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Leonardo Lamberti Miotti

O PAPEL DA ESTRATÉGIA ADESIVA NA RESISTÊNCIA DE UNIÃO DE RESTAURAÇÕES INDIRETAS CIMENTADAS A DENTINA COM CIMENTOS RESINOSOS DUAIS

Santa Maria, RS
2019

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Tese apresentada ao Curso de Doutorado do Programa de Pós-Graduação em Ciências Odontológicas, Área de Concentração em Odontologia, ênfase em Dentística, da Universidade Federal de Santa Maria (UFSM, RS), como requisito parcial para obtenção do grau de **Doutor em Ciências Odontológicas**.

Orientador: Prof. Dr. Alexandre Henrique Susin

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Alexandre Henrique Susin, Dr. (UFSM)
(Presidente da Banca/Orientador)

Letícia Brandão Durand, Dra. (UFSM)

Fábio Zovico Maxnuck Soares, Dr. (UFSM)

Gabriel Kalil Rocha Pereira, Dr. (IMED)

Marciano de Freitas Borges, Dr. (UFN)

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RESUMO

O PAPEL DA ESTRATÉGIA ADESIVA NA CIMENTAÇÃO DE RESTAURAÇÕES INDIRETAS COM CIMENTOS RESINOSOS DUAIS EM DENTINA

AUTOR: Leonardo Lamberti Miotti
ORIENTADOR: Prof. Dr. Alexandre Henrique Susin

No presente trabalho serão apresentados dois estudos acerca da influência da estratégia de cimentação utilizada em cimentações adesivas à dentina de restaurações indiretas, em relação a resistência de união imediata e a longo prazo entre a restauração e o substrato dentinário. O primeiro estudo trata-se de uma investigação laboratorial sobre resistência de união de uma cerâmica híbrida a dentina quando cimentada por diferentes cimentos resinosos duais, sob diferentes estratégias de cimentação. Blocos de uma cerâmica híbrida (VITA Enamic) foram cimentados sobre uma superfície plana de dentina exposta. Foram testados cimentos resinosos duais auto-adesivo (Relyx U200 - 3M-ESPE) e convencional (Relyx Ultimate - 3M-ESPE) sob a estratégia adesiva “Etch-and-rinse” (ER) - com condicionamento ácido da dentina - e sem condicionamento ácido prévio (NT), e diferentes tratamentos de superfície da peça cerâmica (silano ou SingleBond Universal – 3M-ESPE). Os grupos experimentais apresentam como unidade experimental o dente (n=6). Os dentes restaurados foram cortadas em palitos, os quais foram testados em uma máquina de ensaio universal (EMIC) através do ensaio de micro-tração. Metade dos palitos foram testados 24h após o corte e a outra metade 12 meses após imersão em água destilada. Os resultados revelaram que o cimento resinoso dual convencional Relyx Ultimate, utilizado sob a estratégia ER, apresentou os melhores resultados de resistência de união, tanto imediatamente quanto após 12m. Desse modo, concluiu-se que o cimento convencional, sob a estratégia adesiva ER, produziram os maiores valores de resistência de união à dentina. No segundo estudo foi executada uma revisão sistemática da literatura com meta-análise, considerando estudos que avaliaram essas duas categorias de cimentos resinosos (convencionais e auto-adesivos) em ensaios *in vitro*, e incluídos conforme os seguintes critérios de inclusão: estudos que avaliaram resistência de união entre dentina e um material restaurador indireto cimentado com cimentos duais auto-adesivos ou convencionais, com desfecho resistência de união apresentado em mega-pascal (MPA). As revisões dos estudos incluídos foram executadas por 2 avaliadores independentes (LLM e ACF), os quais aplicaram os critérios de exclusão após leitura na integra dos estudos incluídos. Dos 518 estudos encontrados na busca, 36 foram lidos na íntegra após os critérios de inclusão. Desses, 19 foram incluídos na revisão sistemática e na meta-análise. Foram executadas uma análise global comparando o desempenho geral das duas categorias de cimentos, e 3 análises de subgrupos comparando apenas o desempenho a longo prazo dos dois tipos de cimento, e o desempenho individual de cada tipo de cimento quando comparados os resultados imediatos e após envelhecimento. De maneira geral, os cimentos resinosos duais convencionais, utilizados em combinação com sistemas adesivos, apresentaram melhor desempenho em termos de resistência de união, quando utilizados em cimentações à dentina, tanto na análise global quanto a longo prazo. Com base nos resultados de ambos os estudos, os cimentos duais convencionais apresentaram melhor adesividade à dentina quando utilizados em cimentação indireta. Essa categoria de cimento apresenta uma melhor capacidade de adesão ao substrato dentinário, graças ao intermédio do agente adesivo. Já o desempenho dos cimentos auto-adesivos é dependente da marca comercial utilizada, a qual deve ser considerada na escolha desses cimentos para uso clínico.

Palavras-chave: Adesivos. Cimentação. Cimentos Dentários. Cimentos de resina. Cerâmica. Dentina. Falha de restauração dentária. Resina Composta.

ABSTRACT

THE ROLE OF ADHESIVE STRATEGY IN CEMENTATION OF INDIRECT RESTORATIONS WITH DUAL RESIN CEMENTS TO DENTIN

AUTHOR: Leonardo Lamberti Miotti
ADVISOR: Prof. Dr. Alexandre Henrique Susin

Two studies assessing the influence of cementation strategy on indirect restoration cementation to dentin, regarding immediate and long-term bond strength are presented in this composition. The first paper is an *in vitro* study that assess bond strength to dentin of a hybrid ceramic when cemented with different dual resin cements, under different cementation strategies. Ceramic blocks (VITA Enamic) were cemented to a flat exposed dentin surface. Dual resin cements were tested, one self-adhesive (Relyx U200 – 3M-ESPE) and one conventional (Relyx Ultimate – 3M-ESPE), through etch-and-rinse (ER) adhesive strategy or no dentin surface treatment (NT), without previous dentin phosphoric acid etching and combined with different chemical ceramic surface treatment (silane agent vs. Scotchbond Universal). Teeth were considered as experimental unity of experimental groups (n=6). The groups were divided considering cement and cementation strategy used. Stick-shaped specimens were obtained by cutting the cemented restorations. Specimens were submitted to microtensile bond strength in a universal testing machine (EMIC). Half of the specimens were testes 24h after cementation and other half were tested after 12m of distillated water storage. Results showed that Relyx Ultimate, combined with ER strategy, presented better bond strength results immediately and after aging. We concluded that conventional dual resin cement, combined with ER strategy produced better bond strength to dentin when cementing indirect restoration. The second study is a systematic review with meta-analyses that reviewed literature for *in vitro* studies that assessed these two classes of resin cements (conventional and self-adhesive), according to the following inclusion criteria: studies that evaluated bond strength between dentin and indirect restoration cemented with dual conventional or self-adhesive resin cements, with bond strength presented in mega Pascal (MPA) as outcome. Included studies were full-text reviewed by two independent reviewers (LLM and ACF), which applied exclusion criteria. From a total of 518 studies, 36 were screened full-text and reviewed according to exclusion criteria. 19 papers were included in systematic review and meta-analyses. A global analysis comparing conventional and self-adhesive cements, and three subgroups analyses comparing long-term bond strength performance and individually comparing immediate to long-term results of each resin cement class. Conventional resin cements, combined with adhesive system, presented an overall better adhesive performance when used to cement indirect restorations to dentin. Based on the results of both studies, dual conventional resin cements exhibited higher bonding strength to dentin when cementing indirect restorations. This cement category shows higher bond strength to dental substrate due to adhesive agent mediation. Self-adhesive cements performance is directly related to commercial brand, which must be considered when electing this resin cement class to clinical use.

Keywords: Adhesives. Cementation. Composite Resins. Ceramic. Dental Cements. Dental Restoration Failure. Dentin. Resin Cements.

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1 INTRODUÇÃO

Procedimentos restauradores capazes de reestabelecer função e estética, de maneira imperceptível, são vastamente utilizados em situações clínicas que há alguns anos atrás seriam consideradas inviáveis. Onde antes eram utilizadas restaurações cerâmicas com infraestruturas metálicas, agora restaurações livres de metal com excelente estética são confeccionadas (CHU; TRUSHKOWSKY; PARAVINA, 2010). Essa atual versatilidade passa pela evolução dos procedimentos adesivos a estrutura dental e dos próprios materiais restauradores, capazes de serem aderidos, aplicados em menor espessura e com características ópticas semelhantes às dos dentes naturais. Somando-se à notória evolução dos processos de fabricação das restaurações cerâmicas, como a usinagem pela tecnologia CAD/CAM, atualmente é possível executar restaurações cerâmicas estéticas praticamente imperceptíveis após a cimentação e integração com o substrato dental (SON et al., 2010).

A adesão permitiu a aplicação clínica de uma odontologia conservadora, onde os extensos e retentivos preparos cavitários foram substituídos por preparos mínimos, restritos apenas a remoção de tecido cariado ou remoção de retenções em preparos para restaurações indiretas. Uma vez que a preservação da estrutura dental é um fator crítico para a longevidade da estrutura dental e do procedimento restaurador nele executado (VAN DIJKEN; HASSELROT, 2010), a odontologia adesiva e minimamente invasiva tornou-se um campo de muito interesse na literatura atual (GUESS et al., 2013). Apesar dos consideráveis avanços na área e da consolidação da odontologia adesiva, a adesão em dentina ainda é foco de inúmeros estudos, devido a sua complexidade e a maneira como os materiais restauradores interagem com esse substrato. Na cimentação adesiva de restaurações indiretas, o material restaurador é retido por intermédio de cimentos resinosos. Desse modo, restaurações indiretas de materiais resinosos ou cerâmicos, totais ou parciais, representam uma válida opção terapêutica restauradora para dentes com severa destruição coronária (DE ANGELIS et al., 2011).

Quando comparada à cimentação tradicional (com mecanismo de retenção não-adesivo), a cimentação adesiva apresenta algumas vantagens importantes, como por exemplo permitir restaurações parciais indiretas estéticas em dentes anteriores, com maior capacidade de retenção aos substratos, menor solubilidade, com adequada biocompatibilidade e menor microinfiltração marginal (PAVAN et al., 2010). Outra vantagem importante diz respeito ao efeito de reforço da estrutura cerâmica de restaurações indiretas. A presença do cimento resinoso no processo de cimentação pode aumentar a resistência flexural de materiais cerâmicos (XIAOPING; DONGFENG; SILIKAS, 2014). A partir da cimentação adesiva, aumenta a probabilidade de que as possíveis falhas das restaurações cerâmicas sejam de menor severidade, as quais podem ser passíveis de reparo em alguns casos. O menor módulo de elasticidade dos materiais resinosos permite que os cimentos resinosos transmitam consideráveis quantidades de carga para o substrato dental (JIANG et al., 2010; SALAVERRY et al., 2013). A partir dessas vantagens e o aumento do uso clínico, os fabricantes investiram e desenvolveram novos cimentos resinosos, com diferentes estratégias adesivas e protocolos clínicos.

A cimentação adesiva de materiais cerâmicos à estrutura dental com cimentos resinosos pode melhorar a resistência mecânica e reduzir a propagação de trincas ao longo da restauração (FLEMING et al., 2006). Cerâmicas vítreas, quando retidas por cimento resinoso, apresentam taxas de sobrevivência mais favoráveis do que quando cimentadas com outros tipos de cimentos (MALAMENT & SOCRANSKY, 2001; GROTEN & PROBSTER, 1997) Behr e colaboradores (2003), ao avaliarem a resistência à fratura e adaptação marginal de restaurações totalmente cerâmicas quando cimentadas com diferentes tipos de cimento, concluíram que a maior resistência à fratura e a melhor adaptação marginal das restaurações ocorreu quando foram cimentadas com cimento resinoso. (BEHR et al., 2003) Apesar da consolidação da cimentação adesiva, apenas o fato de se usar um cimento resinoso não é suficiente para garantir longevidade as restaurações cerâmicas. O sucesso dessas restaurações está associada ao adequado estabelecimento da adesão com os substratos dentais (XIAOPING et al., 2014). Não há consenso na literatura a respeito de qual estratégia de cimentação, envolvendo os cimentos resinosos, promove melhor adesão aos substratos dentais. Essa questão torna-se ainda mais relevante quando associamos o estabelecimento dessa adesão com as propriedades mecânicas da restauração cimentada.

É notória a evolução dos sistemas cerâmicos nos últimos anos. Inicialmente, as cerâmicas odontológicas consideradas estéticas eram aquelas predominantemente vítreas, as quais são extremamente frágeis e necessitam de infraestruturas metálicas ou de cerâmicas policristalinas. O desenvolvimento das cerâmicas vítreas reforçadas por partículas de carga permitiu que cerâmicas com propriedades ópticas semelhantes as da estrutura dental apresentassem excelentes propriedades mecânicas. Como exemplo, o dissilicato de lítio é uma cerâmica estética que pode ser utilizada até em coroas totais monolíticas em dentes anteriores (KELLY, 2013). Mais recentemente, surgiu um novo conceito de material restaurador onde combinam-se cerâmica e compósito a fim de se obter um material com as características positivas de ambos materiais envolvidos (COLDEA et al., 2013; ELSAKA et al., 2014). Nesse contexto, a cerâmica Vita Enamic (Vita Zahnfabrick), a qual é uma cerâmica vítrea infiltrada por uma rede polimérica, e que propõem-se a ser um material estético, com excelentes propriedades mecânicas e mais resiliente do que uma cerâmica convencional. Apesar dessa proposta inovadora, seu desempenho adesivo ainda carece de mais informações. A interação desses diferentes materiais com o cimento utilizado é de fundamental importância para a longevidade das restaurações, pois uma falha adesiva em uma das duas interfaces resultantes da cimentação (substrato-cimento e cimento-restauração) pode significar o insucesso clínico do procedimento (PEUTZFELDT et al., 2011; ALVES et al., 2015).

O cimento resinoso de cura dual, cujo processo de polimerização ocorre a partir da foto-ativação e ativação química, é recomendado para cimentações onde não há possibilidade de suficiente exposição a luz para uma completa polimerização. Esses cimentos podem apresentar diferentes estratégias de cimentação e, geralmente, são utilizados sobre esmalte e dentina. Essa variação na estratégia de cimentação ocorre principalmente na relação entre o cimento e o substrato: enquanto alguns cimentos necessitam da hibridização prévia do substrato com o sistema adesivo – chamados cimentos convencionais, outros são considerados autoadesivos e não necessitam sequer de condicionamento dos tecidos dentais (ALVES et al., 2015). Os cimentos resinosos convencionais são considerados o padrão ouro para cimentação adesiva e necessitam de um tratamento prévio do substrato dental por um sistema adesivo e da restauração indireta (FEDERLIN; HILLER; SCHMALZ, 2010). Já os cimentos auto-adesivos apresentam uma proposta de simplificação de técnica, uma vez que dispensam a utilização de um sistema adesivo durante o protocolo de cimentação.

Com a tendência de simplificação dos materiais restauradores, os adesivos "universais" ou "multi-modo" surgiram no mercado com a proposta de utilização sob qualquer estratégia adesiva, em apenas um passo e apresentado em apenas um frasco. (PERDIGÃO; SEZINANDO; MONTEIRO, 2012; HANABUSA et al., 2012; PERDIGÃO; LOGUERCIO, 2014; PERDIGÃO et al., 2014) Estudos anteriores como o de Muñoz e colaboradores (2015) mostram que os adesivos universais com MDP na composição apresentam uma adesão estável e satisfatória ao longo do tempo, semelhante aos adesivos convencionais e auto-condicionantes, considerados "padrão ouro" na literatura. (MUÑOZ et al. 2015) Esse excelente desempenho fez com que estes fossem considerados como uma alternativa para uso em estratégias de cimentação de restaurações indiretas, combinados a cimentos resinosos, criando novos sistemas de cimentação. O cimento Relyx Ultimate (3M – ESPE) foi desenvolvido para ser utilizado juntamente com o adesivo Single Bond Universal (3M – ESPE). O sistema aproveita a versatilidade do adesivo universal em relação a hibridização do substrato dental e expande seu uso no preparo das restaurações cerâmicas.

Uma vez que o adesivo Single Bond Universal (3M – ESPE) apresenta silano em sua composição, o fabricante indica seu uso como substituto do agente silano convencional durante a cimentação. A diminuição da sensibilidade técnica é outra vantagem importante desse sistema, uma vez que o primer apresenta caráter de acidez semelhante a um adesivo auto-condicionante. Assim, é possível a aplicação das duas estratégias de tratamento de superfície no mesmo procedimento restaurador, com a aplicação de um único sistema adesivo capaz de hibridizar substrato dental previamente condicionado com acido fosfórico ou não. O adesivo Single Bond Universal apresenta em sua composição o copolímero do ácido polialquenóico e o monômero 10-MDP, que além de promover a adesão química aos substratos dentários, confere ao sistema a característica de acidez necessária aos materiais considerados auto-condicionantes. (ERICKSON; BARKMEIER; LATTA, 2009; YOSHIDA et al., 2000; YOSHIDA et al., 2012).

A estratégia adesiva empregada durante um procedimento restaurador pode ter importante influência na resistência de união ao substrato dental. Em relação a estratégia adesiva de sistemas adesivos, os considerados auto-condicionantes podem apresentar desempenho clínico semelhante aos adesivos convencionais, com condicionamento ácido total prévio a sua aplicação (DELBONS et al., 2015). Já os adesivos universais parecem apresentar um melhor desempenho adesivo quando submetidos à estratégia adesiva de condicionamento ácido seletivo, onde apenas o esmalte é condicionado com ácido fosfórico. (DA ROSA; PIVA; SILVA, 2015). Muitos desses adesivos são empregados em procedimentos de cimentação adesiva, como agente de hibridização do substrato dental combinados com cimentos resinosos convencionais. Já os cimentos resinosos autoadesivos apresentam como indicação do fabricante a cimentação sem condicionamento ácido prévio do substrato dental. Na estratégia autoadesiva, o controle da umidade dentinária parece ser o ponto mais importante em relação a resistência de união à dentina (GUARDA et al., 2010). Apesar de alguns estudos mostrarem a viabilidade clínica dos cimentos autoadesivos, há uma tendência ao melhor desempenho dos cimentos convencionais. Um ensaio clínico randomizado de boca dividida com acompanhamento de até 18 meses, executado por Vogl e colaboradores (2016), comparou dois cimentos resinosos – Relyx Unicem 2 e Relyx Ultimate – em cimentações adesivas de coroas parciais em dentes posteriores de cerâmica. (VOGL et al, 2016) No referido estudo, o cimento autoadesivo foi utilizado sem uso de condicionamento ácido, enquanto que o cimento Relyx Ultimate foi testado com o adesivo universal no tratamento interno da peça cerâmica e de dois modos em relação a estratégia adesiva: com ou sem condicionamento seletivo de esmalte. Não houve condicionamento ácido de dentina no estudo. Apesar das limitações do estudo, os autores concluíram que após 18 meses o sistema Relyx ultimate apresentou maiores taxas de sobrevivência em ambas estratégias adesivas quando comparado com o Relyx Unicem 2, o que confirma sua viabilidade para restaurações parciais em cerâmica. (VOGL et al, 2016) Mesmo com essa importante evidência científica, novos questionamentos podem ser feitos a respeito do desempenho desses dois cimentos resinosos, como por exemplo o desempenho a longo prazo quando utilizado o condicionamento ácido da dentina ou ainda o tratamento da peça cerâmica com primer específico para tal uso.

Não há na literatura atual uma resposta definitiva sobre como os diferentes modos de condicionar o substrato dental podem interferir na adesão dos diferentes tipos de cimentos resinosos duais quando usados em procedimentos restauradores indiretos, principalmente quando há envolvimento de dentina. Essa questão torna-se ainda mais interessante com o advento dos cimentos resinosos convencionais combinados com adesivos universais. Desse modo, torna-se relevante entender qual categoria de cimento resinosos dual (convencional ou auto-adesivo) apresenta melhor adesão à dentina e avaliar o efeito da estratégia adesiva na cimentação de restaurações indiretas em dentina ao utilizar tais cimentos. A partir do contexto exposto, a presente tese de doutorado será dividida em dois artigos:

O primeiro deles, um estudo *in vitro* intitulado ***"Bond strength to dentin of a PICN ceramic cemented with dual resin cements to dentin substrate: effect of different cementation strategies"***, avaliou a resistência de união imediata e a longo prazo de restaurações indiretas de cerâmica quando cimentadas à dentina com cimentos resinosos duais e convencionais, submetidos a diferentes protocolos de cimentação adesiva.

O segundo artigo trata-se de uma revisão sistemática com meta-análise e é intitulado: ***"Is conventional resin cements adhesive performance to dentin better then self-adhesive? A systematic review and meta-analysis of in vitro studies"***, propôs-se a identificar, a partir da revisão de estudos *in vitro* existentes na literatura atual, qual tipo de cimento resinoso apresenta melhor desempenho adesivo quando utilizado para cimentar materiais restauradores indiretos à dentina, tanto imediatamente quanto após métodos de envelhecimento.

2 ARTIGO 1 – BOND STRENGTH TO DENTIN OF A PICN CERAMIC CEMENTED WITH DUAL RESIN CEMENTS TO DENTIN SUBSTRATE: EFFECT OF DIFFERENT CEMENTATION STRATEGIES

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BOND STRENGTH TO DENTIN OF A PICN CERAMIC CEMENTED WITH DUAL RESIN CEMENTS TO DENTIN SUBSTRATE: EFFECT OF DIFFERENT CEMENTATION STRATEGIES

Running title: Adhesion to dentin of different resin cements

Leonardo Lamberti Miotti[1], Andressa Cargnelutti Follak[1], Alexandre Henrique Susin[2]

[1] DDS, MS – Department of Restorative Dentistry, School of Dentistry, Federal University of Santa Maria, Marechal Floriano Peixoto st, 1184 – 312, Centro, Santa Maria - RS, Brazil, Post Code: 97015-372

[2] DDS, MS, PhD, Professor – Department of Restorative Dentistry, School of Dentistry, Federal University of Santa Maria, Marechal Floriano Peixoto st, 1184 – 312, Centro, Santa Maria - RS, Brazil, Post Code: 97015-372

Corresponding author:

Leonardo Lamberti Miotti (e-mail: llmiotti@gmail.com)

Carlos Brenner st, 130, Nossa Senhora de Lourdes, Santa Maria - RS, Brazil
Post Code: 97050-100

Phone number: +55(55) 98407-6871

Bond strength to dentin of a PICN ceramic cemented with dual resin cements to dentin substrate: effect of different cementation strategies

Running title: Adhesion to dentin of different resin cements

Summary: The purpose of the present *in vitro* study is to assess immediate and long-term bond strength of a self-adhesive and conventional resin cement when used to cement a new hybrid restorative material to dentin. Ceramic blocks from a PICN ceramic material (VITA Enamic) were cemented to a flat exposed dentin surface through different cementation protocols. Two dual resin cements were tested, one self-adhesive (Relyx U200 – 3M-ESPE) and one conventional (Relyx Ultimate – 3M-ESPE), through etch-and-rinse (ER) adhesive strategy or no dentin surface treatment (NT), without previous dentin phosphoric acid etching. Teeth were considered as experimental unity of experimental groups (n=6). The groups were divided considering cement and cementation strategy used. Stick-shaped specimens were obtained by cutting the cemented restorations. Specimens were submitted to microtensile bond strength in a universal testing machine (EMIC). Half of the specimens were testes 24h after cementation and other half were tested after 12m of distillated water storage. ANOVA revealed one significant interaction between “time” and “dentin treatment” factors, as ER strategy was associated to bond strength decrease after 12m. Despite, Relyx Ultimate with Etch-and-rinse strategy presented higher immediate bond strength and, even with bond strength reduction after 12m, still presented highest bond strength values. We concluded that conventional dual resin cement, combined with ER strategy produced better bond strength to dentin when cementing indirect restoration

Clinical Relevance: The hybrid ceramic material had an adequate adhesion with conventional and self-adhesive resin cements, however should be used with conventional resin cement combined with etch-and-rinse strategy for better retention to dentin.

Keywords: Adhesives; Cementation; Ceramic; Resin Cements.

Introduction

Adhesive cementation of indirect restoration promotes a reliable union between restorative material and dental substrate. When compared with non-adhesive cementation, resin-luting agents present better retention, lower solubility and micro-leakage, and biocompatibility.[1] Adhesive cementation is higher sensitive to the technique than traditional cements. On this view to acquire the best adhesion the cementation protocol should be rigorously applied.[2]

The Cementation protocol can be extended for changes in the surface of the restoration, such as, 5-10% hydrofluoric acid treatment for silica-based glass-ceramic and silane application to promote chemical adhesion between the organic matrix of cement and inorganic particles of restoration.[3-6] Regarding adhesive strategy for dental substrate, conventional resinous-luting agents establish adhesion through adhesive system hybridization. These cements usage recommendation is in combination with an etch-and-rinse or self-etch adhesive system, depending on commercial brand. Manufacturers constantly develop new luting systems aiming for technique simplification. Whereas conventional resin cements are developed to be used in combination with adhesive system, self-adhesive cements propose a less technique sensitive protocol, with no adhesive association and reduced number of steps.[7] Universal adhesives based on 10-MDP and silane on its chemical formulation were successfully tested as "silane substitutes". Thus, the same product could be used to treat both, ceramic and dental substrate.[8] The clinical viability of these technique simplifiers products is object of research in past years. Considering self-adhesive resin cements, the research conducted by Hitz et al. (2012) tested the bond strength of six different self-adhesive resin cement to dentin and glass ceramic. The authors concluded that not all the tested cements had adequate long-term bond strength, and self-adhesive capacity is directly related to product-specific factors, like composition.[2,9] Apparently, all self-adhesive cement performance should checked in literature before clinical use, since some of them are available for purchase even with bad bonding performance.

Restorative procedures optimization also requires restorative materials evolution. A new class of indirect restorative material was recently developed with the purpose of combining resin composite elastic modulus, which is considered similar to dentin, with ceramic resistance, chemical stability and esthetics.[10] This material was called as polymer-infiltrated ceramic network and is considered a hybrid ceramic material, represented by the trademarked Vita Enamic (Vita Zahnfabrik), that has, in mass, 86% of ceramic inorganic particles and 14% of organic polymer.[11] Despite of stimulant mechanical results obtained in previous studies, its capacity to interact with resin luting agents is an important aspect to be more studied in order to establish the bonding longevity.[11,12]

Therefore, the objective of the present study was to assess immediate and long-term bond strength of self-adhesive and conventional resin cement when used to cement a PICN ceramic to dentin. The study will be conducted on the self-adhesive and total-etch adhesive strategy to cement a hybrid ceramic material on dentin. The null-hypothesis is that the bond strength is not influenced by the cement and adhesive treatment applied.

Methods and Materials

Tooth selection and preparation

The research protocol was reviewed and approved by a local ethics committee.. Thirty-six freshly extracted caries free human third molar, were obtained from a tooth bank. Teeth were cleaned and stored in 0,5% chloramine T solution at 4ºC for a maximum of 30 days before using in this study.

Flat coronal dentin surface was exposed on each tooth by cutting the occlusal enamel and a superficial dentin layer with a water-cooled diamond saw (Labcut 1010, Extec Co, Enfield, EUA) in perpendicular direction. The exposed dentin surface was examined and any remaining enamel was removed by 400-grit SiC paper under running water in a polishing machine (EcoMet 250, Buehler, Lake Bluff, IL, USA), then, the dentin surfaces were abraded with a 600-grit SiC paper under water-cooling for 60s to standardizes the smear layer.

Experimental design

In the present study, teeth were considered as experimental unit. According to sample size calculation, a minimum number of six teeth (n=6) were necessary as sample size to achieve a power of 0,8 and ∝ error probability of 5% (expected variation coefficient of 20% and 20% mean difference between groups. The resin cements Relyx U200 (U200; 3M ESPE, St Paul, MN, USA) and Relyx Ultimate (Ult; 3M ESPE, St Paul, MN, USA) were used as bonding cements and a PICN ceramic Vita Enamic (VITA Zahnfabrick, Bad Säckingen, Germany) was used as indirect restorative material (Table 1). The prepared teeth were randomly assigned into 6 experimental groups, according to the combination of resin cement and ceramic surface` treatment (U200 – Relyx U200 with silane; Ult+Sil – Relyx Ultimate with silane; Ult+SBU – Relyx Ultimate with Scotchbond Universal) and dentin treatment (NT – no dentin treatment; ER – etch-and-rinse with 35% phosphoric acid). Figure 1 shows the group distribution.

Ceramic preparation and Restorative procedures

VITA Enamic is commercially presented as CAD/CAM blocks with 18x14x12mm dimensions. Each block was cut in all 3 axes, to produce specimens with 4.5mm height, 7mm length and 6mm width. 14 fragments were obtained from two and a half blocks After cuting, the bonding surface of each fragment was polished with a 1200-grit SiC paper and ultrasonically cleaned in distillated water for 10 m. The fragments were randomly assigned to the experimental groups (n=6).

For all experimental groups, the cementation steps followed the manufacturer instructions (except for U200 group with ER dentin treatment). The bonding surface of each ceramic fragment was conditioned with 5% hydrofluoric acid for 60s, followed by a cleaning protocol of 37% phosphoric acid for 60s and ultrasonic washed in distillated water for 5 m. Chemical bonding agent (silane or Scotchbond Universal) was applied according to cementation protocols of each experimental group (Table 2). After ultrasonic bath, all ceramic fragments were air-dried for 60s before bonding agent application. After cementation protocol, all restored teeth were stored in distilled water at 37ºC for 24 hours

Microtensile Bond Strength

A single blinded operator performed the microtensile bond strength tests. After 24 h of storage in distilled water at 37^{o} C the restored teeth were sectioned longitudinally to obtain sticks with cross section of $0{,}8mm^2$ checked with a digital caliper (Carbografite, Petrópolis, RJ, Brazil). The specimens of each group were randomly assigned to be tested under microtensile bond strength (μTBS), whereas half of the specimens were tested immediately and the other half, at twelve months of water aging. The specimens were attached to a metallic device with cyanoacrylate. The device were fixed in a universal testing machine (EMIC DL in 1000, equipment and Systems LTDA, PR, Brazil) and submitted to testing with a crosshead speed of 1mm/min, until the fracture.. Pretesting failures specimens that fail prior to be tested on μTBS - were recorded for posterior statistical analysis. A single blinded operator performed the microtensile bond strength tests. The fractured specimens were analyzed under a 60x-of magnification in a stereoscope (Discovery v.20, Zeiss, Oberkochen, Germany) to classify the type of failure as follows: adhesive failure (at interface between resin cement and ceramic or dentin), cohesive failure (cohesive failure in ceramic or dentin) and mixed failures (when both, adhesive and cohesive failures, were presented in the same specimen).

Statistical analysis

In the present experiment, three factors were considered for statistical analysis: Cement (U200, Ult+Sil and Ult+SBU), Dentin treatment (NT and ER) and aging (24h or 12mo). Kolmogorov-Smirnov test was performed to check the normality. A Three-way repeated-measures ANOVA and *post hoc* Tukey test ($\propto$=0,05), using a statistical software package (IBM SPSS Statistics version 21, IBM, Armonk NY, USA) was performed. Pre-test failures were included in the bond strength mean calculation, considered as 0 MPa.[13]

Results

Table 3 shows μTBS mean values comparisons of all 6 experimental groups, considering the different bond strength evaluation times (24h and 12mo). All three cements (u200, Ult+Sil and Ult+SBU) presented similar and statistically higher immediate μTBS when “etch-and-rinse” dentin treatment was used. The “no treatment” groups presented lower μTBS immediate values. This pattern has changed when the 12 months μTBS were considered. After 12 months, Ult+Sil with both dentin treatment (ER – 35,57±5,92; NT – 26,55±7,09), and Ult+SBU with ER dentin treatment (32,36±4,01) showed the higher μTBS values.

The comparison between 24h and 12mo μTBS values revealed that the groups with “Etch-and-Rinse” dentin treatment presented a statistical significant μTBS reduction ($p<0,05$). The three-way ANOVA showed that all three factors (Cement, Dentin treatment and BS evaluation time) individually influenced in μTBS, and only the cross-interaction among Dentin Treatment and BS evaluation time was considered significant (p=0,000), where ER groups presented μTBS decreasing over time. Considering only the cement type, Relyx Ultimate combined with silane (Ult+Sil) presented the best adhesive performance when compared with the other two cement combinations investigated in the present study (p>0,05). Regarding aging factor, baseline μTBS values were statistically higher than 12 months. Considering "dentin treatment" factor, ER groups presented higher μTBS results. Table 4 presents the type of failure distribution of each experimental group in both times (24h and 12m). A relatively low number of cohesive failures and pretest failure were observed in the experiment.

Discussion

In the present study, Relyx U200, a self-etch adhesive, and Relyx Ultimate, a conventional adhesive combined with a universal adhesive, were tested in bond strength to cementation of indirect restorative material. The versatility of this resin cement allowed the comparison of two different ceramic treatments: Silane and Scotchbond Universal. For analysis purpose, Relyx Ultimate was considered as different resin cement when combined with Scotchbond Universal (SBU) ceramic treatment or when combined with silane ceramic treatment. We reject the null hypothesis, since significant differences were observed between resin cements and dentin treatment.

Our results showed that, for Relyx Ultimate, there was no statistical significant difference between both ceramic treatments on any aging tested. These results suggest that clinicians may choose safety between both ceramic treatments protocols.[8,14,15] A previous investigation of Moro et al. (2017) also suggests that both silane and universal adhesive may be applied together, on acquirement of the better bonding results.[8] An important advantage about using SBU as ceramic treatment is the easiness of treating all involved surfaces in a single bottle.

Considering 24h μTBS results, all three cements group submitted to ER dentin treatment presented adequate immediate bonding performance to dentin. Sarr et al. (2010) found, on a previous study, that adequate immediate bond strength to dentin could be obtained with both self-adhesive and conventional resin luting agents, which is in accordance with our findings.[2] Considering the factor dentin treatment, all groups with ER dentin treatment presented higher μTBS when compared with those without treatment (NT). For conventional resin cements, previous studies[16-21] reported the positive effect of etch-and-rinse adhesive approach on immediate bond strength of conventional resin cements to dentin. The adhesion mechanism of etch-and-rinse technique combined with an adhesive system, which provides micromechanical retention by removing the smear layer and plugs and exposing collagen network for further monomer infiltration, can be considered the main reason for higher immediate μTBS.

Self-adhesive resin luting agents were developed to simplify cementation technique, reducing the number of steps and, consequently, technique sensitivity.[22,23] The bonding performance to dentin of these cements is composition-dependent, especially considering acidic functional monomers and their capacity to demineralize and interact with hidroxiapatite.[22] Better adhesive performance of self-adhesive cements to dentin was already reported when combined with dentin conditioning agents. On a published study by Sarr et al. (2010), the authors concluded that self-adhesive bonding capacity depends on product specific factors, as viscosity and composition.[2] In the present study, the U200 luting agent showed lower immediate bond strength values on self-adhesive strategy, and better immediate adhesive results on etch-and-rinse protocol. Saker et al. (2016) tested the effect of different chelating agents - acidic solutions applied on dentin surface previously cementation - on the bond strength of self-adhesive resin cements to dentin. All three chelating agents improved the immediate bond strength, what are in accordance with our findings in the present experiment. The authors' explanation for that was the adequate smears layer removal, and consequently dentinal tubules exposure. We believe that phosphoric acid promoted a similar effect on U200 ER group, what could explain higher μTBS values.[23]

Despite this immediate behavior, where high bonding values were reported, all ER groups presented statistical significant difference in bond strength on aging. The dentin treatment influenced the μTBS on baseline, where all groups etched-and-rinse treated (ER) presented higher μTBS when compared with those without treatment (NT). Previous studies already reported *in vitro* bond strength decreasing after aging of different resin cements and adhesive strategies.[18,24,25] Ritter et al. (2009) tested different conventional resin luting agents, used through different adhesive approaches. Concerning the bonding to enamel, all groups submitted to etch-and-rinse protocol presented higher bond strength results. When bonding to dentin was considered, groups with self-etch protocol presented better results. When submitted to aging protocol, even lower bonding strength results were observed.[26] Our study found that U200 ER group presented the most considerable μTBS values decreased after aging. Ult+sil ER and Ult+SBU ER groups, despite showing reduction on bond performance, still showed the highest bond strength values after aging. In fact, our study submitted all resin luting agents to etch-and-rinse protocol, even self-adhesive cement. Hybrid-layer degradation is directly associated to pour adhesive agent penetration trough collagen network, leaving exposed collagen fibrils, which are prone to degradation process.[27,28] We speculate that SBU had and adequate ability to fill in the spaces between collagen, and consequently preserve bond strength to acceptable levels. As observed on previous study, on dentin, etch-and-rinse strategy seems to be more sensitive to degradation over stress and time. Self-etching strategy is related to better long-term bond strength to dentin results. The use of Self-etching or self-adhesive resin cements should follow selective enamel etching approach, without phosphoric acid etching to dentin, but only on enamel.[26,29,30]

New restorative materials must be assessed regarding all properties before its clinical use. Vita Enamic (VITA Zahnfabrick) is a new ceramic system, considered hybrid since UDMA and TEGDMA monomers are present the composition. On previous studies, Vita Enamic showed good mechanical properties.[12,31,32] The present study investigated Vita Enamic regarding its adhesive performance. Our results revealed that this ceramic had an acceptable adhesive performance, since high μTBS values were obtained with all three cement groups tests. Furthermore, the present *in vitro* study found important differences between tested factors associate to indirect restoration bonded to dentin. Clinical studies should be conducted to verify the clinical influence of these factors in the survival of Vita Enamic indirect restorations and cements under different protocols of cementation. Other aspects joined to the clinical application as cavity characteristics, and physiological aging were not considered in this study.

Conclusion

From the findings in the present *in vitro* study, we concluded that the conventional resin cement (Relyx Ultimate) combined with silane ceramic treatment presented higher μTBS values to dentin when compared to the other tested cement. Etch-and-rinse adhesive approach produced better overall results. This dentin treatment presents μTBS values reduction after 12m, although self-etch approach values remained stable over time. Etch-and-rinse is not indicated for self-adhesive cements, as a considerable adhesive degradation was observed in long-term.

References

[1] Pavan S, Dos Santos PH, Berger S & Bedran-Russo KB (2010) The effect of dentin pretreatment on the microtensile bond strength of self-adhesive resin cements *The Journal of Prosthetic Dentistry* **104(4)** 258-264.

[2] Sarr M, Mine A, De Munck J, Cardoso MV, Kane AW, Vreven J, Van Meerbeek B & Van Landuyt KL (2010) Immediate bonding effectiveness of contemporary composite cements to dentin *Clinical Oral Investigations* **14(5)** 569-577.

[3] Conrad HJ, Seong WJ & Pesun IJ (2007) Current ceramic materials and systems with clinical recommendations: a systematic review *Journal of Prosthetic Dentistry* **98** 389-404.

[4] Chen L & Suh BI (2012) Bonding of resin materials to all-ceramics: a review *Current Research in Dentistry* **3(1)** 7-17.

[5] Brentel AS, Özcan M, Valandro LF, Alarça LG, Amaral R & Bottino MA (2007) Microtensile bond strength of a resin cement to feldspathic ceramic after different etching and silanization regimens in dry and aged conditions *Dental Materials* **23(11)** 1323-1331.

[6] Peumans M, Hikita K, De munck J, Van Landuyt K, Poitevin A, Lambrechts P & Van Meerbeek B (2007) Effects of ceramic surface treatments on the bond strength of an adhesive luting agent to CAD-CAM ceramic *Journal of Dentistry* **35(4)** 282-288.

[7] Vaz RR, Hipólito VD, D'Alpino PH & Goes MF (2012) Bond strength and interfacial micromorphology of etch-and-rinse and self-adhesive resin cements to dentin *Journal of Prosthodontics* **21** 101-111.

[8] Moro AFV, Ramos AB, Rocha GM & Perez CDR (2017) Effect of prior silane application on the bond strength of a universal adhesive to a lithium dissilicate ceramic *The Journal of Prosthetic Dentistry* **118(5)** 666-671.

[9] Hitz T, Stawarczyk B, Fischer J, Hammerle CHF & Sailer I (2012) Are self-adhesive resin cements a valid alternative to conventional resin cements? A laboratory study of the long-term bond strength *Dental Materials* **28(11)** 1183-1190.

[10] Della Bona A, Corazza PH & Zhang Y (2014) Characterization of a polymer-infiltrated ceramic-network material *Dental Materials* **30(5)** 564-569.

[11] Leung BT, Tsoi JK, Matinlinna JP & Pow EH (2015) Comparison of mechanical properties of three machinable ceramics with an experimental fluorophlogopite glass ceramic *The Journal of Prosthetic Dentistry* **114(3)** 440-445.

[12] Awada A & Nathanson D (2015) Mechanical properties of resin-ceramic CAD/CAM restorative materials *The Journal of Prosthetic Dentistry* **114(4)** 587-593.

[13] Pongprueksa P, De Munck J, Karunratanakul K, Barreto BC, Van Ende A, Senawongse P, & Van Meerbeek B (2016) Dentin bonding testing using a mini-interfacial fracture toughness approach *Journal of Dental Research* **95(3)** 327-333.

[14] Fornazari IA, Wille I, Meda EM, Brum RT & Souza EM (2017) Effect of surface treatment, silane, and Universal adhesive on Microshear Bond strength of nanofilled composite repairs *Operative Dentistry* **42(4)** 367-374.

[15] Yoshihara K, Nagaoka N, Sonoda A, Maruo Y, Makita Y, Okihara T, Irie M, Yoshida Y & Van Meerbeek B (2016) Effectiveness and stability of silane coupling agent incorporated in 'universal' adhesives *Dental Materials* **32(10)** 1218-1225.

[16] Prochnow EP, Amaral M, Bergoli CD, Silva TB, Saavedra G & Valandro LF (2014) Microtensile bond strength between indirect composite resin inlays and dentin: effect of cementation strategy and mechanical aging *The Journal of Adhesive Dentistry* **16** 357-363.

[17] Poggio C, Pigozzo M, Ceci M, Scribante A, Beltrami R & Chiesa M (2016) Influence of different luting protocols on shear bond strength of computer aided design/computer aided manufacturing resin nanoceramic material to dentin *Dental Research Journal* **13** 91-97.

[18] Stape THS, Menezes MS, Aguiar FHB, Quagliatto PS, Soares CJ & Martins LRM (2014) Long-term effect of chlorhexidine on the dentin microtensile bond strength of conventional and self-adhesive resin cements: A two-year in vitro study *International Journal of Adhesion & Adhesives* **50** 228-234.

[19] Fuentes MV, Escribano N, Baracco B, Romero M & Ceballos L (2016) Effect of indirect composite treatment microtensile bond strength of self-adhesive resin cements *Journal of Clinical and Experimental Dentistry* **8(1)** 14-21.

[20] Fuentes MV, Ceballos L & Gonzáles-López S (2013) Bond strength of self-adhesive resin cements to different treated indirect composites *Clinical Oral Investigations* **17** 717-724.

[21] Susuki TY, Godas AG, Guedes AP, Catelan A, Pavan S, Briso AL & Dos Santos PH (2013) Microtensile bond strength of resin cements to caries-affected dentin *The Journal of Prosthetic Dentistry* **110(1)** 47-55.

[22] Kambara K, Nakajima M, Hosaka K, Takahashi M, Thanatvarakorn O, Ichinose S, Foxton RM & Tagami J (2012) Effect of smear layer treatment on dentin bond of self-adhesive cements *Dental Materials Journal* **31(6)** 980-987.

[23] Saker S, Alnazzawi A & Ozcan M (2016) Adhesive strength of self-adhesive resins to lithium disilicate ceramic and dentin: effect of dentin chelating agents *Odontology* **104** 53-59.

[24] Piwowarczyk A, Bender R, Ottl P & Lauer HC (2007) Long-term bond between dual-polymerizing cementing agents and human hard dental tissue *Dental Materials* **23(2)** 211-217.

[25] Shafiei F & Memarpour M (2010) Effect of chlorexidine application on long-term shear bond strength of resin cements to dentin *Journal of Prosthodontics Research* **54(4)** 153-158.

[26] Ritter AV, Ghaname E & Pimenta LA (2009) Dentin and enamel bond strengths of dual-cure composite luting agents used with dual-cure dental adhesives *Journal of Dentistry* **37(1)** 59-64.

[27] Perdigão J, Reis A & Loguercio AD (2013) Dentin adhesion and MMPs: A comprehensive review *Journal of esthetic and restorative dentistry* **25(4)** 219-241.

[28] Montagner AF, Sarkis-Onofre R, Pereira-Cenci T & Cenci MS (2014) MMP Inhibitors on dentin stability: A systematic review and Meta-analysis *Journal of Dental Research* **93(8)** 733-743.

[29] Van Landuyt KL, Peumans M, De Munck J, Lambrechts P & Van Meerbeek B (2006) Extension of a one-step self-etch adhesive into a multi-step adhesive *Dental Materials* **22** 533-544.

[30] Szesz A, Parreiras S, Reis A & Loguercio AD (2016) Selective enamel etching in cervical lesions for self-etch adhesives: A systematic review and meta-analysis *Journal of Dentistry* **53** 1-11.

[31] Facenda JC, Borba M & Corazza PH (2018) A literature review on the new polymer-infiltrated ceramic-network material (PICN) *Journal of Esthetic and Restorative Dentistry* **00** 1-6.

[32] Goujat A, Abouelleil H, Jeannin C, Pradelle N, Seux D & Grosgogeat B (2018) Mechanical properties and internal fit of 4 CAD-CAM block materials *The Journal of Prosthetic Dentistry* **119(3)** 384-389.

Tables

Table 1. Materials used in the study experiment.

Material (manufacturer)	Classification (Batch number)	Composition
Relyx U200 – color A2 (3M ESPE, St Paul, MN, USA)	Self-adhesive resin cement (587658)	**Base**: 2-propenoic acid, 2-methyl, 1,1-[1-(hydroxymethyl)-1,2-ethanediyl] ester, TEGDMA, silica treated with silane, glass fiber, sodium persulfate, tere-butylperoxy-3,5,5-trimethyl hexanoate **Catalyst**: dy-methyl methacrylate, silica treated with silane, sodium p-toluenesulfonate, 1-benzyl-5-phenyl barbituric acid, salts of calcium, 1,12-dodecanediol dimethacrylate, calcium hydroxide, and titanium dioxide
Relyx Ultimate – color A2 (3M ESPE, St Paul, MN, USA)	Multi-mode resin cement (591508)	**Base**: silane-treated glass powder, 2-propenoic acid, 2-methyl-,1,1-[1-(hydroxymethyl)-1,2-ethanediyl] ester, reaction products with 2-hydroxy-1,3-propanediyl DMA and phosphorus oxide, TEG-DMA, silane treated silica, oxide glass chemicals, sodium persulfate, tert-butyl peroxy-3,5,5-trimethylhexanoate, copper (II) acetate monohydrate **Catalyst**: silane-treated glass powder, substituted DMA, 1,12-dodecane DMA, silane treated silica, 1-benzyl-5-phenyl-barbic-acid, calcium salt, sodium p-toluenesulfinate, 2-propenoic acid, 2-methyl-, [(3-metoxypropyl) imino]di-2,1-ethanediyl ester, calcium hydroxide, titanium dioxide
Scotchbond Universal (3M ESPE, St Paul, MN, USA)	Multi-mode Adhesive system (645026)	MDP Phosphate Monomer, Dimethacrylate resins, HEMA, Vitrebonde Copolymer, Filler, Ethanol, Water, Initiators, Silane
Vita Enamic – color A1 (VITA Zahnfabrick)	Hybrid ceramic (366658)	**Ceramics:** Silica Dioxide (58-63%), Aluminum Oxide (20-23%), Sodium Oxide (9-11%), Potassium Oxide (4-6%), 2%), Zirconia (<1%), Calcium oxide (<1%), **Polymers**: UDMA and TEGDMA

Table 2. Cementation protocols of each experimental group.

Group	Cement	Dentin treatment	Cementation Protocol
U200 NT	Relyx u200	No treatment	a, e, f and g
U200 ER	Relyx u200	Total-etch	a, c, e, f and g
Ult+Sil NT	Relyx Ultimate + Silane	No treatment	a, d, e, f and g
Ult+Sil ER	Relyx Ultimate + Silane	Total-etch	a, c, d, e, f and g
Ult+Sbu NT	Relyx Ultimate + Scotchbond Universal	No treatment	b, d, e, f and g
Ult+Sbu ER	Relyx Ultimate + Scotchbond Universal	Total-etch	b, c, d, e, f and g

Legend:

- **a-** Silane active application on ceramic surfaces for 60s;
- **b-** Scotchbond Universal application on ceramic surfaces for 20s, followed by gentle air stream for 5s.
- **c-** Etch dentin with 37% phosphoric acid for 15s; rinse thoroughly, water excess removal, leaving preparation visibly moist.
- **d-** Scotchbond Universal application on dentin, rubbing for 20s, gentle stream of air for 5s until the solvent is evaporated and light-cure for 10s.

e-	Cement manipulation: mixing base and catalyst paste for 20s, then application on ceramic surface;
f-	Ceramic restoration positioned over dentin surface, stabilized by a compressive load of 750g,
g-	Excess cement material removed with a microbrush and light-curing on each restoration surface for 20s using LED curing unit calibrated at $1200 mW/cm^2$.

Table 3. μTBS mean values comparisons of all 6 experimental groups, considering the different bond strength evaluation times - 24h and 12 months.

Group	Ceramic Treatment	Dentin Treatment	μTBS (SD) 24 hours	μTBS (SD) 12 months
U200 NT	Silane	No treatment	21,52(8,40) – B	14,28(6,38) – d
U200 ER	Silane	Etch-and-rinse	**44,00(3,96) – A**	**18,3(5,84) – c,d**
Ult+Sil NT	Silane	No treatment	30,13(8,51) – B	26,54(7,09) – b,c
Ult+Sil ER	Silane	Etch-and-rinse	**56,76(6,90) – A**	**35,57(5,92) – a,b**
Ult+SBU NT	ScotchBond Universal	No treatment	24,19(11,14) – B	16,81(5,86) – c,d
Ult+SBU ER	Scotchbond Universal	Etch-and-rinse	**45,87(4,74) – A**	**32,36(4,01) – a,b**

Different letters indicates statistical significant differences (p<0,05). Uppercase letter for comparisons between 24h bond strength means and lowercase Letter for comparisons between 12m means. Bold letters indicate statistical significant difference between 24h and 12m results in the experimental group (p<0,05).

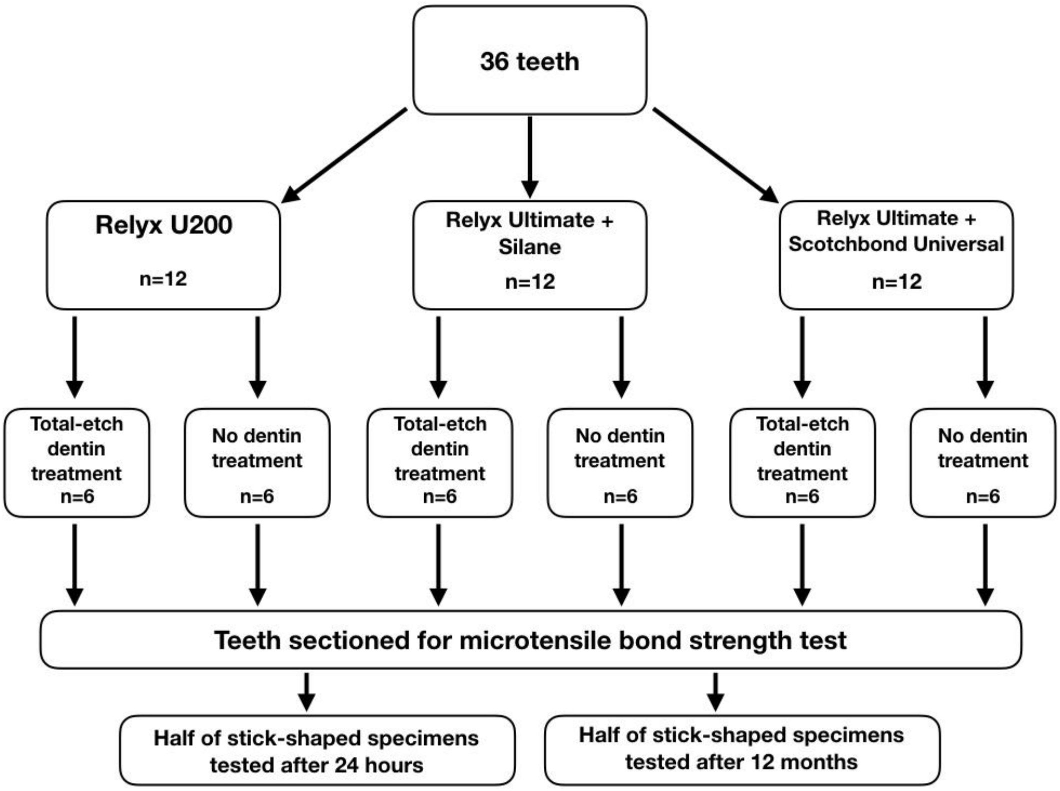
Table 4. Failure type distribution of each experimental group.

Storage time	Group	Tested specimens / pretest failures	Adhesive failure - Dentin (%)	Adhesive failure - ceramic (%)	Mixed failure (%)	Cohesive Failure (%)
24 hours	**U200 NT**	57/4	25 (43,86%)	4 (7,02%)	28 (49,12%)	0 (0%)
	U200 ER	59/0	11 (18,64%)	18 (30,50%)	30 (50,86%)	0 (0%)
	Ult+Sil NT	52/4	17 (32,69%)	0 (0%)	32 (61,54%)	3 (5,77%)
	Ult+Sil ER	59/0	0 (0%)	11 (18,65%)	46 (77,96%)	2 (3,39%)
	Ult+SBU NT	51/3	12 (23,53%)	20 (39,22%)	19 (37,25%)	0 (0%)
	Ult+SBU ER	50/0	0 (0%)	33 (66%)	16 (32%)	1 (2%)
12 months	**U200 NT**	53/6	23 (43.39%)	2 (3,78%)	28 (52,83%)	0 (0%)
	U200 ER	56/2	21 (37,50%	7 (12,50%)	28 (50,00%)	0 (0%)
	Ult+Sil NT	57/0	14 (24,57%)	3 (5,26%)	39 (68,42%)	1 (1,75%)
	Ult+Sil ER	64/0	13 (20,31%)	8 (12,50%)	39 (60,94%)	4 (6,25%)
	Ult+SBU NT	49/5	8 (16,33%)	22 (44,90%)	19 (38,77%)	0 (0%)
	Ult+SBU ER	50/0	4 (8,00%)	26 (52,00%)	19 (38,00%)	1 (2%)

Adhesive failure – Dentin: adhesive interface failure between dentin and cement;
Adhesive failure – Ceramic: adhesive interface failure between ceramic and cement
Mixed failure: interfacial failure (adhesive) simultaneously between ceramic, cement and dentin (no cohesive failures are considered in this category)
Cohesive failure: non-interfacial failures (on ceramic or dentin)

Figures

Figure 1. Diagram flowchart of experiment design.



3 ARTIGO 2 – IS CONVENTIONAL RESIN CEMENTS ADHESIVE PERFORMANCE TO DENTIN BETTER THAN SELF-ADHESIVE? A SYSTEMATIC REVIEW AND META-ANALYSIS OF IN VITRO STUDIES

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IS CONVENTIONAL RESIN CEMENTS ADHESIVE PERFORMANCE TO DENTIN BETTER THAN SELF-ADHESIVE? A SYSTEMATIC REVIEW AND META-ANALYSIS OF IN VITRO STUDIES

Running title: Influence of cement type on bonding to dentin

Leonardo Lamberti Miotti[1], Andressa Cargnelutti Follak[1], Anelise Fernandes Montagner[2], Roselaine Terezinha Pozzobon[3], Bruno Lopes da Silveira[3], Alexandre Henrique Susin[3]

[1] DDS, MS – Department of Restorative Dentistry, School of Dentistry, Federal University of Santa Maria, Marechal Floriano Peixoto st, 1184 – 312, Centro, Santa Maria - RS, Brazil, Post Code: 97015-372

[2] DDS, MS, PhD – School of Dentistry, Federal University of Pelotas, Gonçalves Chaves st, 457 – fifth floor, Pelotas – RS, Brazil. Post Code: 96015560

[2] DDS, MS, PhD, Professor – Department of Restorative Dentistry, School of Dentistry, Federal University of Santa Maria, Marechal Floriano Peixoto st, 1184 – 312, Centro, Santa Maria - RS, Brazil, Post Code: 97015-372

Corresponding author:

Leonardo Lamberti Miotti (e-mail: llmiotti@gmail.com)

Carlos Brenner st, 130, Nossa Senhora de Lourdes, Santa Maria - RS, Brazil
Post Code: 97050-100

Phone number: +55(55) 98407-6871

Is conventional resin cements adhesive performance to dentin better than self-adhesive? A systematic review and meta-analysis of in vitro studies

Running title: Influence of cement type on bonding to dentin

Summary: Adhesive strategy on cementation plays an important role for indirect restoration longevity. The purpose of the present study is systematically review the up-to-date literature for *in vitro* studies that assess bonding performance of conventional and self-adhesive resin cements when used to cement indirect restorations to non-altered dentin, and compare their *in vitro* adhesive performance through meta-analyses. The current literature was reviewed for studies that assessed these two classes of resin cements, according to the following inclusion criteria: studies that evaluated bond strength between dentin and indirect restoration cemented with dual conventional or self-adhesive resin cements, with bond strength presented in mega Pascal (MPA) as outcome. Included studies were full-text reviewed by two independent reviewers (LLM and ACF), which applied exclusion criteria. From a total of 518 studies, 36 were screened full-text and reviewed according to exclusion criteria. 19 papers were included in systematic review and meta-analyses. A global analysis comparing conventional and self-adhesive cements, and three subgroups analyses comparing long-term bond strength performance and individually comparing immediate to long-term results of each resin cement class. Conventional resin cements presented higher bond strength results when compared with self-adhesive resin cements, considering immediate and long-term results. We concluded that conventional multi-step resin cements presented an overall better adhesive performance when used to cement indirect restorations to dentin.

Clinical Relevance: Conventional multi-step resin cements presented higher adhesive performance to dentin when compared with simplified self-adhesive cements, and may be considered first clinical option for indirect restoration cementation.

Keywords: Adhesives; Cementation; Ceramic; Dentin Bonding Agents; Resin Cements; Self-adhesive;

Introduction

Adhesive dentistry allowed restorative procedures with minimal tooth preparation. Consequently more dental substrate is preserved, what is considered an important factor concerning restoration longevity.[1] Resinous luting agents improved indirect restorative treatments, promoting better retention, lower solubility with reinforcement effect over restoration and tooth structure.[2,3] The first dual resin cements, currently called "conventional resin cements" or "regular cements"[4] were developed as systems, containing the resinous luting agent and an especific adhesive system or primer, used as adhesion agent. Its adhesive strategy can be etch-and-rinse or self-etch, depending on the adhesion agent.

In beginning of 00's, the self-adhesive luting agents concept was conceived: a new class of resin cements that is capable of combine the use of adhesive and the cement in a single application, with no need for dental substrate and restoration surface pre-treatment.[5] With adhesive and cement in one single formulation, these cements promote simultaneous demineralization and substrate penetration. The technique simplification results in less operator sensitive procedure, compared to traditional multi-step conventional resin cements.[6] This luting agent family is considered a heterogeneous group of resin cements, with considerable differences in terms of composition, setting reaction, pH and bonding performance.[7]

Dentin adhesion still remains a concerning matter for long-term retention. The adhesive interface can be considered the weakest link of adhesion chain, and can jeopardize restorative procedure longevity.[8] To date, studies assessing dual resin cements adhesion to dentin are controversial. As long as some *in vitro* investigations assert that multi-step conventional resinous luting agents promotes higher and more stable adhesion to dentin,[2,8-10] other indicates adequate bonding performance of self-adhesive resin cements.[11-13] Hitz et al. (2012) also stated that not all self-adhesive resin cements could be considered a valid alternative to substitute conventional multi-step resin cements, as chemical formulation is crucial for its performance.[14]

Given that opinion divergence, the present study aims to systematically review the present literature for *in vitro* studies that assessed bonding performance to non-altered dentin of conventional and self-adhesive resin cements when cementing indirect restorations. The null hypothesis was that there would be no difference in bonding strength between the two classes of resin cements tested, even considering long-term bond strength.

Material and Methods

The present systematic review was conducted according to Cochrane Handbook for systematic reviews of interventions[15] and reported according to PRISMA statement[16]. A research question was defined to guide the literature search strategy and set the variables analyzed on meta-analysis: "Does the dual resinous cement type (conventional or self-adhesive) influence immediate and long-term bond strength to dentin when used to cement an indirect restoration?"

Search Strategy

The electronic databases MEDLINE via PubMed, Scopus and ISI Web of science were used to search and identify manuscripts that could be included in the present study. Computer search of databases and reference lists review of included studies were the search strategies used in this review. All included studies were published before January 9th, 2018. No publication year or language limit was applied.

The MEDLINE via PubMed search was performed with MeSH terms and keywords as follows: "**((((((((dentin[MeSH Terms]) OR dentin) OR dentins) OR dentine) OR dentines)) AND (((((bond strength*) OR microtensile bond strength) OR microshear bond strength) OR microtensile) OR microshear)) AND (((adhesive cementation) OR resin luting agent*) OR conventional resin luting cement*) OR self-adhesive luting cement*) OR adhesive cementation strategies) OR adhesive*) OR dental cement*) OR dental cements[MeSH Terms]) OR dental adhesives) OR adhesive, dental) OR adhesives, dental) OR dental adhesive) OR cement, dental) OR luting agent*) OR cements, dental) OR dental bonding[MeSH Terms]) OR dental bonding) OR bonding, dental) OR curing, dental cement) OR dental cement curing) OR bonding strategy) OR bonding strategies) OR cementation strategy) OR cementation strategies) OR adhesive bond*) OR etching protocol) OR universal adhesive*) OR multimode adhesive*) OR multi-mode adhesive*) OR self-adhesive resin cement*) OR bonding method*) OR dual-polymerizing resin cement*) OR adhesion) OR cementation) OR adhesive cement[MeSH Terms]) OR adhesive cement) OR resin cements[MeSH Terms]) OR resin cements) OR cements,**

resin) OR resin cement) OR cement, resin) OR cementation[MeSH Terms]) OR cementation)) AND ((((((((((ceramic* indirect restoration) OR indirect composite resin) OR indirect resin composite) OR indirect resin) OR indirect composite restorations) OR dental porcelain[MeSH Terms]) OR dental porcelain) OR porcelain*) OR porcelain, dental) OR dental porcelains) OR porcelains, dental)". The following search terms were used for Scopus and ISI Web of science manuscript search: **"(bond AND strength) AND (resin AND cement) AND (dentin) AND (indirect AND restoration)".**

Results of the database search (the titles and abstracts) were reviewed by two authors (LLM and ACF), and selected for further review if they met the following Inclusion criteria: *in vitro* studies that assessed bond strength, where an indirect restorative material (composite resin or ceramic) were cemented to dentin and at least one self-adhesive resin cement was tested. Immediate or long-term bond strength values were considered. The abstracts were selected by consensus of both reviewers, and if consensus was not reached, the abstract was set aside for further evaluation. Studies considered eligible had their full texts selected for assessment regarding exclusion criteria.

Included studies full texts were independently reviewed by two authors (LLM and ACF) taking into consideration the exclusion criteria: at least one group must follow the resin cement manufacturer's cementation protocol, the study must test at least one conventional resin cement (control group for meta-analysis), resin cements must be dual (chemical and photo-activation simultaneously), adhesion substrate must be coronary and sound dentin, without enamel for cementation. Bond strength test must use micro scale (micro-tensile - µTBS or micro-shear - µSBS) and values should be presented in Mpa, with mean and standard deviation. An e-mail request was sent multiple times to authors when data were missing from the paper. If the authors did not provide such data, the study was then excluded. Only phosphoric acid etching was accepted as surface substrate modification. Any other dentin substrate modification was not accepted. Studies with no test groups on sound dentin were excluded. Disagreements about studies eligibility were solved through discussion and consensus with a third reviewer (AFM).

Data extraction

A data extraction was defined and performed by one author (LLM) and revised by a second author (AFM) using a standardized outline. Similar information was categorized according to the main outcomes considered in this review. Each study had the following data extracted: Publication year, sample size, resin cements assessed, presence of aging protocol and bond strength test used. Bond strength mean (MPa) and standard deviation (SD) values were also extracted in this step for further meta-analyses.

Risk of bias assessment

The risk of bias of included studies was evaluated independently by two authors (LLM and ACF), considering an adapted score for *in vitro* studies reported in previous systematic reviews.[17,18] The following parameters were considered when checking the risk of bias: Randomization of teeth for experimental groups, teeth free of caries or previous restoration, materials used according the manufacturer's instructions, teeth with similar dimensions, adhesive procedures performed by a single operator, sample size calculation and blinded operator of the testing machine. Each parameter received a score, based on its description on paper: 1- if it was correctly described on text; 0- if the information was not described on text. The risk of bias classification was calculated according to the sum of "1" that the study received: 1-2 = high risk, 3-5= medium risk, 6-7= low risk of bias.

Data analysis

Pooled effect estimates were obtained by comparing bond strength means from conventional resin cement and self-adhesive resin cement in a global analysis and three different sub-analyses, according to the presence of aging method before bond strength test (immediate or long-term). Each tested cement, according to inclusion and exclusion criteria were considered as an independent test group. Studies that reported immediate and long-term results were analyzed in both subgroups. No aging methods or time were considered, only if the specimens were submitted to an aging process. Statistical heterogeneity between studies was evaluated through Cochran Q test, with threshold p value of 0.1 and inconsistency I^2, where values >50% were considered indicative of high heterogeneity.[15]

All analyses were performed with Review Manager (RevMan version 5.3 software, Cochrane Collaboration, Copenhagen, Denmark, 2014), using random effect method. The amount of specimens was considered as the amount of experimental units. For statistical significance evaluation, a p value ≤ 0.05 was considered (Z-test). To illustrate the meta-analyses calculation, forest plots were generated.

Results

The flowchart summarizing the studies selection process, according to PRISMA statement[16] is presented in figure 1. Search strategy resulted in 518 potentially eligible studies, with 309 papers in MEDLINE via PubMed, 94 papers in Scopus and 115 papers in ISI Web of Science. Figure 1 illustrates a flowchart describing the studies selection process, according to PRISMA statement.[16] From those studies, 457 were excluded without meeting the eligibility criteria, and 26 were duplicates. First screening resulted in 35 studies for further full-text evaluation. According to exclusion criteria, 16 studies were excluded: 2 presented bond strength test in macro scale[19,20] ,7 with no adequate control group or conventional resin cement tested,[21-27] 5 studies without self-adhesive resin cement assessed[28-32] ,1 study without dentin substrate[33] ,1 did not present µTBS numerically.[34] Afterwards exclusion criteria, 19 studies were included for meta-analyses.

All meta-analysis included studies were published between 2009 and 2016. Only two studies[4,13] used bovine incisors, as other two studies[9,35] used pre-molars with inlay preparations. All other meta-analysis papers used human molars. In the present collection, considering resin cement classification, the conventional etch-and-rinse resin cement Relyx ARC[4,8-10,12,36-41] and the conventional self-etch resin cement Panavia F2.0 [7,11,35,38-44] were the most frequent assessed conventional resin cements. Relyx Unicem[7,10-13,35,36,38,41-44], followed by Relyx U100 [4,8,9,37,45] and G-cem[10,11,41,43,44] were the most assessed self-adhesive resin cements.

The methodological test used in all 19 studies was microtensile bond strength (µTBS) with non-trimming beams. The most studies presented long-term bond strength results [7-9,11,12,35-40,42], with different aging methods: five studies [9,35-37,40] performed mechanical cycling, with number of cycles from 50.000[36] to 2.000.000 cycles[37], loading from 50N[40] to 100N[37] and frequency from 1Hz[36] to 4Hz[9,37], two studies stored specimens in artificial saliva[8,36] and two stored in distilled water[12,38], with storage time varying from 1 month[12] to 24 months[36], three studies performed termo-cycling [7,11,42], all with same parameters (5000 cycles, 5º - 55ºC), and two studies employed a simulated pulpal pressure aging design[39,40] for 7 days[40] and 3 months[39]. Two papers[36,40] performed more than one aging method, but in both studies, the specimens were submitted to only on aging method. The complete descriptive data per study in this collection is presented in table 1.

Meta-analyses

Data from 19 selected studies were submitted to meta-analyses calculation. Meta-analyses were executed considering a global analysis (conventional vs. self-adhesive resin cements – figure 2), and three subgroup analyses: 1 – Conventional vs. self-adhesive cements considering only after aging results (figure 3); 2 – Immediate vs. aging bond strength of self-adhesive cements (figure 4); 3 – Immediate vs. aging bond strength of conventional resin cements (figure 5).

The global meta-analysis results are presented in figure 2. In this analysis, heterogeneity (I^2 test) was 99%, Cochran *Q* and *Z* (p=0.03) tests were <0.05, sustaining the control group (Conventional resin cements). Considering immediate and after aging results pooled, conventional resin cements showed better bond strength results. The first subgroup analysis (conventional vs. self-adhesive after aging) presented Cochran Q and Z (p=0.03) tests <0.05, with I^2=99%, favoring conventional resin cements (figure 3). Subgroup analyses 2 and 3, which analyzed both resin cements types separately, showed different results. Subgroup analysis 3 (figure 4) showed difference between immediate and long-term bond strength results for self-adhesive cements, favoring immediate bond strength (p=0.03, I^2=99%). On the other hand, subgroup analysis for conventional resin cements (figure 5) presented Cochrane *Q* test <0.05. However, Z test was >0.05 (p=0.06), what indicates no difference between groups (I^2=98%).

Medium or high-risk of bias was found in all meta-analyses included studies (table 2). In the present collection, only three studies took in consideration teeth dimensions[4,35,37], one study with same operator for adhesive technique[7], two studies presented sample size calculation[35,38] and two studies presented blinded operator for adhesive test[4,7].

Discussion

The present review compared *in vitro* performance to dentin of two different resin cement types: conventional vs. self-adhesive. This study is a first step to define which adhesive strategy is more reliable when cementing coronary indirect restorations. The overall results showed that the conventional adhesive approach, when resin cement is combined with an adhesive system or primer agent, has a trend to higher immediate and long-term bond strength to dentin. The null hypotheses of the present study were rejected, since multi-step conventional resin cements presented higher overall and long-term bond strength results.

Heterogeneity was considered high and statistically significant in all performed meta-analyses ($p<0,05$). We believe that methodology discrepancies, especially about aging methods, were main responsible for this heterogeneity. Because of this methodological variety, it was impossible to categorize studies according to aging methods, but if at least one aging method was utilized. Furthermore, more methodological rigor is necessary for the neglected risk of bias parameters in this review.

The conventional class of cement was the first type of adhesive resinous luting agents, which used an intermediate adhesion agent (adhesive system or a specific primer) between restorative material and dental substrate. In the present collection, two most assessed conventional resin cement were Relyx ARC (3M-Espe, St.Paul, MN, USA) and Panavia F2.0 (Kuraray Medical Inc, Okayama, Japan), an etch-and-rinse and self-etch resin cement, respectively. Both systems were tested with different adhesion agents: while Relyx ARC was used combined with Adper Singlebond [4,8,9,10,12,36,37,38,39,40,41] (3M-Espe, St.Paul, MN, USA), Panavia 2.0 was used with ED primer (Kuraray Medical Inc, Okayama, Japan), a self-etch primer which is included in the Panavia F2.0 system [7,11,35,38,39,42,40,43,44]. Our findings in this review are precisely illustrated by studies like Prochnow et al. (2014) and Fuentes et al. (2016), where Relyx ARC was the conventional resin cement, and Aguiar et al. (2010) and Sarr et al. (2010), where Panavia F2.0 was tested. Despite adhesive strategy, etch-and-rinse or self-etch, multi-step conventional dual resin cements seems to produce higher immediate and long-term dentin bond strength than simplified self-adhesive cements [9,10,39,43,44].

Results concerning immediate and long-term bond strength revealed that multi-step conventional resin cements did not present statistically significant difference, what indicates more stable adhesion over time. Exposed dentinal collagen fibrils suffer degradation mechanisms, like hydrolysis by water, mechanical fatigue, denaturation or even collagenolytic process from MMPs and cathepsins, inherently present on dentin.[46] The ability to envelop exposed collagen fibrils is directly dependent of priming steps, wetting characteristics of bonding agent and its chemical composition.[12] Despite being more technique sensitive because, conventional resin cements uses a specific bond agent, more capable to interpenetrate demineralized dentin substrate.

The mechanism of adhesion to dentin is an important matter to explain and understand the self-adhesive worse performance in the present studies collection. De Munck et al. (2004) published one of the first studies assessing self-adhesive cements, what was a new class of resin cements at the time. The idea was a resin-based cement that combines the use of cement and adhesive in a single application, with no need for dental substrate and restorative material pre-treatments.[5] Its adhesive properties were claimed to be similar to self-etch adhesives, since was based upon acidic monomers capable to demineralize and promote micro-mechanical retention, with some products being capable of chemical interaction with hydroxyapatite.[5] Dentin hybridization requires the hybrid layer formation through superficial demineralization, followed by resin monomers infiltration and polymerization, creating micro-mechanical retention. Without etch-and-rinse process, the self-etch process does not remove smear layer, but dissolves and incorporate it to hybrid layer.

Acidic monomers are responsible for simultaneously prime and condition dental substrates, and the adhesion establishment is dependent on these components.[47] Demineralization capacity of self-etching systems is considered limited, specifically when compared to etching acids like phosphoric acid.[48] De Munck et al. (2004) assessed Relyx Unicem (most tested self-adhesive resin cement in the present meta-analyses) interaction to dentin with ultra-structural transmission electron microscopy (TEM) and field-emission scanning electron microscopy (Fe-SEM), and verified that Unicem only interacted superficially with underlying dentin, without hybrid layer or tags formation. Furthermore, the authors observed irregular interaction zone. When the cement was applied over a fractured dentin piece, without smear layer over it, hardly any cement-dentin interaction was observed. Its interaction with intra-tubular dentin was similar as inter-tubular dentin. The self-etch cement tested in the same study (Panavia F), formed as called by the authors “true hybrid layer”.[5] Another issue concerning self-adhesive resin cements is its pH-neutralization behavior. These cements have a low pH upon mixing and manipulation, which plays an important role in adhesion process. Cements with insufficient pH neutralization after self-curing experience a decrease in mechanical properties whichever can jeopardize long-term adhesion.[49,50] This behavior is considered material dependent, since is directly related to composition and may diverge among different commercial brands.[50] In fact we believe that lack of interaction with substrate, combined with reduced etching and demineralization capacity of acidic monomers and lack of pH neutralization for some cements are the major responsible for lower dentin bond strength here related.

The results of this systematic review with meta-analyses do not refute the use of self-adhesives resin cements. Considering root canal glass-fiber posts cementation, self-adhesives presented better performance when compared with conventional resin cements[17,51]. Another point to deliberate is about self-adhesive cement interaction with restorative materials. Published *in vitro* studies assessing the interaction self-adhesive cement to indirect restorative materials showed adequate bond strength to theses substrates, with a brand dependent tendency regarding chemical composition.[50,52] The adhesion to dentin still is object of scientific assessment, as is considered the weak link in adhesion chan. For self-adhesive resin cements, it seems to be the major problem that requires researchers and manufacturers attention for further material and clinical protocols development.

An important limitation of the present review is the fact that only included *in vitro* studies, with controlled environment and variables. The extracted data reveals only the adhesion to dentin weight in the retention of an indirect restoration to dentin, without considering other important parameters like tooth preparation design and retention, restoration type and extension, tooth position technique sensitivity and operator[53] may influence restoration survival.

Conclusion

Despite elevated heterogeneity and limitations of the present review of *in vitro* studies with meta-analyses, conventional multi-step resin cements showed better overall adhesive performance to dentin when compared to simplified self-adhesive resin cements. Bond strength to dentin of self-adhesive cements is directly related to chemical composition.

References

[1] Van Dijken JW & Hasselrot L (2010) A prospective 15-year evaluation of extensive dentin-enamel-bonded pressed ceramic coverages *Dental Materials* **26** 929-939.

[2] Pavan S, Dos Santos PH, Berger S & Bedran-Russo KB (2010) The effect of dentin pretreatment on the microtensile bond strength of self-adhesive resin cements *The Journal of Prosthetic Dentistry* **104(4)** 258-264.

[3] Xiaoping L, Dongfeng R & Silikas N (2014) Effect of etching time and resin bond on the flexural strength of IPS e.max Press glass ceramic *Dental Materials* **30(12)** 330-336.

[4] Skupien JA, Porto JAS, Munchow EA, Cenci MS & Pereira-Cenci T (2015) Impairment of resin cement application on the bond strength of indirect composite restoration *Brazillian Oral Research* **29(1)** 1-7. (15)

[5] De Munck J, Vargas M, Van Landuyt K, Hikita K, Lambrechts & Van Meerbeek B (2004) Bonding of an auto-adhesive luting material do enamel and dentin *Dental Materials* **20** 963-971.

[6] Cantoro A, Goracci C, Carvalho CA, Coniglio I, & Ferrari M (2009) Bonding potential of self-adhesive luting agents used at different temperatures to lute composite onlays *Journal of Dentistry* **37(6)** 454-461.

[7] De Angelis F, Minnoni A, Vitalone LM, Carluccio F, Vadini M, Paolantonio M & D'Arcangelo C (2011) Bond strength evaluation of three self-adhesive luting systems used for cementing composite and porcelain *Operative Dentistry* **36(6)** 626-634. (11)

[8] Stape THS, Menezes MS, Aguiar FHB, Quagliatto PS, Soares CJ & Martins LRM (2014) Long-term effect of chlorhexidine on the dentin microtensile bond strength of conventional and self-adhesive resin cements: A two-year in vitro study *International Journal of Adhesion & Adhesives* **50** 228-234. (9)

[9] Prochnow EP, Amaral M, Bergoli CD, Silva TB, Saavedra G & Valandro LF (2014) Microtensile bond strength between indirect composite resin inlays and dentin: effect of cementation strategy and mechanical aging *The Journal of Adhesive Dentistry* **16** 357-363. (2)

[10] Fuentes MV, Escribano N, Baracco B, Romero M & Ceballos L (2016) Effect of indirect composite treatment microtensile bond strength of self-adhesive resin cements *Journal of Clinical and Experimental Dentistry* **8(1)** 14-21. (14)

[11] Giannini M, Takagaki T, Bacelar-Sá R, Vermelho PM, Ambrosano GMB, Sadr A, Nikaido T & Tagami J (2015) Influence of resin coating on bond strength of self-adhesive resin dentin *Dental Materials Journal* **34(6)** 882-827. (8)

[12] Vaz RR, Hipólito VD, D'Alpino PH & Goes MF (2012) Bond strength and interfacial micromorphology of etch-and-rinse and self-adhesive resin cements to dentin *Journal of Prosthodontics* **21** 101-111. (10)

[13] Guarda GB, Gonçalves LS, Correr AB, Moraes RR, Sinhoreti MAC & Correr-Sobrinho L (2010) Luting glass ceramic restorations using a self-adhesive resin cement under different dentin conditions *Journal of applied oral Science* **18(3)** 244-248. (18)

[14] Hitz T, Stawarczyk B, Fischer J, Hammerle CHF & Sailer I (2012) Are self-adhesive resin cements a valid alternative to conventional resin cements? A laboratory study of the long-term bond strength *Dental Materials* **28(11)** 1183-1190.

[15] Higgins JPT & Green S (2011) Cochrane handbook for Systematic Reviews of Interventions. Version 5.1.0 *The Cochrane Collaboration* **available from** www.cochrane-handbook.org.

[16] Moher D, Liberati A, Tetzlaff J & Altman DG (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement *PLoS Med* **6(21)**.

[17] Sarkis-Onofre R, Skupien JA, Cenci MS, Moraes RR & Pereira-Cenci T (2014) The role of resin cement on bond strength of glass-fiber posts luted into root canals: a systematic review and meta-analysis of in vitro studies *Operative Dentistry* **39** 31-44.

[18] Moraes AP, Sarkis-Onofre R, Moraes RR, Cenci MS, Soares CJ & Pereira-Cenci T (2015) Can silanization increase the retention of glass-fiber posts? A systematic review and meta-analysis of in vitro studies *Operative Dentistry* **40** 567-580.

[19] Furukawa K, Inai N & Tagami J (2002) The effects of luting resin bond to dentin on the strength of dentin supported by indirect resin composite *Dental Materials* **18(2)** 136-142.

[20] Turkmen C, Durkan M, Cimilli H & Oksuz M (2011) Tensile bond strength of indirect composites luted with three new self-adhesive resin cements to dentin *Journal of Applied Oral Science: Revista FOB* **19(4)** 363-369.

[21] Saker S, Alnazzawi A & Ozcan M (2016) Adhesive strength of self-adhesive resins to lithium disilicate ceramic and dentin: effect of dentin chelating agents *Odontology* **104** 53-59. (1)

[22] Vieira-Filho WS, Alonso RCB, González AHM, D'Alpino PHP & Di Hipólito V (2017) Bond strength and chemical interaction of self-adhesive resin cements according to dentin region *International Journal of Adhesion and Adhesives* **73** 22-27. (21)

[23] Hikita K, Van Meerbeek B, De Munck B, Ikeda T, Van Landuyt K, Maida T, Lambrechts P & Peumans M (2007) Bonding effectiveness of adhesive luting agents to enamel and dentin *Dental Materials* **23** 71-80. (22)

[24] Gotti VB, Feitosa VP, Salvatore S, Correr-Sobrinho L & Correr AB (2014) Indirect resin composite restorations bonded to dentin using self-adhesive resin cements applied with an electric current-assisted method *American Journal of Dentistry* **27(5)** 233-236. (23)

[25] Di hipólito V, Azevedo LC, Piveta FB, Vieira-Filho WS, Anauate-Netto C, Alonso RCB & D'Alpino PHP (2014) Effect of dentinal surface preparation on the bonding of self-adhesive luting cements *Journal of Adhesion and Technology* **28(19)** 1907-1924. (24)

[26] Barcellos DC, Batista GR, da Silva MA, Rangel PM Torres CRG & Fava M (2011) Evaluation of bond strength of self-adhesive cements to dentin with or without application of adhesive systems *The Journal of Adhesive Dentistry* **13** 261-265. (25)

[27] Broyles AC, Pavan S & Bedran-Russo AK (2013) Effect of dentin surface modification on the microtensile bond strength of self-adhesive resin cements *Journal of Prosthodontics* **22** 59-62. (26)

[28] Marocho SM, Ozcan M, Amaral R, Bottino MA & Valandro LF (2013) Effect of resin cement type on the microtensile bond strength to lithium disilicate ceramic and dentin using different test assemblies *The Journal of Adhesive Dentistry* **15(4)** 361-368.

[29] Ariyoshi M, Nikaido T, Foxton RM & Tagami J (2008) Microtensile bond strengths of composite cores to pulpal floor dentin with resin coating *Dental Materials Journal* **27(3)** 400-407.

[30] Chung CWM, Yiu CKY, King NM, Hiraishi N & Tay FR (2009) Effect of saliva contamination on bond strength of resin luting cements to dentin *Journal of Dentistry* **37(12)** 923-931.

[31] Sultana S, Nikaido T, Matin K, Ogata M, Foxton RM & Tagami J (2007) Effect of resin coating on dentin bonding of resin cement in Class II cavities *Dental Materials Journal* **26(4)** 506-513.

[32] Takahashi R, Nikaido T, Ariyoshi M, Kitayama S, Sadr A & Foxton RM (2010) Thin resin coatin by dual-application of all-in-one adhesives improves dentin bond strength of resin cements for indirect restorations *Dental Materials Journal* **29(5)** 615-622.

[33] Kim JY, Cho GY, Roh BD & Shin Y (2016) Effect of curing mode on shear bond strength of self-adhesive cement to composite blocks *Materials* **9(3).**

[34] Escribano N & Macorra JC (2006) Microtensile bond strength of self-adhesive luting cements to ceramic *The Journal of Adhesive Dentistry* **8** 337-341. (27*)*

[35] Inukai T, Abe T, Ito Y, Pilecki P, Wilson RF, Watson TF & Foxton RM (2012) Adhesion of indirect MOD resin composite inlays luted with self-adhesive and self-etching resin cements *Operative Dentistry* **37(5)** 474-484. (6)

[36] Aguiar TR, André CB, Correr-Sobrinho L, Arrais CAG, Ambrosano GMB & Giannini M (2014) Effect of storage times and mechanical load cycling on dentin bond strength of conventional and self-adhesive resin luting cements *The Journal of Prosthetic Dentistry* **111** 404-410. (3)

[37] Feitosa SA, Corazza PH, Cesar PF, Bottino MA & Valandro LF (2014) Pressable feldspathic inlays in promolars: effect of cementation strategy and mechanical cycling on the adhesive bond between dentin and restoration *The Journal of Adhesive Dentistry* **16** 147-153. (4)

[38] Susuki TY, Godas AG, Guedes AP, Catelan A, Pavan S, Briso AL & Dos Santos PH (2013) Microtensile bond strength of resin cements to caries-affected dentin *The Journal of Prosthetic Dentistry* **110(1)** 47-55. (5)

[39] Bacchi A, Abuna G, Babbar A, Sinhoreti MAC & Feitosa VP (2015) Influence of 3-month simulated pulpal pressure on the microtensile bond strength of simplified resin luting systems *The Journal of Adhesive Dentistry* **17** 265-271. (12)

[40] Bacchi A, Abuna G, Consani RL, Sinhoreti MAC, Sauro S & Feitosa VP (2015) Effects of simulated pulpal pressure, mechanical and thermocycling challenge on the microtensile bond strength of resin luting cements *International Journal of Adhesion & Adhesives* **60** 69-74. (13)

[41] Fuentes MV, Ceballos L & González-López (2013) Bond strength of self-adhesive resin cements to different treated indirect composites *Clinical Oral Investigation* **17** 717-724. (17)

[42] D'Arcangelo C, De Angelis F, D'Amario M, Zazzeroni S, Ciampoli C & Caputi S (2009) The influence of luting systems on the microtensile bond strength of dentin to indirect resin-based composite *Operative Dentistry* **34(3)** 328-336. (7)

[43] Aguiar TR, Di Francescantonio M, Ambrosano GMB & Giannini M (2010) Effect of curing mode on bond strength of self-adhesive resin luting cements to dentin *Journal of Biomedical Materials Research Part B: Applied Biomaterials* **93B** 122-127. (19)

[44] Sarr M, Mine A, De Munck J, Cardoso MV, Kane AW, Vreven J, Van Meerbeek B & Van Landuyt KL (2010) Immediate bonding effectiveness of contemporary composite cements to dentin *Clinical Oral Investigations* **14(5)** 569-577. (20)

[45] Rigolin FJ, Miranda ME, Flório FM & Basting RT (2014) Evaluation of bond strength between leucite-based and lithium disilicate-based ceramics to dentin after cementation with conventional and self-adhesive resin agents *Acta Odontológica Latinoamericana* **17(1)** 16-24. (16)

[46] Perdigão J, Reis A & Loguercio AD (2013) Dentin adhesion and MMPs: A comprehensive review *Journal of esthetic and restorative dentistry* **25(4)** 219-241.

[47] Van Meerbeek B, Yoshihara K, Yoshida Y, Mine A, De Munck J & Van Landuyt KL (2011) State of the art of self-etch adhesives *Dental Materials* **27** 17-28.

[48] Mena-Serrano A, Kose C, De Paula EA, Tay LY, Reis A, Loguercio AD & Perdigão J (2013) A new universal simplified adhesive: 6-month clinical evaluation *Journal of Esthetic and Restorative Dentistry* **25(1)** 55-69.

[49] Zorzin J, Petschelt A, Ebert J & Lohbauer U (2012) pH neutralization and influence on mechanical strength in self-adhesive resin luting agents *Dental Materials* **28** 672-679.

[50] Zorzin J, Belli R, Wagner A, Petschelt A & Lohbauer U (2014) Self-adhesive resin cements:adhesive performance to indirect restorative ceramics *The Journal of Adhesive Dentistry* **16(6)** 541-546.

[51] Skupien JA, Sarkis-Onofre R, Cenci MS, Moraes RR & Pereira-Cenci T (2015) A systematic review of factors associated with the retention of glass fiber posts *Brazillian Oral Research* **29(1)** 1-8.

[52] Sabatini C, Patel M & D'Silva E (2012) In vitro shear bond strength of three self-adhesive resin cements and a resin-modified glass ionomer cement to various prosthodontic substrates *Operative Dentistry* **38** 186-196.

[53] Frankenberger R, Reinelt C, Petschelt A & Krämer N (2009) Operator vs. material influence on clinical outcome of bonded ceramic inlays *Dental Materials* **25** 960-968.

Tables

Table 1. Descriptive data from included studies in meta-analyses.

Paper	Type of teeth	Restorative material	Aging methods	Conventional cements	Self-adhesive cements
D'Arcangelo et al, 2009	Human	Resin Composite / Ceramic	- Thermo-cycling (5.000 cycles, 5º - 55ºC)	- CoreXFlow (Dentsply DeTey) - Enacem HF (Micerium, Italy) - Panavia F2.0 (Kuraray)	- Relyx Unicem (3M ESPE)
Aguiar et al, 2010	Human	Resin Composite	- No aging	- Panavia F2.0 (Kuraray)	- Relyx Unicem (3M ESPE) - BisCem (Bisco) - G-Cem (GC)
Sarr et al. 2010	Human	Ceramic	- No aging	- Panavia F2.0 (Kuraray) - Clearfil Esthetic cement (Kuraray) - Calibra (Dentsply) - Variolink II (Ivoclar Vivadent)	- Relyx Unicem (3M ESPE) - Maxcem (Kerr) - Monocem (Shofu, Japan) - G-Cem (GC) - Multilink Sprint (Ivoclar Vivadent)
Guarda et al, 2010	Bovine	Ceramic	- No aging	- Variolink II (Ivoclar Vivadent)	- Relyx Unicem (3M ESPE)
De Angelis et al, 2011	Human	Resin Composite / Ceramic	- Thermo-cycling (5.000 cycles, 5º-55ºC)	- Enacem HF (Micerium, Italy) - Panavia F2.0 (Kuraray)	- Relyx Unicem (3M ESPE) - MaxCem Elite (Kerr) - iCEM Self adhesive (Heareus Kulzer)
Inukai et al, 2012	Human	Resin Composite	- Mechanical cycling (250.000 cycles, 100N, 4Hz)	- Panavia F2.0 (Kuraray)	- Relyx Unicem (3M ESPE) - Clearfil SA cement (Kuraray)
Fuentes et al, 2013	Human	Resin Composite	- No aging	- Relyx ARC (3M ESPE)	- Relyx Unicem (3M ESPE) - G-Cem (GC) - Maxcem Elite (Kerr)
Suzuki et al, 2013	Human	Resin Composite	- 6m water storage	- Relyx ARC (3M ESPE) - Panavia F (Kuraray)	- Relyx Unicem (3M ESPE)
Aguiar et al, 2014[1]	Human	Resin Composite	- Mechanical cycling (50.000 cycles, 80N, 1Hz) - 12m and 24m storage on artificial saliva	- Relyx ARC (3M ESPE) - Clearfill esthetic cement (Kuraray)	- Relyx Unicem (3M ESPE) - Clearfil SA Cement (Kuraray)

Feitosa et al, 2014	Human	Ceramic	- Mechanical cycling (2.000.000 cycles, 100N, 4Hz)	- Relyx ARC (3M ESPE)	- Relyx U100 (3M ESPE)
Rigolin et al, 2014	Human	Ceramic	- No aging	- Variolink II (Ivoclar Vivadent) - Multilink (Ivoclar Vivadent)	- Relyx U100 (3M ESPE)
Prochnow et al, 2014	Human	Resin Composite	- Mechanical cycling (1.000.000 cycles, 88N, 4Hz)	- Relyx ARC (3M ESPE)	- Relyx U100 (3M ESPE)
Vaz et al, 2014		Y	- 1m storage in artificial saliva	- Relyx ARC (3M ESPE) - C&B cement (Bisco)	- Relyx Unicem (3M ESPE)
Stape et al, 2014	Human	Resin Composite	- 24m storage in artificial saliva	- Relyx ARC (3M ESPE)	- Relyx U100 (3M ESPE)
Giannini et al, 2015	Human	Resin Composite	- Thermo-cycling (5.000 cycles, 5º-55ºC)	- Panavia F2.0 (Kuraray)	- Relyx Unicem (3M ESPE) - Relyx Unicem 2 (3M ESPE) - Clearfill SA Cement (Kuraray) - G-cem (GC, Japan)
Skupien et al, 2015	Bovine	Resin Composite	- No aging	- Relyx ARC (3M ESPE)	- Relyx U100 (3M ESPE)
Bacchi et al, 2015a	Human	Resin Composite	- 3m Simulated pulpal pressure	- Relyx ARC (3M ESPE) - Panavia F2.0 (Kuraray)	- Relyx U200 (3M ESPE)
Bacchi et al, 2015b[1]	Human	Resin Composite	- 7d Simulated pulpal pressure - Mechanical cycling (200.000 cycles, 50N, 2Hz) - Thermo-cycling (5.000 cycles, 5º-55ºC)	- Relyx ARC (3M ESPE) - Panavia F2.0 (Kuraray)	- Relyx U200 (3M ESPE)
Fuentes et al, 2016	Human	Resin Composite	- No aging	- Relyx ARC (3M ESPE)	- Relyx Unicem (3M ESPE) - G-Cem (GC) - Speedcem (Ivoclar Vivadent) - Maxcem Elite (Kerr) - Smartcem2 (Dentsply)

- All studies used Microtensile Bond strength (µTBS) as bond strength test.
[1] These studies used more than one aging method in same specimens.

Table 2. Risk of Bias assessment of included studies.

Study	Random	Caries	Materials	Teeth	Adhesive	Sample	Blinding	Risk
D'Arcangelo et al, 2009	Y	Y	N	N	N*	N	N*	High
Aguiar et al, 2010	Y	Y	Y	N	N*	N	N*	Medium
Sarr et al. 2010	N	Y	Y	N	N*	N	N*	High
Guarda et al, 2010	Y	Y	Y	N	N*	N	N*	Medium
De Angelis et al, 2011	N	Y	N	N	Y	N	Y	Medium
Inukai et al, 2012	Y	Y	N	Y	N*	Y	N*	Medium
Fuentes et al, 2013	Y	Y	Y	N	N*	N	N*	Medium
Suzuki et al, 2013	N	Y	N	N	N*	Y	N*	High
Aguiar et al, 2014	N	Y	Y	N	N*	N	N*	High
Feitosa et al, 2014	Y	Y	N	Y	N*	N	N*	Medium
Rigolin et al, 2014	Y	Y	Y	N	N*	N	N*	Medium
Prochnow et al, 2014	Y	Y	Y	N	N*	N	N*	Medium
Vaz et al, 2014	N	Y	Y	N	N*	N	N*	High
Stape et al, 2014	Y	Y	N	N	N*	N	N*	High
Giannini et al, 2015	N	Y	Y	N	N*	N	N*	High
Skupien et al, 2015	Y	Y	Y	Y	N*	N	Y	Medium
Bacchi et al, 2015a	Y	Y	Y	N	N*	N	N*	Medium
Bacchi et al, 2015b	Y	Y	Y	N	N*	N	N*	Medium
Fuentes et al, 2016	Y	Y	Y	N	N*	N	N*	Medium

Figures

Figure 1. Flowchart of study selection according to PRISMA statement.

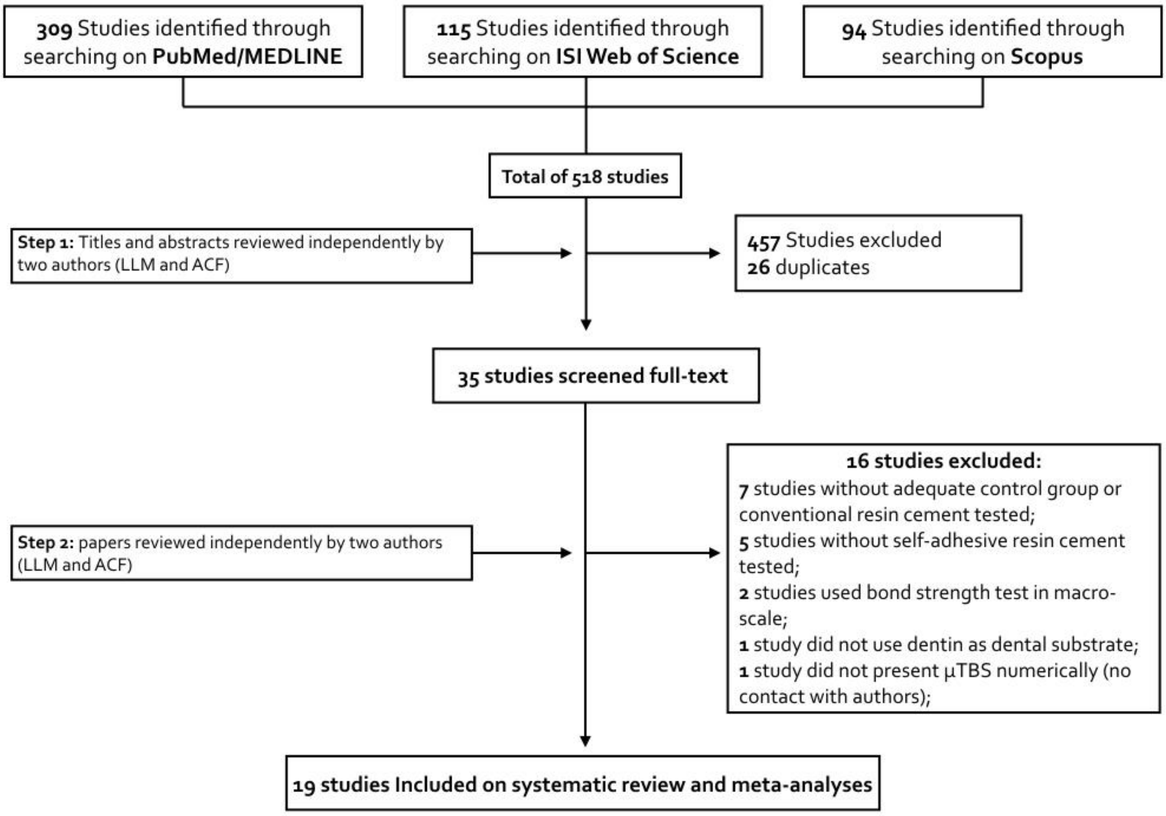


Figure 2. Global analysis comparing conventional (control) vs. self-adhesive resin cements.

Study or Subgroup	Self-adhesive Mean	Self-adhesive SD	Self-adhesive Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI	Year
Aguiar et al, 2010	11.7	7.9	168	15.5	4.3	56	6.3%	-3.80 [-5.44, -2.16]	2010
Sarr et al, 2010	12.8	8.4	198	20.1	9.3	192	6.3%	-7.30 [-9.06, -5.54]	2010
Guarda et al, 2010	18.5	3.2	30	19	5	30	6.3%	-0.50 [-2.62, 1.62]	2010
Inukai et al, 2012	17.2	4.3	64	20	4.1	32	6.3%	-2.80 [-4.57, -1.03]	2012
Fuentes et al, 2013	13.5	6.9	37	24.1	7.2	14	6.1%	-10.60 [-14.98, -6.22]	2013
Suzuki et al, 2013	17.2	6.5	32	16.3	9.8	64	6.2%	0.90 [-2.39, 4.19]	2013
Aguiar et al, 2014	19.1	2.3	80	14.5	3.5	80	6.3%	4.60 [3.68, 5.52]	2014
Feitosa et al, 2014	6.5	2.6	48	3.4	3.1	48	6.3%	3.10 [1.96, 4.24]	2014
Rigolin et al, 2014	10.3	3.9	52	12.3	5	115	6.3%	-2.00 [-3.40, -0.60]	2014
Prochnow et al, 2014	8.7	6	28	35.1	9.1	48	6.2%	-26.40 [-29.80, -23.00]	2014
Vaz et al, 2014	31.3	7.4	60	30.2	12.9	120	6.2%	1.10 [-1.87, 4.07]	2014
Stape et al, 2014	13.1	3.4	80	41.5	3.3	80	6.3%	-28.40 [-29.44, -27.36]	2014
Skupien et al, 2015	9.7	5.3	43	18.9	12.8	84	6.2%	-9.20 [-12.36, -6.04]	2015
Bacchi et al, 2015a	21.2	3.1	60	24	9.1	120	6.3%	-2.80 [-4.61, -0.99]	2015
Bacchi et al, 2015b	21.2	3.1	60	22.7	7.7	180	6.3%	-1.50 [-2.87, -0.13]	2015
Fuentes et al, 2016	14.4	8.3	80	33.2	11.8	22	6.0%	-18.80 [-24.06, -13.54]	2016
Total (95% CI)			**1120**			**1285**	**100.0%**	**-6.47 [-12.32, -0.63]**	

Heterogeneity: Tau² = 140.44; Chi² = 2864.11, df = 15 (P < 0.00001); I² = 99%
Test for overall effect: Z = 2.17 (P = 0.03)

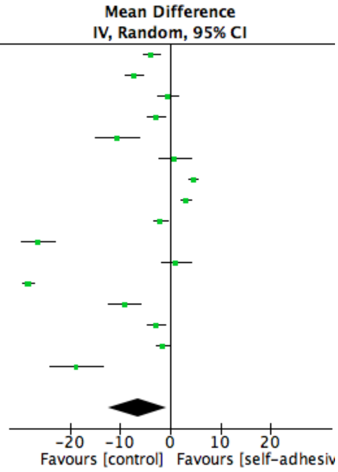


Figure 3. First subgroup analysis – conventional (control) vs. self-adhesive resin cements after aging.

Study or Subgroup	Control Mean	Control SD	Control Total	Self-adhesive Mean	Self-adhesive SD	Self-adhesive Total	Weight	Mean Difference IV, Random, 95% CI	Year
D'Arcangelo et al, 2009	15.8	14.3	120	13.2	8.5	40	8.1%	2.60 [−1.07, 6.27]	2009
De Angelis et al, 2011	16.6	10.5	48	9.7	5.1	72	8.2%	6.90 [3.70, 10.10]	2011
Inukai et al, 2012	15.8	3.9	32	13.8	3.9	64	8.4%	2.00 [0.35, 3.65]	2012
Suzuki et al, 2013	16.6	8.5	64	14.6	3.9	36	8.3%	2.00 [−0.44, 4.44]	2013
Vaz et al, 2014	34.3	12.1	120	28.3	7.1	60	8.3%	6.00 [3.19, 8.81]	2014
Stape et al, 2014	27.8	3.6	80	9.9	2.9	80	8.4%	17.90 [16.89, 18.91]	2014
Prochnow et al, 2014	32.7	10.7	56	5.2	4.6	30	8.2%	27.50 [24.25, 30.75]	2014
Feitosa et al, 2014	3.4	2.8	48	4.7	2	48	8.4%	−1.30 [−2.27, −0.33]	2014
Aguiar et al, 2014	11.5	6.5	80	20.6	5.3	80	8.4%	−9.10 [−10.94, −7.26]	2014
Giannini et al, 2015	33.2	5.8	45	40.2	9.6	180	8.3%	−7.00 [−9.20, −4.80]	2015
Bacchi et al, 2015a	17.5	5	180	7.8	0.9	60	8.5%	9.70 [8.93, 10.47]	2015
Bacchi et al, 2015b	18.4	8.2	120	6.2	1.1	60	8.4%	12.20 [10.71, 13.69]	2015
Total (95% CI)			**993**			**810**	**100.0%**	**5.76 [0.58, 10.94]**	

Heterogeneity: $Tau^2 = 82.47$; $Chi^2 = 1478.91$, df = 11 ($P < 0.00001$); $I^2 = 99\%$
Test for overall effect: Z = 2.18 (P = 0.03)

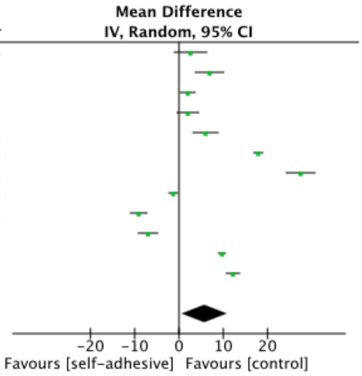


Figure 4. Second subgroup analysis – Self-adhesive cements performance comparing immediate vs. long-term results.

Study or Subgroup	No Aging Mean	No Aging SD	No Aging Total	Aging Mean	Aging SD	Aging Total	Weight	Mean Difference IV, Random, 95% CI	Year
Inukai et al, 2012	16.1	4.3	64	13.8	3.9	64	11.2%	2.30 [0.88, 3.72]	2012
Suzuki et al, 2013	17.2	6.5	32	14.6	3.8	32	10.9%	2.60 [−0.01, 5.21]	2013
Aguiar et al, 2014	19.1	2.3	80	20.6	5.3	80	11.2%	−1.50 [−2.77, −0.23]	2014
Prochnow et al, 2014	8.7	6	28	5.2	4.6	30	10.8%	3.50 [0.73, 6.27]	2014
Vaz et al, 2014	31.3	7.4	60	28.3	7.1	60	10.9%	3.00 [0.41, 5.59]	2014
Stape et al, 2014	13.1	3.3	80	9.9	2.9	80	11.2%	3.20 [2.24, 4.16]	2014
Feitosa et al, 2014	6.5	2.6	48	4.7	2	48	11.2%	1.80 [0.87, 2.73]	2014
Bacchi et al, 2015b	21.2	3.1	60	6.2	1.1	60	11.3%	15.00 [14.17, 15.83]	2015
Bacchi et al, 2015a	21.2	3.1	60	7.8	0.9	60	11.3%	13.40 [12.58, 14.22]	2015
Total (95% CI)			**512**			**514**	**100.0%**	**4.84 [0.34, 9.33]**	

Heterogeneity: $Tau^2 = 46.57$; $Chi^2 = 1010.94$, df = 8 ($P < 0.00001$); $I^2 = 99\%$
Test for overall effect: Z = 2.11 (P = 0.03)

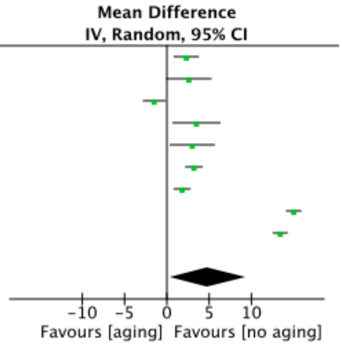
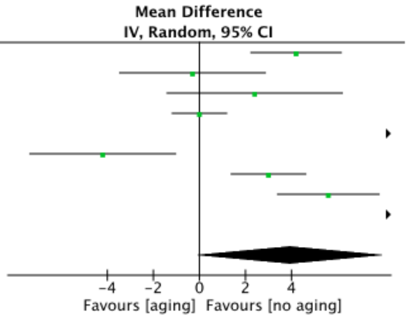


Figure 5. Third subgroup analysis – Conventional resin cements performance comparing immediate vs. long-term results

Study or Subgroup	No aging Mean	No aging SD	No aging Total	Aging Mean	Aging SD	Aging Total	Weight	Mean Difference IV, Random, 95% CI	Year
Inukai et al, 2012	20	4.1	32	15.8	3.9	32	11.2%	4.20 [2.24, 6.16]	2012
Suzuki et al, 2013	16.3	9.8	64	16.6	8.4	64	10.8%	−0.30 [−3.46, 2.86]	2013
Prochnow et al, 2014	35.1	9.1	48	32.7	10.7	56	10.5%	2.40 [−1.41, 6.21]	2014
Feitosa et al, 2014	3.4	3.1	48	3.4	2.8	48	11.4%	0.00 [−1.18, 1.18]	2014
Stape et al, 2014	41.5	3.2	80	27.7	3.6	80	11.4%	13.80 [12.74, 14.86]	2014
Vaz et al, 2014	30.1	12.9	120	34.3	12.1	120	10.8%	−4.20 [−7.36, −1.04]	2014
Aguiar et al, 2014	14.5	3.5	80	11.5	6.5	80	11.3%	3.00 [1.38, 4.62]	2014
Bacchi et al, 2015a	24	9.1	120	18.4	8.3	120	11.2%	5.60 [3.40, 7.80]	2015
Bacchi et al, 2015b	27.7	7.7	180	17.5	5	180	11.4%	10.20 [8.86, 11.54]	2015
Total (95% CI)			**772**			**780**	**100.0%**	**3.94 [−0.24, 8.12]**	

Heterogeneity: $Tau^2 = 39.56$; $Chi^2 = 419.22$, df = 8 ($P < 0.00001$); $I^2 = 98\%$
Test for overall effect: Z = 1.85 (P = 0.06)



4 DISCUSSÃO

Ambos os artigos anteriormente apresentados analisam o impacto da estratégia adesiva utilizada em procedimentos de cimentação de restaurações indiretas em dentina. Em relação a cimentação adesiva, o termo "estratégia adesiva" refere-se principalmente à classificação do cimento resinoso dual utilizado, pois o tipo de cimento resinoso indica qual tratamento prévio da superfície dental é necessário. Os cimentos autoadesivos, por exemplo, dispensam qualquer tratamento prévio da superfície dental com condicionadores ácidos. Para aplicação desses cimentos, a limpeza do substrato é a condição necessária para o estabelecimento da adesão. O menor número de passos faz com que esses cimentos sejam considerados "simplificados", com menor sensibilidade técnica (CANTORO et al., 2009). Em ambos os estudos, a estratégia "convencional", onde o cimento resinoso necessita de um agente adesivo intermediário ao substrato dental, apresentou os melhores resultados de resistência de união imediatos e a longo prazo à dentina. Enquanto que no artigo 1 os resultados da investigação *in vitro* mostraram um desempenho superior do cimento resinoso dual convencional, a revisão sistemática com meta-análise do artigo 2 revela uma tendência geral de melhor comportamento adesivo da estratégia adesiva "convencional", tanto imediatamente quanto após processos de degradação e envelhecimento.

Apesar dos resultados encontrados, alguns estudos anteriores indicaram performances adesivas satisfatórias dos cimentos resinosos autoadesivos (GUARDA et al, 2010; ; DEMUNCK et al., 2004; SCHENKE et al., 2008; TASCHNER et al., 2012). Taschner e colaboradores (2012) executaram um estudo clínico com 24 meses de acompanhamento onde compararam um cimento autoadesivo e um cimento convencional quando utilizados na cimentação de inlays fabricadas com uma cerâmica vítrea reforçada por leucita (IPS Empress – Ivoclar Vivadent). Nesse estudo, o cimento autoadesivo (Relyx Unicem – 3M ESPE) apresentou desempenho clínico semelhante ao cimento convencional (Variolink II – Ivoclar Vivadent). (TASCHNER et al., 2012) Outro estudo que corrobora com esses achados é o de Hitz e colaboradores (2012), o qual analisou vários cimentos resinosos autoadesivos e identificou que alguns desses cimentos apresentaram valores de resistência de união à dentina e à cerâmica vítrea semelhantes aos cimentos resinosos convencionais testados. Os autores concluem que alguns cimentos autoadesivos podem ser excelentes alternativas aos cimentos convencionais para cimentação adesiva. (HITZ et al., 2012) Essa divergência de achados e opiniões entre esses estudos e aqueles apresentados na presente tese pode ser explicada por um ponto muito importante envolvendo essa categoria de cimentos resinosos: a variação de formulação. Hitz el al. (2012) mostraram uma grande variação no desempenho adesivo de vários cimentos resinosos testados. Os autores encontraram uma enorme variação de composição dos cimentos resinosos testados, principalmente envolvendo a matriz orgânica desses produtos. Os monômeros funcionais utilizados em compostos com características “auto-condicionantes’ desempenham um papel fundamental no estabelecimento da adesão com o substrato dental, pois o condicionamento da superfície mineral depende diretamente da capacidade acídica de seus monômeros funcionais. (VAN MEERBEEK et al., 2011) Além disso, estudos anteriores também mostraram que a capacidade de desmineralização desses componentes é relativamente limitada, principalmente ao compararmos tais componentes com condicionadores ácidos específicos. (MENA-SERRANO et al, 2013). Essa grande variabilidade de composição pode ser considerada como o principal motivo para o desempenho geral inferior dos cimentos autoadesivos, especialmente considerando estudos que encontraram marcas comerciais capazes de promover adesão adequada. Em uma análise global, aqueles cimentos com composição química pouco efetiva do ponto de vista adesivo acabam contribuindo de maneira negativa no desempenho geral desses cimentos resinosos duais.

Outro ponto importante que também pode explicar esse desempenho inferior dessa classe de cimentos é o entendimento do complexo mecanismo de adesão envolvido na interação com a dentina. Uma adequada hibridização da dentina depende da formação de uma camada híbrida entre agente adesivo e substrato desmineralizado, a partir da adequada infiltração de monômeros com baixo peso molecular e sua adequada conversão em cadeias poliméricas. Compostos cujo funcionamento adesivo é auto-condicionante dissolvem e incorporam o mineral da estrutura dental à camada híbrida. De Munck et al. (2004) identificaram que o cimento resinoso autoadesivo testado conseguiu uma interação apenas superficial e irregular com a estrutura dental. No mesmo estudo, o cimento resinoso convencional conseguiu de fato formar uma camada-híbrida adequada, graças a ação do sistema adesivo utilizado em combinação ao cimento resinoso. (De Munck et al., 2004) Os sistemas adesivos são compostos com maior facilidade de escoar sobre a estrutura dental e preencher os espaços deixados pelo condicionamento do substrato, com moléculas de menor peso molecular e menor porcentagem de carga em sua composição. Apesar de apresentar mais passos em seu protocolo de utilização, os cimentos convencionais conseguem aproveitar as características positivas dos sistemas adesivos, e assim, promover adequada adesão.

Apesar dos resultados *in vitro* indicarem essa tendência ao pior desempenho dos cimentos autoadesivos ao aderir à dentina, isso não significa que essa classe de cimentos resinosos seja contraindicada para uso clínico. A literatura apresenta alguns estudos anteriores que indicaram adequada capacidade adesiva dessa família de cimentos resinosos (DEMUNCK et al., 2004; MUÑOZ et al., 2014; SCHENKE et al., 2008; TASCHNER et al., 2012). Taschner e colaboradores (2012) executaram um estudo clínico com 24 meses de acompanhamento onde compararam um cimento autoadesivo e um cimento convencional quando utilizados na cimentação de inlays fabricadas com uma cerâmica vítrea reforçada por leucita (IPS Empress – Ivoclar Vivadent). Nesse estudo, o cimento autoadesivo (Relyx Unicem – 3M ESPE) apresentou desempenho clínico semelhante ao cimento convencional (Variolink II – Ivoclar Vivadent) após 24 meses de uso clínico (TASCHNER et al., 2012). Outro estudo que corrobora com esses achados é o de Hitz e colaboradores (2012), o qual analisou vários cimentos resinosos autoadesivos e identificou que alguns desses cimentos apresentaram valores de resistência de união à dentina e à cerâmica vítrea semelhantes aos cimentos resinosos convencionais testados. Os autores concluem que alguns cimentos autoadesivos podem ser excelentes alternativas aos cimentos convencionais para cimentação adesiva. (HITZ et al., 2012)**.** Peumans et al. (2010) ao avaliarem durante 24 meses restaurações do tipo inlay cimentadas com cimentos autoadesivos, identificaram que apenas 1 restauração foi perdida por falha adesiva devido a falha do cimento resinoso. (PEUMANS et al., 2010). Mesmo assim, o sucesso clínico dessa classe de cimentos resinosos ainda é fortemente associada a marca comercial, devido a grande variabilidade de composições disponíveis no mercado. Além disso, Em situações clínicas como cimentação de pinos de fibra de vidro em condutos radiculares, os cimentos autoadesivos apresentaram uma melhor performance adesiva, especialmente por não necessitarem de passos clínicos como por exemplo evaporação de solvente do agente adesivo, além de menor sensibilidade a técnica, sendo indicados para esse fim. (SKUPIEN et al., 2015; SARKIS-ONOFRE et al., 2014). Sua característica de uso simplificada permite o uso dessa categoria de cimentos resinosos em situações de difícil acesso e isolamento do campo operatório, tornando esses materiais uma escolha interessante para essas situações.

5 CONCLUSÃO

Com base nos achados dos artigos que compõem a presente tese, pode-se concluir que os cimentos resinosos convencionais, com um maior número de passos clínicos, apresentam um maior potencial adesivo à dentina quando comparados a cimentos resinosos simplificados, chamados autoadesivos. O maior número de passos clínicos, graças ao uso de um sistema adesivo, fornece melhores condições de uma adequada hibridização do substrato dentinário, e consequentemente, melhor estabelecimento da adesão. Apesar disso, a maior sensibilidade técnica dos cimentos “multi-steps” também deve ser considerada ao utilizar essa classe de cimento resinoso. Os cimentos autoadesivos não devem ser descartados do uso clínico, tendo em vista que algumas marcas comerciais apresentam adequada performance adesiva à dentina, além de que a simplificação técnica favorece procedimentos restauradores de difícil acesso, como a cimentação de pinos de fibra de vidro.

REFERÊNCIAS

ALVES, M. et al. Effect of Adhesive Cementation Strategies on the Bonding of Y-TZP to Human Dentin. **Operative Dentistry**, n. C, p. 15–52, 2015.

BEHR, M. et al. The influence of different cements on the fracture resistance and marginal adaptation of all-ceramic and fiber-reinforced crowns. **The Internation Journal of Prosthodontics**, v. 16, n. 5, p. 538-542, 2003.

CANTORO, A. et al. Bonding potential of self-adhesive luting agents used at different temperatures to lute composite onlays. **Journal of Dentistry,** v.36, n.6, p. 454-461, 2009.

CHU, S.J.; TRUSHKOWSKY, R.D.; PARAVINA, R.D. Dental color matching instruments and systems**. Journal of Dentistry,** v. 38, p. 2–16, 2010.

COLDEA, A.; SWAIN, M.V.; THIEL, N. Mechanical properties of polymer-infiltrated-ceramic-network materials. **Dental Materials**, v.29, p. 419-426, 2013.

DE ANGELIS, F. et al. Bond Strength Evaluation of Three Self-adhesive Luting Systems Used for Cementing Composite and Porcelain. **Operative Dentistry**, v. 36, n. 6, p. 626–634, 2011.

DELBONS, F.B. et al. Randomized clinical trial of four adhesion strategies in posterior restorations - 18-month results. **The Journal of Esthetic and Restorative Dentistry**, v. 27, n. 2, p. 107-117, 2015.

DE MUNCK, J. et al. Bonding of an auto-adhesive luting material to enamel and dentin. **Dental Materials**, v. 20, p.963–971, 2004.

DE MUNCK, J. et al. Fracture toughness versus micro-tensile bond strength testing of adhesive-dentin interfaces. **Dental Materials**, v. 29, n. 6, p. 635–644, 2013.

ELSAKA, S. E.; CAM, C. A D. Bond Strength of Novel CAD / CAM Restorative Materials to Self-Adhesive Resin Cement : The Effect of Surface Treatments. **The journal of adhesive dentistry**, v. 16, n. 6, p. 531–540, 2014.

ERICKSON, R. L.; BARKMEIER, W. W.; LATTA, M. A. The role of etching in bonding to enamel: a comparison of self-etching and etch-and-rinse adhesive systems. **Dental Materials**, v.25, p.1459-1467, 2009.

FEDERLIN, M.; HILLER, K.A.; SCHMALZ, G. Controlled, prospective clinical split-mouth study of cast gold vs.ceramic partial crowns: 5.5 year results. **American Journal of Dentistry**, v. 23, p. 161–167, 2010.

FLEMING, G. J. et al. The strengthening mechanism of resin cements on porcelain surfaces. **Journal of Dental Research**, v.85, p.272-276, 2006.

GARCIA-GODOY, F. et al. Long-term degradation of enamel and dentin bonds: 6-year results in vitro vs. in vivo. **Dental Materials**, v. 26, n. 11, p. 1113–1118, 2010.

GROTEN, M.; PROBSTER, L. The influence of different cementation modes on the fracture resistance of feldspathic ceramic crowns. **The international Journal of Prosthodontics**, v. 10, p. 169-177, 1997.

GUARDA, G.B. et al. Luting glass ceramic restorations using a self-adhesive resin cement under different dentin conditions. **Journal of Applied Oral Science**, v.18, n. 3, p. 244-248, 2010.

GUESS, P.C. et al. Influence of preparation design and ceramic thicknesses on fracture resistance and failure modes of premolar partial coverage restorations. **The Journal of Prothetic Dentistry**, v. 110, n. 4, p. 264-273, 2013.

HANABUSA, M. et al. Bonding effectiveness of a new ‘‘multi-mode’’ adhesive to enamel and dentine. **Journal of Dentistry**, v. 40, n. 6, p. 475-484, 2012.

HITZ, T. et al. Are self-adhesive resin cements a valid alternative to conventional resin cements? A laboratory study of the long-term bond strength. **Dental Materials**, v. 28, n. 11, p. 1183-1190, 2012.

JIANG, W.; BO, H.; YONGCHUN, G.; LONGXING, N**.** Stress distribution in molars restored with inlays or onlays with or without endodontic treatment: a three- dimensional finite element analysis**. The Journal of Prosthetic Dentistry,** v. 103, p. 6-12, 2010.

KELLY, J.R. Dental ceramics What is this stuff anyway? **Journal of American Dental Association**, v. 139, suppl 4, p. 4-7, 2013.

MALAMENT K. A.; SOCRANSKY, S. S. Survival of Dicor glass-ceramic dental restorations over 16 years. Part III: effect of luting agent and tooth or tooth-substitute core structure. **Journal of Prosthetic Dentistry**, v.86, p.511-519, 2001.

MENA-SERRANO, A. et al. A new universal simplified adhesive: 6-month clinical evaluation. **Journal of esthetic and restorative dentistry**, v.25, p.55-69, 2013.

MUÑOZ, M. et al. In vitro longevity of bonding properties of universal adhesives to dentin. **Operative Dentistry**, v. 40, n. 3, p. 282-292, 2015.

PAVAN, S. et al. The effect of dentin pretreatment on the microtensile bond strength of self-adhesive resin cements**. The Journal of Prosthetic Dentistry,** v. 104, p. 258-264, 2010.

PERDIGAO, J.; SEZINANDO, A.; MONTEIRO, P.C. Laboratory bonding ability of a multi-purpose dentin adhesive. **American Journal of Dentistry**, v. 25, n. 3, p. 153-158, 2012.

PERDIGAO, J.; LOGUERCIO, A.D. Universal or multi-mode adhesives: why and how? **Journal of Adhesive Dentistry**, v. 16, n. 2, p. 193-193, 2014.

PERDIGAO, J. et al. Immediate adhesive properties to dentin and enamel of a universal adhesive associated with a hydrophobic resin coat. **Operative Dentistry,** v. 39, n. 5, p. 489-499, 2014.

PERDIGÃO, J. et al. Morphological field emission-SEM study of the effect of six phosphoric acid etching agents on human dentin. **Dental materials**, v. 12, n. 4, p. 262–271, 1996

PEUMANS, M; DE MUNCK, J; VAN LANDUYT, K; POITEVIN, A; LAMBRECHTS, P; VAN MEERBEEK, B. Two-yea clinical evaluation of a self-adhesive luting agent for ceramic inlays. **The journal of adhesive dentistry,** v.12, p.151-161, 2010.

PEUTZFELDT, A.; SAHAFI, A.; FLURY, S. Bonding of restorative materials to dentin with various luting agents. **Operative Dentistry**, v.36, n.3, p.266-273, 2011.

ROSA, W.L.; DE O, D.A.; PIVA, E.; SILVA, A.F. Bond strength of universal adhesives: A systematic review and meta-analysis. **Journal of Dentistry**, v. 43, n. 7, p. 765-776, 2015.

SALAVERRY, A. et al. Effect of Resin Cements and Aging on Cuspal Deflection and Fracture Resistance of Teeth Restored with Composite Resin Inlays**. The Journal of Adhesive Dentistry**, v. 15, n.6, p. 1-8, 2013.

SARKIS-ONOFRE, R. et al. The role of resin cement on bond strength of glass-fiber posts luted into root canals: a systematic review and meta-analysis of in vitro studies. **Operative dentistry**, v.39, n.1, p. 31-44, 2014.

SCHENKE, F. et al. Marginal integrity of partial ceramic crowns within dentin with different luting techniques and materials. **Operative Dentistry,** v.33, n. 5, p. 516-525, 2008.

SKUPIEN, J. et al. A systematic review of factores associated with the retention of glass fiber posts. **Brazillian Oral Research**, v.29, n.1, p. 1-8, 2015.

SON, H.J. et al. Influence of dentin porcelain thickness on layered all-ceramic restoration color. **Journal of Dentistry**, v. 38, p71–77, 2010.

TASCHNER, M. et al. Leucite-reinforced glass ceramic inlays luted with self-adhesive resin cement: a 2-year in vivo study. **Dental Materials**, v. 28, p. 535-540, 2012.

TAY, F. R.; PASHLEY, D. H. Aggressiveness of contemporary self-etching systems. I: Depth of penetration beyond dentin smear layers. **Dental Materials**, v. 17, n. 4, p. 296–308, 2001.

VAN DIJKEN, J.W.; HASSELROT, L. A prospective 15-year evaluation of extensive dentin-enamel-bonded pressed ceramic coverages. **Dental Materials**, v. 26, p. 929-939, 2010.

VAN MEERBEEK, B. et al. State of the art of self-etch adhesives. **Dental Materials**, v.27, p. 17-28, 2011.

VAZ, R.; HIPÓLITO, V.; D'ALPINO, P.; GOES, M. Bond strength and interfacial micromorphology of etch-and-rinse and self-adhesive resin cements to dentin. **Journal of Prosthodontics**, v.21, p. 101-111, 2012.

VOGL, V. et al. Controlled, prospective, randomized, clinical split-mouth evaluation of partial ceramic crowns luted with a new, universal adhesive system/resin cement: results after 18 months. **Clinical Oral Investigation**, v. 20, n. 9, p. 2481-2492, 2016.

XIAOPING, L.; DONGFENG, R.; SILIKAS, N. Effect of etching time and resin bond on the flexural strength of IPS e.max Press glass ceramic. **Dental Materials**, v. 30, n. 12, p. 330-336, 2014.

YOSHIDA, Y. et al. Evidence of Chemical Bonding at Biomaterial-Hard Tissue Interfaces. **Journal of Dental Research,** v. 79, p. 709-714, 2000.

YOSHIDA, Y. et al. Self-assembled Nano-layering at the Adhesive Interface. **Journal of Dental Research**, v. 91, n. 4, p. 376–381, 2012.

ANEXO A – NORMAS PARA PUBLICAÇÃO NO PERIÓDICO *OPERATIVE DENTISTRY*

Manuscript Submission (Author Guidelines)

General Requirements

Operative Dentistry requires electronic submission of all manuscripts. All submissions must be sent to Operative Dentistry using the Allen Track upload site. A mandatory and nonrefundable $50.00 fee is required at submission. Your manuscript will only be considered officially submitted after it has been approved through our initial quality control check, and any quality problems have been resolved. You will have 6 days from when you start the process to submit and approve the manuscript. After the 6 day limit, if you have not finished the submission, your submission may be removed from the server. You are still able to submit the manuscript, but you must start from the beginning. Be prepared to submit the following manuscript files in your upload:

- A Laboratory or Clinical Research Manuscript file must include: o a title

  o a running (short) title
  o a clinical relevance statement
  o a concise summary (abstract)
  o introduction, methods & materials, results, discussion and conclusion
  o references (see Below)

- The manuscript body **MUST NOT** include any:

  o Author identifying information such as:

  ▪ Authors names or titles

  - ▪ Acknowledgements
  - ▪ Correspondence information
  - ▪ Response to reviewer files should also NOT include any author identifying information, such as a signature at the end, etc.

    o Figures

    o Graphs

    o Tables

- An acknowledgement, disclaimer and/or recognition of support (if applicable) must be uploaded as a separate file and uploaded as

miscellaneous material.

- Appendix material that you would like us to publish electronically with your article, but not as part of your printed manuscript (such as indices, supplemental tables, etc.), should be submitted as ***supplemental material***. It will not be typeset, and will appear exactly as you provide to Operative Dentistry. References submitted as part of supplemental material should appear in our preferred reference format. Supplemental material is viewable by the reviewers, and so SHOULD NOT contain any author identifiable information.

- All figures, illustrations, graphs and tables must also be provided as individual files. Figures should be submitted without figure letters or numbers within the image itself, these designations will be added by the journal staff as needed. All Figures should be high-resolution images, which are used by the editor in the actual typesetting of your manuscript. Please refer to the instructions below for acceptable formats and sizes.
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- Journal article-multiple authors: Eick JD, Gwinnett AJ, Pashley DH & Robinson SJ (1997) Current concepts on adhesion to dentin *Critical Review of Oral and Biological Medicine* **8(3)** 306-335.
- Journal article: special issue/supplement: Van Meerbeek B, Vargas M, Inoue S, Yoshida Y, Peumans M, Lambrechts P & Vanherle G (2001) Adhesives and cements to promote preservation dentistry *Operative Dentistry* **(Supplement 6)** 119-144.
- Abstract: Yoshida Y, Van Meerbeek B, Okazaki M, Shintani H & Suzuki K (2003) Comparative study on adhesive performance of functional monomers *Journal of Dental Research* **82(Special Issue B)** Abstract #0051 p B-19.
- Corporate publication: ISO-Standards (1997) ISO 4287 Geometrical Product Specifications Surface texture: Profile method – Terms, definitions and surface texture parameters *Geneve: International Organization for Standardization* **1st edition** 1-25.
- Book-single author: Mount GJ (1990) *An Atlas of Glass-ionomer Cements* Martin Duntz Ltd, London.
- Book-two authors: Nakabayashi N & Pashley DH (1998) *Hybridization of Dental Hard Tissues* Quintessence Publishing, Tokyo.
- Book-chapter: Hilton TJ (1996) Direct posterior composite restorations In: Schwarts RS, Summitt JB, Robbins JW (eds) *Fundamentals of Operative Dentistry* Quintessence, Chicago 207-228.
- Website-single author: Carlson L (2003) Web site evolution; Retrieved online July 23, 2003 from: http://www.d.umn.edu/~lcarlson/cms/evolution.html

- Website-corporate publication: National Association of Social Workers (2000) NASW Practice research survey 2000. NASW Practice Research Network, 1. 3. Retrieved online September 8, 2003 from: http://www.socialworkers.org/naswprn/default

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