect of accelerated aging on the color and opacity of resin cements. **Operative dentistry**, v. 35, n. 6, p. 605–609, 2010.

GUARDA, G. B.; CORRER, A. B.; GONC, L. S. Effects of Surface Treatments , Thermocycling , and Cyclic Loading on the Bond Strength of a Resin Cement Bonded to a Lithium Disilicate Glass Ceramic. **Operative dentistry**, v. 38–2, p. 208–217, 2013.

GUPTA, DHADED, S. Review article Optical Coherence Tomography: A new era in dentistry Gupta G1, Dhaded S2, BN Shalini3. **Bangladesh Journal of Medical Science**, v. 13, n. 4, p. 388–390, 2014.

LIN, C. L. et al. Examination of ceramic/enamel interfacial debonding using acoustic emission and optical coherence tomography. **Dental Materials**, v. 30, n. 8, p. 910–916, 2014.

MENA-SERRANO, A. et al. Effect of sonic application mode on the resin-dentin bond strength and nanoleakage of simplified self-etch adhesive. **Clinical Oral Investigations**, v. 18, n. 3, p. 729–736, 2014.

MORITA, R. K. et al. Case Report Minimally Invasive Laminate Veneers : Clinical Aspects in Treatment Planning and Cementation Procedures. v. 2016, 2016.

NAZARI, A. et al. 3D assessment of void and gap formation in flowable resin composites using optical coherence tomography. **The journal of adhesive dentistry**, v. 15, n. 3, p. 237–43, 2013.

ÖZTÜRK, E. et al. Effect of resin shades on opacity of ceramic veneers and polymerization efficiency through ceramics. **Journal of Dentistry**, v. 41, n. SUPPL.5, p. 8–14, 2013.

PEREIRA, A. G. et al. Influence of Battery Level of a Cordless LED Unit on the Properties of a Nanofilled Composite Resin. **Oper Dent**, v. 41, n. 4, p. 409–416, 2016.

PETRESCU, E. et al. OCT and SEM Imagistic Investigations of Composite Resin-IPS Empress Ceramic Interfaces. **Recent Advances in Applied and Biomedical Informatics and Computational Engineering in Systems Applications. Proceedings of the 11th WSEAS International Conference on Applied Informatics and Communications (AIC 2011). Proceedings of the 4th WSEAS Internat**, p. 431–434, 2011.

SAMPAIO, C. S. et al. Volumetric shrinkage and film thickness of cementation materials for veneers: An in vitro 3D microcomputed tomography analysis. **The Journal of Prosthetic Dentistry**, p. 1–8, 2016.

SCOTTI, N. et al. Effect of Lithium Disilicate Veneers of Different Thickness on the Degree of Conversion and Microhardness of a Light-Curing and a Dual-Curing Cement. p. 384–388, 2016.

SOUZA, T. R. DE; FILHO, J. C. B. L.; BEATRICE, L. C. DE S. Cimentos auto-adesivos : eficácias e controvérsias. **Revista Dentística on line**, v. 10, n. 21, p. 20–25, 2011.

SUNDFELD, D. et al. The Effect of Hydrofluoric Acid Concentration and Heat on the Bonding to Lithium Disilicate Glass Ceramic. **Brazilian Dental Journal**, v. 27, p. 727–733, 2016.

TURKISTANI, A. et al. Sealing performance of resin cements before and after thermal cycling: Evaluation by optical coherence tomography. **Dental Materials**, v. 30, n. 9, p. 993–1004, 2014.

APÊNDICE:

Tooth-ceramic veneer interface evaluation using image by optical coherence tomography

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ABSTRACT

Objectives: The aim of this research was to evaluate, using imaging by optical coherence tomography (OCT), ceramic veneers interface with different resin-based cements (RBC), conventional technique (C) or using sonic vibration device (SVD) before RBC cure reaction.

Methods: IPS e.max (Ivoclar-Vivadent) veneers were prepared for use with bovine enamel, and divided into six groups (n=5), according to the RBC used: All Cem Veneer (FGM Dentscare), ACC/ ACSV; NX3 (Kerr), NX3C/ NX3SV; and RelyX Veneer (3M ESPE), RVC/ RVSV. ACC, NX3C and RVC underwent conventional technique cementation, whilst ACSV, NX3SV and RVSV received the SVD operating at 170 Hz before RBC cure reaction. The OCT system (Ganymede SD-OCT, Thorlabs). An algorithm was developed in MATLAB to noise reduction and A-scan analysis to filtered images. Histograms were extracted from samples through Image J software. T-student and Anova statistics were used when the cases of normality were indicated, and Mann-Whitney and Kruskall-Wallis, were employed otherwise.

Results: Failures were clearly visualized in OCT images and confirmed by A-scans. There was no statistical difference between the conventional technique and the use of the SVD technique to avoid failures. Furthermore, after thermal cycling, only RVSV presented statistically different results with respect to the other groups.

Significance: OCT is a unique method to visualize *in vitro* and *in vivo* potential failures in veneers interface. It was found no evidence that a SVD device prevented failure insertion in the resin cements layer for the parameters used in this work.

Keywords: optical coherence tomography, lithium dissilicate, resin based cement, veneers cemented, interface failures.

1 Introduction

Proper evaluation of dental materials characteristics be it *in vitro,* in a laboratory environment, or *in vivo,* being used by patients and verified in a clinical environment, is of paramount importance. Dental materials used as restorative materials, bonding agents, resin-based cements, polymeric composites, fiber reinforced composites and sealants need to be properly characterized prior to being widely employed. Some of those materials can lead to gap and void formation after placement, failures that can lead to dental and esthetic problems. In general, the methods to evaluate such materials are invasive and/or destructive, such as electrochemical leakage tests, dye infiltration, microscopy on sectioned samples, and others [1–3]. Furthermore, most of the methods cannot be used in clinical practice. Noninvasive and nondestructive methods are therefore highly desirable, particularly if they have the potential to be clinically used. Imaging techniques play an important role in materials evaluation, such as electronic and optical microscopy and their variations [4]. Among the optical imaging methods, optical coherence tomography (OCT) [5] has played a major role in dentistry, particularly in dental materials evaluation in laboratory environment [6], but also in clinical practice. It is a well characterized noninvasive and nondestructive method able to generate 2D and 3D images in basically real time, with spatial resolution around 5-10 μm and typical penetration depth of 1-3 mm in biotissue. This allows imaging of biostructures in hard or soft dental tissues. Among the several published works on OCT assessment of enamel/dentin/dental materials, we can mention 3D assessment of failures, such as voids and bubbles formation in flowable resin composites [7], resin-dentin interfacial gaps validation of OCT against confocal microscopy [8], comparison with Quantitative Light Induced Fluorescence [9], evaluation of integrity of dental sealants [10], and determination of shrinkage in restorative composites [11].

Among dental materials used as prosthesis for oral aesthetics reasons, ceramic veneers, also known as facets or lumineers, are reduced veneer laminates with thickness varying from 0.2 to 0.7 mm. It represents the best material for high quality aesthetic rehabilitation. Their use requires minimum or even no tooth preparation and are being increasingly employed by practitioners, as they allow for color correction, shape and teeth position [12]. It was made possible by the improvement of ceramic systems that was provided due to the addition of lithium disilicate crystals to the feldspatic porcelain formulation, thus increasing mechanical properties and maximizing the adhesion forces to dental structures [13–15].

Adhesive dentistry is fundamental for the treatment with lumineers, and consequently cementation is a decisive procedure for the clinical success [13]. Since lumineers do not offer mechanic retention to tooth structure [13] resin based materials are most appropriated for bonding. This type of cement presents the best aesthetic performance and mechanical tool, since it dissipates the oclusal forces from the ceramic to the tooth avoiding cracks and microcracks on the ceramic, and a good working time [12,16–18].

However, a weak point in the clinical procedure is that the only current means of assessing its performance is visual inspection. In the laboratory, mainly destructive techniques are being used. The use of OCT on evaluation of lumineers in a laboratory environment has already been described in [19,20]. In a pioneer work, an *in vivo* evaluation of a single patient in a clinical environment [21] was performed. It was reported that 14 lumineers were assessed 6 months after placement in the patient anterior teeth, and one of them presented failure, detected by the OCT image and confirmed with color change [21].

In the present work, we describe an *ex vivo* laboratory evaluation of ceramic veneers interface prepared with three different resin-based cements (RBC), through the conventional manual technique or using an ultrasonic device before resin-based cement cure reaction. Thermal cycling was also applied to the studied samples.

The aim of this work was to observe the interface defects formation, failures such as air bubbles and gaps, and correlate them with the types of resin-based cements and cementation technique. Two-dimensional OCT images were performed to verify the veneer’s adaptation to the tooth surface.

2 Materials and methods

The materials used in this study are described in table 1, and consists of three resin-based cements, and their respective silane and adhesive systems. It should be noticed there are two conventional two-step adhesive systems, which requires previous acid etching, and one self-etching adhesive system. The colors of the resin-based cements were translucent, clear and A1 for All Cem Veneer (FGM, Joinville, SC, Brazil), Nexus Third Generation -NX3- (Orange, CA, USA) and Rely-X Veneer (Saint Paul, MN, USA), respectively – the light ones of each manufacturer.

Table 1. Composition, manufacturers, bath numbers and instruction of use of the materials studied.

Materials	Manufacturer (batch number)	Composition	Instruction of use for teeth and ceramic veneers
IPS e.max Ceram	Ivolcar Vivadent, Schann, Liechtenstein (U37422)	Silicon Dioxide, Aluminium Oxide, Sodium Oxide, Potassium Oxide, Zinc Oxide, Calcium Oxide, Phosphorus pentoxide, Fluorine, 1,3 Butanediol, other oxides, pigments, glycerine	9. Fluoride acid at 10% etching for 90s 10. Wash and dry 11. Phosphoric acid at 37% etching for 20s 12. Wash and dry 13. Silane application for 60s (each silane of respective manufacturer) 14. Adhesive application (each adhesive of respective manufacturer) 15. Cement application of each manufacturer 16. A) Conventional Tecniques Groups: Positioning veneer over the tooth, and light curing. B) Sonic Vibration Groups: Positionig the veneer over the tooth; positioning the Smart Sonic Device over the veneer; remove the excess flow with a microbrush; Light cure
Condac	FGM Dentscare Ltda Joinville, SC, Brazil (120815)	Orto Phosphoric acid at 37%	
Condac Porcelain	FGM Dentscare Ltda Joinville, SC, Brazil (120815)	Fluoride acid at 10%,	
Bonding Agent Silane Prosil	FGM Dentscare Ltda, Joinville, SC, Brazil (030815)	3-Metacriloxipropiltrimetoxisilano Ethanol	
Relyx Ceramic Primer	3M ESPE, Saint Paul, MN, USA (N764840)	Ethyl Alcohol, Water, Methacryloxypropyl Trimethoxysilane	
Silane Primer	Kerr, Orange, CA, USA (5797399)	Ethanol, Organosilane ester	

All Cem Veneer	FGM, Dentscare Ltda, Joinville, SC, Brazil (210415)	Glass of Boron Barium, BIS(EMA), Diuretano, TEGDMA, Silane treated silica, Ethyl 4-dimethylaminobenzo, Camphorquinone	Tooth preparation: **5** Fosforic acid at 37% etching for 30s **6** Wash and dry in oil free air **7** Adhesive application with microbrush
Ambar Adhesive System	FGM Dentscare Ltda, Joinville, SC, Brazil (020615)	UDMA, HEMA, Etil 4-dimetilaminobenzoato, Ethanol, Camphorquinone, Silanized silicon dioxide, Hydrophilic methacrylate monomers, Methacrylated acid monomers	
Rely-X Veneer	3M ESPE, Saint Paul, MN, USA (N776873)	Silane treated ceramic, TEGDMA, BISGMA, Silane treated silica, Reacted polycaprolactone polymer, Titanium dioxide, EDMAB, Benzotriazol, Diphenyliodonium hexafluorophosphate	Tooth preparation: **8** Fosforic acid at 37% etching for 30s **9** Wash and dry in oil free air **10** Adhesive application with microbrush
Adper Single Bond 2	3M ESPE, Saint Paul, MN, USA (N763602)	Ethyl alcohol, BISGMA, Silane treated silica (nanofiller), HEMA, Copolymer of acrylic and itaconic acids, Glycerol 1,3-dimethacrylate, Water, UDMA, Diphenyliodonium hexafluorophosphate, EDMAB	
NX3 Nexus Third Generation	Kerr, Orange, CA, USA (5797394)	Poly(oxy-1,2-ethanediyl), α,α'-[(1-methylethylidene)di-4,1-phenylene]bis[ω-[(2-methyl-1-oxo-2-propen-1-yl)oxy]-7,7,9 (or 7,9,9)-trimethyl-4,13-dioxo-3,14-dioxa-5,12-diazahexadecane-1,16-diyl, Bismethacrylate, 2,2'-ethylenedioxydiethyl dimethacrylate, 2-hydroxyethyl methacrylate, 3-trimethoxysilylpropyl methacrylate	Tooth preparation: **11** Adhesive application with microbrush
Optibond All in One Adhesive System	Kerr, Orange, CA, USA (5732932)	GPDM, camphorquinone, water acethone, ethanol 2-hydroxyethyl methacrylate, acethone, propan-2-one, propanone	

2.1 Ethical aspects and sample selection

This *ex vivo* study was approved by the Ethical Committee on Animal Experiments (Center of Biological Sciences, Universidade Federal de Pernambuco, protocol number 23076.018892/2015-10).

Thirty bovine incisors recently extracted obtained from a local slaughterhouse were selected. The chosen teeth could not present significant variations regarding the tooth substrate tonality, neither roughness nor deep groves, which were selection criteria. The teeth were immersed in Chloramine-T 0,5% (Sigma-Aldrich, St. Louis, MO) solution for disinfection, polished with pumice and water, through Robinson's brush coupled in handpiece and stored in distilled water.

a. Sample Preparations

i. Teeth Preparation

For sample preparation, the teeth were lightly polished with silicon carbide sandpaper with 600, 800 and 1200 granulations for surface regularization. Then they were sectioned with double-faced diamond disks 7016 (KG Sorensen, Cotia, São Paulo, Brazil) coupled in handpiece under refrigeration, aiming to obtain 5 mm x 5 mm square shaped fragments from the flatter area of the buccal surface, previously to inclusion in chemically activated acrylic resin (JET, São Paulo, SP, Brazil). Later the teeth fragments were analysed by OCT in order to evaluate enamel surface and those which presented roughness were discarded and changed.

ii. Ceramic Preparation

In ceramic preparations, the veneers were standardized by color (A1), hue and value. Their lateral dimensions were approximately 5 mm x 5 mm, with 0.5 mm thickness, made of lithium disilicate ceramic (E.max, Ivoclar Vivadent). High translucency insert of lithium disilicate was chosen, to provide a better light transmission through the ceramic and high conversion degree of the resin based cements [22,23]. The ceramic samples underwent OCT analysis to evaluate possible cracks, but no defect was observed.

For cementation, ceramic veneers internal surface treatment consisted of fluoride acid at 10% etching (FGM) for 90 seconds, and air/water washing for 10 seconds; next phosphoric acid at 37% etching (FGM) at the same surface for 20 seconds to remove remaining waste, followed by other air/water washing. Then a silane layer was applied for 60 seconds, and dried with an air jet oil-free for 10 seconds. Finally, the adhesives corresponding to each resin-based cement were applied.

iii. **Cementation**

The samples were randomly divided into six groups (n=5), according to the resin-based cement and cementation technique, as shown in table 2. For comparison with the conventional procedure, a sonic device was employed (Smart Sonic Device, FGM Dentscare Ltda, Joinville, SC, Brazil), capable of generating vibration oscillation in 5 different frequencies: 144.5, 150, 167.5, 170, 223.5 Hz. This study employed 170 Hz frequency, and the choice was based by convenience, since the device starts the vibration in this frequency, and has been used before for different application [24]. When in contact with hard surfaces, the oscillatory frequency will vary according to the applied pressure. To avoid large vibration oscillations the operator must apply the device with gentle pressure. The samples were cemented by conventional technique and SVD technique by the same calibrated person.

Group (n=5)	Resin-based cement	Cementation technique
ACC	All Cem Veneer	Conventional technique
ACSV	All Cem Veneer	Employment of Sonic Vibration
NX3C	Nexus Third Generation – NX3	Conventional technique
NX3SV	Nexus Third Generation – NX3	Employment of Sonic Vibration
RVC	Rely-X Veneer	Conventional technique
RVSV	Rely-X Veneer	Employment of Sonic Vibration

Table 2. Experimental groups composition, according to the resin-based cement and the cementation technique.

For cementation, resin-based cement was applied over the veneers and they were positioned over the enamel surface. After positioning, the excess of material was removed with a microbrush. Groups ACC, NX3C and RVC were photoactivated immediately after this moment, according to the respectives manufacturer's instructions. For groups ACSV, NX3SV and RVSV the SVD tip was positioned over the veneers with soft pressure, being the apparatus calibrated with 170 Hz, aiming to promote the cement flow and removal of excesses previously to photoactivation, following the respective manufacturer's instructions. All the samples were photoactivated for 20 seconds with the Radii-cal (SDI, Victoria, Australia), emitting 1200 mW/cm^2 power density.

After fixation, samples were stored in distilled water and remained in a biological stove (Fanem, São Paulo, SP, Brazil) at 37ºC during 48h. Then the specimens were scanned by OCT before thermal cycling. The OCT's system and principle of operation are detailed in the corresponding section 2.2.

Samples were thermocycled with alternate baths of 5 ± 3ºC and 55 ± 3ºC, applied at 500 cycles each one for 15 seconds (Nova Ética, Vargem Grande Paulista, SP, Brazil), simulating thermal changes in the oral cavity [25]. Next, specimens were stored again in distilled water in biological stove at 37ºC for 48h before the last OCT analysis.

2.2 Optical Coherence Tomography

Before the cementation procedure, all teeth and internal ceramic surfaces were submitted to OCT scanning, to verify the presence of any irregularity. After this, OCT analysis was performed in two other moments: 48h after cementation and 48h after the thermal cycling (Figure 1).

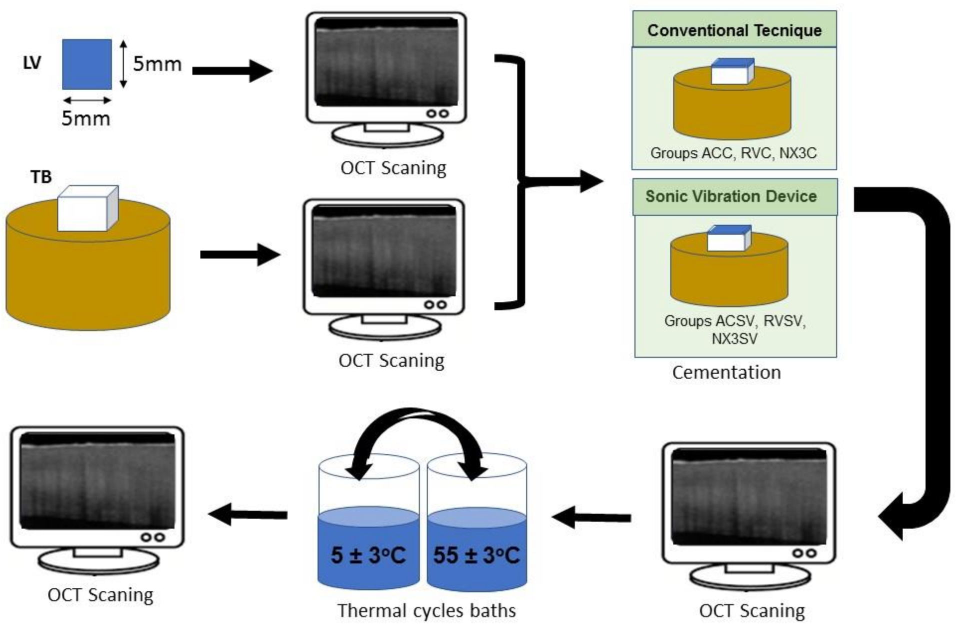

Figure 1: Sequence of sample preparation and OCT scanning. LV – laminate veneer; TB, tooth block.

The OCT system employed was the Ganymede Spectral Domain OCT (Thorlabs Inc, Newton, New Jersey, USA), operating at 930 nm central wavelength, 29 kHz axial scan rate, 2.7 mm maximum imaging depth, 8 μm lateral resolution and 5.8 μm / 4.4 μm axial resolution in air/water, respectively.

Spectral Domain OCT (SD-OCT) systems operate in the Fourier Domain to determine the optical properties of the samples by analyzing the reflected and backscattered light from the sample. The broadband light source emits a beam that travels through the Michelson interferometer until reaching perpendicularly the sample. The back-scattered light travels to the spectrometer where the unique phase delay for each wavelength is detected. The depth information is acquired using a Fast Fourier Transformation (FFT). This depth profile of a single point in the sample is referred to as A-scan. Through a Galvo mirror, it is possible to emit and collect light from several points of the sample along a line, referred to as B-scan, the two-dimensional image created, as shown in Figure 2, together with the A-scan.

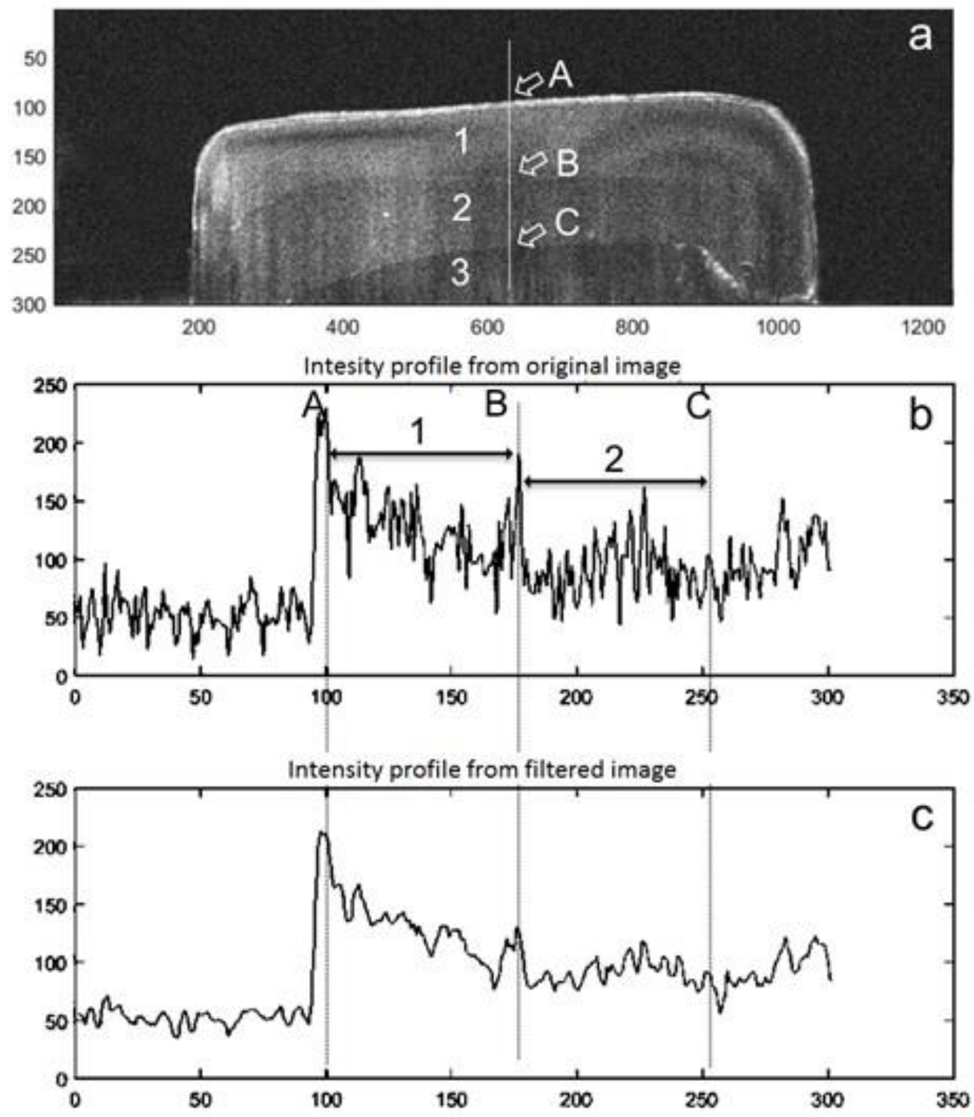

Figure 2. (a) OCT image generated from a sample. **(b)** A-scan obtained from the column corresponding to the dashed line in figure (a). **(c)** The same A-scan filtered through MATLAB. In the A-scan image it is possible to identify three peaks, corresponding to the following interfaces: A – air and ceramic veneer; B – ceramic veneer and resin-based cement; C – resin-based cement and enamel substrate. The interval distance between each peak corresponds to the distance, in pixels, between the cited structures. In this way, 1 – ceramic veneer; 2 – resin-based cement; 3 – enamel portion.

A teflon guidance device was made to ensure the OCT images performed before and after the thermal cycling could be obtained from the same regions into the samples, and the refractive index considered to the ceramic veneers was 1.45 [19].

2.3 Image processing data

An algorithm was developed using MATLAB language (Mathworks Inc, Natick, Massachusetts, USA) to obtain A-scan data from OCT images. In general, OCT images present speckle noise and it is necessary to filter it to obtain a better quality image. A low-pass filter (average filter, 3x3) was employed (Figure 2b). Then, a single column was analyzed to obtain qualitatively information about a selected region in samples images (OCT’s A-Scan), as shown in figures 2b and 2c. After the images were processed in Matlab, the layer cementation thickness was evaluated in ImageJ Program (Imaging Processing and Analysis in Java, National Institutes of Health, Bethesda, MD, USA) and quantified pixel’s gray tones, in order to further verify the failures. Each measured thickness was transformed from pixels to mm according to program setup. For the statistical analysis, information from histograms of Image J extraction were fixed according to the number of pixels (intensity) and the gray tones of each group.

2.4 Statistical analysis

For cases in which the normality was indicated, T-student test was used to compare the measurements between two interest groups, and ANOVA test was used to compare three or more groups of interest. In cases in which normality was not indicated, Mann-Whitney test was applied for comparison of measurements between the two interest groups and Kruskall-Wallis test for comparison between three or more interest groups.

To evaluate the influence of the use or not of the SVD, Chi-square test for independent samples was applied, and if the assumptions were not satisfied, Fisher's exact test was applied. All conclusions were taken considering the significance level of 5%.

3 Results

The representative images shown in Figure 2 are as obtained directly from the OCT system and digitally treated as described before. Also shown are the A-scan for each image, indicating its position in the sample. In figure 3, a representative sample with failures and areas of well-suited interface cementation are shown, with A-scans of the indicated columns. Figures 3a and 3b show a typical picture where one can identify the ceramic veneer region and the ceramic veneer/cement and cement/enamel interfaces. Figures 3c through 3h shows the equivalent A-scan in the regions indicated in figures 3a and 3b by a white line. The broad horizontal stripes are due to birefringence inherent to the fabrication process.

The failures – gap and air bubble – are clearly seen both in the images and in the respective A-scans (see caption of figure 3 for details). From those data, the failures dimensions could be quantified.

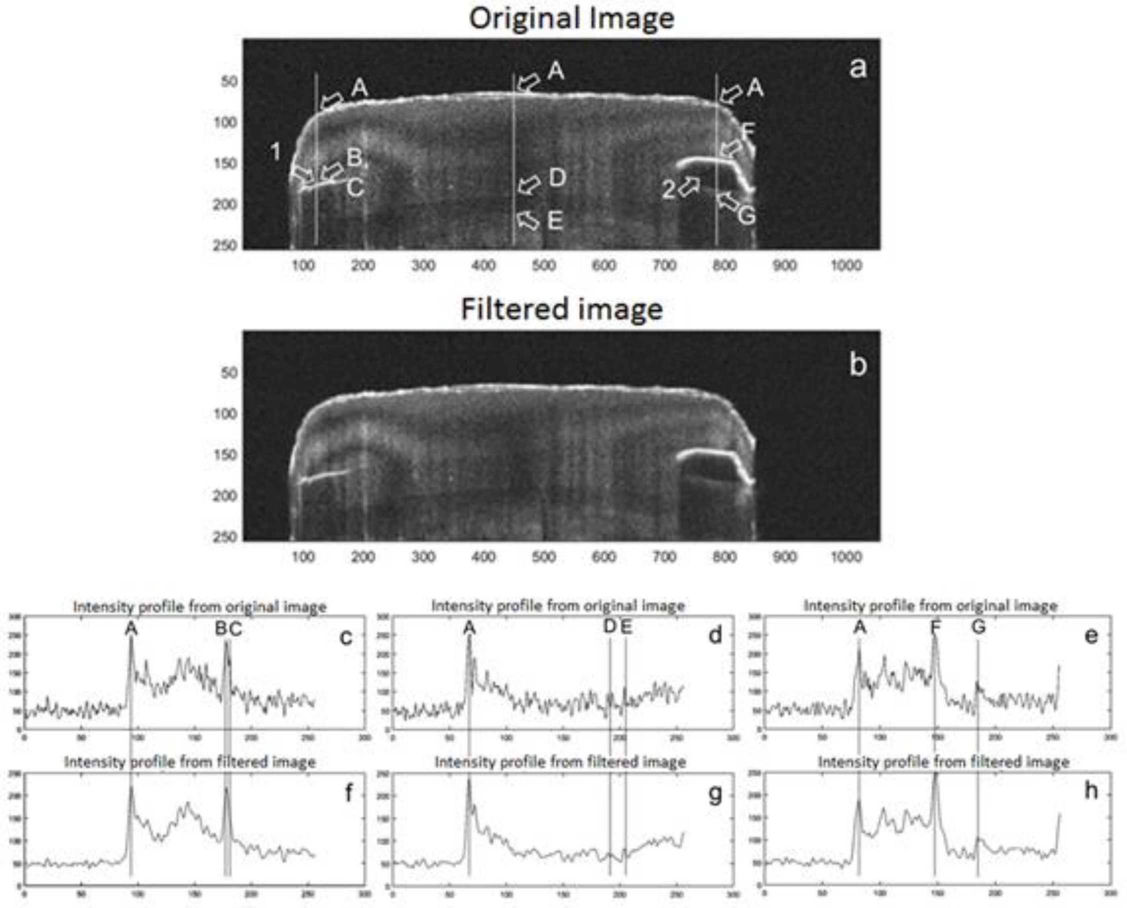

Figure 3. Representative images of a sample. OCT images and A-scans obtained from three different points. **(a)** Original OCT image and **(b)**, the same image filtered through MATLAB. **(c)**, **(d)**, **(e)**, A-scan obtained from the columns 112, 448 and 786, respectively, in figure **(a)**. **(f)**, **(g)**, **(h)**, A-scan obtained from the columns 112, 448 and 786, respectively, in figure **(b)**, after processing and filtering by MATLAB. 1 – a gap at the ceramic veneer-cement interface; 2 – an air bubble into the resin-based cement. Similar to that described in figure 2, each peak observed in A-scan corresponds to an interface into the sample. In this way: A – air and ceramic veneer; B and C – the interfaces of the gap present in figures **(c)** and **(f)**; D and E represents a well-suited interface between the ceramic veneer and RBC, and RBC and enamel substrate. F and G – ceramic veneer and air (air bubble margins).

Statistical analysis of the samples was based on the histogram obtained for each specimen. Regarding the cementation layer thickness, Table 3 shows the means of each group, according to the cementation technique and the thermal cycling.

Group	Brand	Tecnique	Mean	Standard-Deviation	p-value[1]
Before Thermocycling	All Cem	SV	0.24	0.15	0.351
		Conventional Tecnique	0.27	0.14	
		Total	0.25	0.14	
	Relyx Veneer	SV	0.39	0.18	0.203
		Conventional Tecnique	0.27	0.19	
		Total	0.36	0.19	
	NX3	SV	0.32	0.27	0.612
		Conventional Tecnique	0.26	0.19	
		Total	0.29	0.24	
After Thermocycling	All Cem Veneer	SV	0.28	0.16	0.265
		Conventional Tecnique	0.36	0.23	
		Total	0.30	0.19	
	Relyx Veneer	SV	0.33	0.15	**0.013***
		Conventional Tecnique	0.23	0.13	
		Total	0.29	0.15	
	NX3	SV	0.25	0.15	0.221
		Conventional Tecnique	0.28	0.14	
		Total	0.26	0.14	

1- Mann Whitney Non-parametric Test; * Statistically significant.

Table 3: Comparison of the average thickness according to the technique employed versus brands, before and after the thermocycling.

Table 4 shows that there was no thickness difference in cement layer with or without failures according to thermocycling.

Group	Cimentation Layer	Mean	Standard-Deviation	p-value[1]
Before Thermocycling	Without Failure	0.28	0.17	0.787
	With Failure	0.30	0.23	
	Total	0.29	0.20	
After Thermocycling	Without Failure	0.28	0.15	0.504
	With Failure	0.30	0.18	
	Total	0.29	0.16	

1-Mann Whitney Non-parametric Test; * Statistically significant.

Table 4: Comparison of cement failure before and after thermocycling groups.

4 DISCUSSION

In ceramic rehabilitation with high aesthetic performance, excellent restoration quality is imperative, since the layer of underlying resin cement strongly influences the beauty and longevity of the treatment. Failures in this type of intervention are closely related to faults in this interface. The presence of voids and defects in the cement layer, which may lead to marginal infiltration, pigmentation, secondary caries, restoration detachment, postoperative sensitivity and provide tension points for fracture of the underlying porcelain. Avoiding failures in cement layer of aesthetic restorations allows a longer lifespan of the treatment [13,16,20,22,26].

The OCT was employed to evaluate the underlying layer of cement, since it is a widely exploited imaging technique applied to dentistry. Its ability to observe characteristics of the cementation interface without the need for exposure to ionizing radiation, the generation of real-time and high-definition images makes it the main non-destructive method of evaluation [19,20].

Resin based materials are the first choice for sealing of restoration interfaces. Scotti [16] observed that ceramic thickness between 0.6 and 1.0 mm presented no significant difference between the degree of conversion (DC) in studied RBC, thus the only factor that had influenced in quality of polymerization was the brand and the kind of the RBC used.

It was observed that figures 3a and 3b presents white and dark curved bands (indicated by number “1” in fig. 3a). This is due to birefringence that occurs in all veneers, due to pressure during the fabrication process, which leads to a typical interference signature. The A-scan shown in figs. 3c and 3f correspond to a gap in the RBC – ceramic veneer interface, represented by the points “B” and “C”. Therefore, when analyzing the A-scan it is possible to identify two peaks in this area, corresponding, respectively, to the upper and lower margins of the gap, represented in Fig. 3c by the letters “B” and “C”. After filtering process of A-scans, it was possible to observe the reduction in the noise, so it is easier to identify the peaks correspondents to the interface. It could be clearly seen that no failure is presented in figures 3d and 3g of this sample; in this way, the letters “D” and “E” represents the upper and lower margins of cementation layer. Finally, the A-scans registered in figures 3e and 3h correspond to the area in which it is possible to visualize an air bubble in the cementation interface, in which points “F” and “G” represent the air bubble margins, as indicated in figure 3a.

It was observed in this study, through the extraction of A-scans obtained by the OCT’s images processing, that even with a good adaptation of the ceramic part to the substrate, microgaps that can result in micro infiltrations are more frequent than it was desired, since it was expected no gap at all. A possible cause for this occurrence would be the greater difficulty to control over the contraction force that was generated by the configuration factor, better known as factor C [26,27], and presence of smashed bubbles during the process of the veneers’ adaptation. In these cases, where smashed bubbles failures are present, the A-scans shows 2 peaks.

Volumetric shrinkage that occurs in resin cement must be considered too, since this characteristic can lead to the formation of gaps and misalignments within the cemented interface. In an ideal cementation, the resin cement should not undergo polymerization contraction and the insertion should be adjacent to the structures that it proposes to join, so there is no incorporation of faults and does not absorb water over time [26].

In this research, it was observed that the alternative technique employing the SVD, in order to create a flow after the insertion of RBC and expel possible bubbles included in the layer, had no statistics significance between groups in which the conventional technique and the alternative technique were tested. Our results corroborate with the findings of ref. [28], which applied the SVD in fiberglass post cementation, even though a difference vibration frequency than ours was employed. Furthermore, this result had no significant influence on the average thickness of the cement line.

Regarding the cement thickness according to the brand and type of cement before and after thermocycling, there was no statistically significant difference in thickness for the RBC tested, with or without the use of the SVD for groups cemented with All Cem Veneer and NX3. However, when specimens were cemented with RelyX Veneer associated to the SVD, a modification occurred in behavior about the presence of failures. The RVSV group present the best leakage of all. Further studies need to be performed about this group.

It was observed that the areas in which failures appeared, the cement thickness did not increase. This may be because no water sorption has occurred. NX3C and NX3SV, exhibited the worst results in failures after thermocycling. It can be explained due to the adhesive system used, which is the only self-etching in this study. Whilst conventional adhesive systems require the phosphoric acid at 37% etching previous to adhesive application, single step self-etching adhesive systems has acid monomers in their composition, but not with the same pH as the phosphoric. For this reason, they do not exhibit the same pattern of enamel surface conditioning [27–31].

5 CONCLUSION

In the present study, OCT was employed to evaluate the ceramic veneers interface prepared with three different resin-based cements, through the conventional technique and using an ultrasonic device before RBC cure reaction. There was no evidence that the alternative cementation technique tested provides prevention on failures insertion in RBC layer and also the three RBC presented the same behavior before and after thermocycling. The OCT has been clearly shown to be an effective technique for veneers evaluation, being potentially capable of *in vivo* evaluation of placed veneers.

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REFERENCES

[1] Zhou Z-R, Yu H-Y, Zheng J, Qian L-M, Yan Y. Clinical evaluation and laboratory wear-testing methods. Dent. Biotribology, Springer; 2013, p. 31–42.

[2] Knibbs PJ. Methods of clinical evaluation of dental restorative niaterials. J Oral Rehabilition 1997;24:109–23.

[3] Chuang SF, Liu JK, Chao CC, Liao FP CY. Effects of flowable composite lining and operator experience on microleakage and internal voids in class II composite

restorations. J Prosthteic Dent 2001;85:713–9. doi:10.1067/mpr.2001.113780.

[4] Balas C. Review of biomedical optical imaging—a powerful, non-invasive, non-ionizing technology for improving in vivo diagnosis. Meas Sci Technol 2009;20:104020. doi:10.1088/0957-0233/20/10/104020.

[5] Hsieh Y-S, Ho Y-C, Lee S-Y, Chuang C-C, Tsai J, Lin K-F, et al. Dental optical coherence tomography. Sensors 2013;13:8928–49. doi:10.3390/s130708928.

[6] Lin CL, Kuo WC, Chang YH, Yu JJ, Lin YC. Examination of ceramic/enamel interfacial debonding using acoustic emission and optical coherence tomography. Dent Mater 2014;30:910–6. doi:10.1016/j.dental.2014.05.023.

[7] Nazari A, Sadr A, Shimada Y, Tagami J, Sumi Y. 3D assessment of void and gap formation in flowable resin composites using optical coherence tomography. J Adhes Dent 2013;15:237–43. doi:10.3290/j.jad.a28623.

[8] Bakhsh TA, Sadr A, Shimada Y, Tagami J, Sumi Y. Non-invasive quantification of resin-dentin interfacial gaps using optical coherence tomography: Validation against confocal microscopy. Dent Mater 2011;27:915–25. doi:10.1016/j.dental.2011.05.003.

[9] Maia AMA, de Freitas AZ, de L. Campello S, Gomes ASL, Karlsson L. Evaluation of dental enamel caries assessment using Quantitative Light Induced Fluorescence and Optical Coherence Tomography. J Biophotonics 2016;9:596–602. doi:10.1002/jbio.201500111.

[10] Braz AKS, Aguiar CM, Gomes ASL. Evaluation of the integrity of dental sealants by optical coherence tomography. Dent Mater 2011;27:e60–4. doi:10.1016/j.dental.2010.11.010.

[11] Monteiro GQDM, Montes MAJR, Rolim TV, Mota CCBDO, Kyotoku BDBC, Gomes ASL, et al. Alternative methods for determining shrinkage in restorative

resin composites. Dent Mater 2011;27:e176–85. doi:10.1016/j.dental.2011.04.014.

[12] Friendman M. Masters of esthetic dentistry: Porcelain veneer restorations : a clinician’s opinion about a disturbing trend. J Esthet Restor Dent 2001;13:318–27.

[13] Sundfeld D, Correr-sobrinho L, Inocêncya N, Pini P, Costa AR, Sundfeld RH, et al. The Effect of Hydrofluoric Acid Concentration and Heat on the Bonding to Lithium Disilicate Glass Ceramic. Braz Dent J 2016;27:727–33. doi:10.1590/0103-6440201601024.

[14] de Andrade OS, Ferreira LA, Borges GA, Adolfi D. Ultimate Ceramic Veneers: A Laboratory-Guided Preparation Technique for Minimally Invasive Restorations. Am J Esthet Dent 2013;3:8–22. doi:10.11607/ajed.0054.

[15] Sampaio CS, Barbosa JM, Cáceres E, Rigo LC, Coelho PG, Bonfante EA, et al. Volumetric shrinkage and film thickness of cementation materials for veneers: An in vitro 3D microcomputed tomography analysis. J Prosthet Dent 2016:1–8. doi:10.1016/j.prosdent.2016.08.029.

[16] Scotti N, Comba A, Cadenaro DDSM, Fontanive L, Breschi DDSL, Scotti R. Effect of Lithium Disilicate Veneers of Different Thickness on the Degree of Conversion and Microhardness of a Light-Curing and a Dual-Curing Cement. Int Jounal Prosthodont 2016;29:384–8. doi:10.11607/ijp.4811.

[17] Morita RK, Hayashida MF, Pupo YM, Berger G, Reggiani RD, Betiol EAG, et al. Case Report Minimally Invasive Laminate Veneers : Clinical Aspects in Treatment Planning and Cementation Procedures. Case Rep Dent 2016;2016. doi:10.1155/2016/1839793.

[18] Guarda GB, Correr AB, Gonc LS. Effects of Surface Treatments , Thermocycling

, and Cyclic Loading on the Bond Strength of a Resin Cement Bonded to a Lithium Disilicate Glass Ceramic. Oper Dent 2013;38–2:208–17. doi:10.2341/11-076-L.

[19] de Andrade Borges E, Fernandes Cassimiro-Silva P, Osório Fernandes L, Leônidas Gomes AS. Study of lumineers' interfaces by means of optical coherence tomography. SPIE Biophotonics South Am 2015;9531:953147. doi:10.1117/12.2180979.

[20] Petrescu E, Negrutiu ML, Sinescu C, Pop DM, Rominu M, Ogodescu A, et al. OCT and SEM Imagistic Investigations of Composite Resin-IPS Empress Ceramic Interfaces. Recent Adv Appl Biomed Informatics Comput Eng Syst Appl Proc 11th WSEAS Int Conf Appl Informatics Commun (AIC 2011) Proc 4th WSEAS Intern 2011:431–4.

[21] Fernandes LO, Graça NDRL, Melo LSA, Silva CH V., Gomes ASL. Optical coherence tomography investigations of ceramic lumineers. Procedings SPIE 2016;9692:96920P. doi:10.1117/12.2213672.

[22] Hernandes DKL, Arrais CAG, de Lima E, Cesar PF, Rodrigues JA. Influence of resin cement shade on the color and translucency of ceramic veneers. J Appl Oral Sci 2016;24:391–6. doi:10.1590/1678-775720150550.

[23] Öztürk E, Chiang YC, Coşgun E, Bolay Ş, Hickel R, Ilie N. Effect of resin shades on opacity of ceramic veneers and polymerization efficiency through ceramics. J Dent 2013;41:8–14. doi:10.1016/j.jdent.2013.06.001.

[24] Cuadros-Sanchez J, Szesz A, Hass V, Patzlaff RT, Reis A, Loguercio AD. Effects of sonic application of adhesive systems on bonding fiber posts to root canals. J Endod 2014;40:1201–5. doi:10.1016/j.joen.2013.12.034.

[25] Monteiro GQM, Montes MAJR, Gomes ASL, Mota CCBO, Campello SL, Freitas

AZ. Marginal analysis of resin composite restorative systems using optical coherence tomography. Dent Mater 2011;27:e213–23. doi:10.1016/j.dental.2011.08.400.

[26] Turkistani A, Sadr A, Shimada Y, Nikaido T, Sumi Y, Tagami J. Sealing performance of resin cements before and after thermal cycling: Evaluation by optical coherence tomography. Dent Mater 2014;30:993–1004. doi:10.1016/j.dental.2014.05.010.

[27] Noronha Filho JD, Brandão NL, Poskus LT, Guimarães JGA, Silva EM da. A critical analysis of the degree of conversion of resin-based luting cements. J Appl Oral Sci 2010;18:442–6. doi:10.1111/j.1834-7819.2012.01703.x.

[28] Mushashe AM, Otavio R, Ferreira J, Eduardo C, Rezende E, Filho FB, et al. Effect of sonic vibrations on bond strength of fiberglass posts bonded to root dentin. Braz Dent J 2017;28:30–4.

[29] Shinohara S, Oliveira M, HIPÓLITO V, Giannini M, GOES M. Sem Analysis of the Acid-Etched Enamel Patterns Promoted By Acidic Monomers and Phosphoric Acid. J Appl Oral Sci 2006;14:427–35. doi:10.1590/S1678-77572006000600008.

[30] Tsujimoto A, Barkmeier W, Takamizawa T, Latta M, Miyazaki M. The Effect of Phosphoric Acid Pre-etching Times on Bonding Performance and Surface Free Energy with Single-step Self-etch Adhesives. Oper Dent 2016;41:441–9. doi:10.2341/15-221-L.

[31] Pena CE, Rodrigues JA, Ely C, Giannini M, Reis AF. Two-year Randomized Clinical Trial of Self-etching Adhesives and Selective Enamel Etching. Oper Dent 2016;41:249–57.

ANEXO

A - Parecer da Comissão de Ética no Uso de Animais

Universidade Federal de Pernambuco
Centro de Ciências Biológicas

Av. Prof. Nelson Chaves, s/n
50670-420 / Recife - PE - Brasil
fones: (55 81) 2126 8840 | 2126 8351
fax: (55 81) 2126 8350
www.ccb.ufpe.br

Recife, 02 de julho de 2015

Ofício nº 68/15

Da Comissão de Ética no Uso de Animais (CEUA) da UFPE
Para: Profº. Anderson Stevens Leonidas Gomes
Departamento de Física
Universidade Federal de Pernambuco
Processo nº 23076.018892/2015-10

Os membros da Comissão de Ética no Uso de Animais do Centro de Ciências Biológicas da Universidade Federal de Pernambuco (CEUA-UFPE) avaliaram seu projeto de pesquisa intitulado "**Análise da interface de laminados cerâmicos através da técnica de tomografia por coerência óptica**".

Concluímos que os procedimentos descritos para a utilização experimental dos animais encontram-se de acordo com as normas sugeridas pelo Colégio Brasileiro para Experimentação Animal e com as normas internacionais estabelecidas pelo National Institute of Health Guide for Care and Use of Laboratory Animals as quais são adotadas como critérios de avaliação e julgamento pela CEUA-UFPE.

Encontra-se de acordo com as normas vigentes no Brasil, especialmente a Lei 11.794 de 08 de outubro de 2008, que trata da questão do uso de animais para fins científicos e didáticos.

Diante do exposto, emitimos **parecer favorável** aos protocolos experimentais a serem realizados.

Origem dos animais: figrorifico Bandeira Ltda;Sexo: macho e fêmea; Nº total de animais 100.

Atenciosamente,

Pedro V. Carelli

Prof. Dr. Pedro V. Carelli
Presidente da CEUA / CCB - UFPE
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B – Normas da revista Dental Material

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Dent Mater, 1989; 5:157-160. Avoid referencing abstracts if possible. If unavoidable, reference as follows: 3. Demarest VA and Greener EH . Storage moduli and interaction parameters of experimental dental composites. J Dent Res, 1996; 67:221, Abstr. No. 868.

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[2] Strunk Jr W, White EB. The elements of style. 4th ed. New York: Longman; 2000.
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[3] Mettam GR, Adams LB. How to prepare an electronic version of your article. In: Jones BS, Smith
RZ, editors. Introduction to the electronic age, New York: E-Publishing Inc; 2009, p. 281–304.
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[4] Cancer Research UK. Cancer statistics reports for the UK, http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/;2003
[accessed 13.03.03].
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[dataset] [5] Oguro M, Imahiro S, Saito S, Nakashizuka T. Mortality data for Japanese oak wilt disease and surrounding forest compositions, Mendeley Data, v1; 2015. http://dx.doi.org/10.17632/xwj98nb39r.1.
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