UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
FACULDADE DE ODONTOLOGIA

CAROLINA LOPES DA SILVA

O USO DE SISTEMA ADESIVO CONTENDO SILANO AUMENTA A RESISTÊNCIA DE UNIÃO DE REPARO DE RESINA COMPOSTA ENVELHECIDA?

Porto Alegre
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Trabalho de Conclusão de Curso apresentado ao Curso de Graduação em Odontologia da Faculdade de Odontologia da Universidade Federal do Rio Grande do Sul, como requisito parcial para obtenção do título de Cirurgião-Dentista.

Orientadora: Tathiane Larissa Lenzi.

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Orientadora: Tathiane Larissa Lenzi.

Porto Alegre, 10 de julho de 2019.

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Dedico este trabalho a Deus pois, como diz em Romanos 11:36: “todas as coisas foram criadas por Ele e tudo existe por meio dEle e para Ele”. Este trabalho só foi possível por causa dEle e, portanto, pertence a Ele.

AGRADECIMENTOS

Agradecer nunca é demais, é um exercício que deixa a alma leve e tudo mais feliz. Neste trabalho, particularmente, tenho a agradecer muitas pessoas e oportunidades, das quais sem eu não teria realizado nem metade do que consegui.

Agradeço primeiramente a Jesus, meu maior Irmão, que tem me dado amor e saúde a cada dia de vida, graça e misericórdia para ir sempre mais longe, sabedoria e inteligência para alcançar os objetivos almejados. Este trabalho é parte de um grande sonho que Ele colocou no meu coração, um propósito que tem ganhado mais sentido e força a cada dia.

À minha orientadora Tathi, meus agradecimentos não caberiam nestas páginas, pois ela desempenhou diferentes papeis neste período que trabalhamos juntas, indo muito além de uma simples orientadora, sempre com tanta paciência e cuidado. Foi professora, que ensinou em todos os momentos que compartilhamos, transmitindo conhecimentos, dicas e ideias que alimentaram minha jornada acadêmica e construção profissional, trabalharam minha autonomia, senso crítico e pensamento científico, sendo como a cereja do bolo desses anos na graduação. Foi uma amiga que me fez companhia em momentos difíceis e estressantes, sempre dando conselhos inteligentíssimos que me faziam pensar: “é verdade, como não pensei nisso antes? ”, compartilhando experiências e vivências, tanto profissionais quanto de outras áreas da vida, que faziam com que a ansiedade existente em mim se acalmasse e que minha admiração por ela crescesse a cada ciclo desse processo. Desempenhou um papel tão completo que foi até uma mãe, corrigindo quando necessário e sempre com muito carinho, me fazendo perceber os erros e melhores caminhos para continuar o serviço. Comemorou cada etapa completa do trabalho e da minha graduação, me fazendo sentir acolhida e numa relação de muito afeto. Acho que por estar num ambiente de Odontopediatria, onde o acolhimento e criação de vínculo são cruciais para desempenhar nosso trabalho, o sentimento de família é inevitável e eu sou muito grata por receber todo esse carinho de uma pessoa que é inspiração para mim. Prof, do fundo do meu coração, muito obrigada!

Falando em Odontopediatria, não tem como não agradecer a esta área da profissão, aos pacientes e professores envolvidos, pois, literalmente, esta clínica salvou a minha trajetória na faculdade. É comum alguns alunos desanimarem ao longo do processo de formação profissional e eu também passei por um momento

de dúvida e incerteza, mas, ao aprender e praticar o atendimento a pacientes infantis, me senti revigorada para continuar na Odontologia e entendi o propósito e o porquê atuar nesta área da saúde. Independentemente do que estudamos ou no que trabalhamos, sempre haverá algo que despertará o melhor que existe em nós e trará sentido para o que estamos fazendo; que sejamos gratos ao encontrar.

Uma das coisas da vida que me encanta é como desenvolvemos relacionamentos a partir da afinidade e o fato disso acontecer sem planejarmos ou até mesmo imaginarmos. Na faculdade não foi diferente e fiz amizades que me dão muito orgulho. Agradeço a esses colegas que se tornaram meus amigos e irmãos, responsáveis por muito do que vivi ter sido especial. Não preciso necessariamente citar nomes pois, ao ler estes agradecimentos, cada um irá se identificar e entender sobre o que estou falando. Eles foram o motivo da alegria de vários dias, o suporte nos momentos mais complicados, o incentivo de compartilhar e se doar mais pelo outro. Foram casa fora de casa. Sempre que precisei de uma conversa, um apoio em questões mais diversas, companhia, ajuda em qualquer que fosse a situação ou, simplesmente, dar risadas, lá estavam eles. Aprendi e ensinei, recebi e doei; permitiram trocas constantes que contribuíram para moldar quem somos hoje, ao final deste ciclo. Nestes amigos, vejo profissionais excelentes que eu indicarei para pacientes, pessoas ótimas que fazem a diferença onde passam e amigos de verdade que trouxeram ainda mais valor ao que foi vivido nesses últimos cinco anos. Os agradecimentos a essas pessoas vão além dessas simples palavras, transbordam para atitudes e se estendem para o resto da nossa amizade. Amigos, obrigada por tudo!

Por último e, obviamente, não menos importante, minha gratidão vai à minha família. Toda construção tem seu fundamento, toda planta tem sua raiz e tudo se inicia pela base; eles são a minha base. A base que me orientou durante toda a minha vida da forma mais coerente possível, dentro da nossa realidade, passando princípios e ensinamentos valiosos, que não foram e nem serão perdidos. A base da onde sempre saiu o incentivo e impulso para fazer mais, buscar mais e ser mais do que sou, com o objetivo de alcançar o máximo do que posso ser. A base que me ensinou a ter a fé que é o combustível de tudo o que faço e tudo que planejo. A base que me deu suporte através de espaço para dar conta de tudo, respeitando minhas necessidades, entendendo minhas responsabilidades e me incentivando nas oportunidades. A base que tirou recursos onde não havia para que eu sempre

tivesse o que precisava para realizar esse sonho e, agora, ele está se completando, fazendo com que tudo tenha valido a pena. Obrigada por me darem os nutrientes necessários para meu crescimento e desenvolvimento, alimentarem minhas ideias e projetos e podarem tudo aquilo que me impede de crescer e seguir em frente. Obrigada por cuidarem de mim e me permitirem florescer, meus frutos sempre serão graças a vocês, os meus sonhos são por vocês e se completam através de vocês.
O meu amor mais verdadeiro e o meu obrigada mais sincero, que se expandem dessas linhas para toda a eternidade.

Muitos outros personagens fizeram parte dessa conquista, desde o vestibular até a defesa desse trabalho. Sou muito grata por sempre ser rodeada por pessoas especiais e que me incentivam em todos os desafios. Se eu escrevesse sobre cada uma das que estiveram comigo durante o processo de confecção dessa pesquisa e as que me acompanharam ao longo desses últimos anos, estes agradecimentos teriam mais páginas que o trabalho inteiro. Então, aqui resumo meus sentimentos em simples palavras: muito obrigada!

“Toda dádiva que é boa e perfeita vem do alto, do Pai que criou as luzes no céu. Nele não há variação nem sombra de mudança.”

Tiago 1:17

RESUMO

O objetivo deste estudo foi avaliar o efeito de um adesivo universal contendo silano, com e sem aplicação prévia de silano, na resistência de união de reparo de resina composta. Quarenta blocos de resina composta nanohíbrida (Z350 XT, cor A1E; 3M ESPE) foram armazenados em água destilada por 14 dias e submetidos a 5000 ciclos de termociclagem. Após o envelhecimento, os blocos foram abrasionados com lixa de granulação 320 e condicionados com gel de ácido fosfórico a 37% por 30 segundos, seguido de lavagem e secagem. Os corpos de prova foram então divididos aleatoriamente em quatro grupos experimentais: sistema adesivo convencional - Adper Single Bond 2 (3M ESPE) e sistema adesivo universal contendo silano - Single Bond Universal (3M ESPE), com e sem aplicação prévia de silano (RelyX Ceramic Primer; 3M ESPE). Após os tratamentos de superfície e protocolos adesivos, os blocos foram reparados com resina composta (Z350 XT, cor A3B; 3M ESPE). Os corpos de prova foram seccionados em palitos após 24 horas de armazenamento em água destilada e submetidos ao teste de microtração. Dez blocos de resina composta não envelhecida foram usados como grupo de referência para determinar a resistência coesiva do material. Os dados obtidos foram submetidos à Análise de Variância de dois fatores e Teste de Tukey. Análise de Variância de um fator e Teste Dunnet foram usados para comparar os valores de resistência coesiva com os valores de resistência de união dos grupos reparados ($\alpha = 0,05$). Os valores de resistência de união de reparo com o Single Bond Universal ($42,3 \pm 7,4$ MPa) foram maiores aos obtidos com o Adper Single Bond 2 ($31,6 \pm 10,0$ MPa). A aplicação de silano aumentou a resistência de união de reparo (com silano: $40,8 \pm 9,8$ MPa; sem silano: $33,1 \pm 9,3$ MPa). A resistência de união de reparo variou de 39,3% a 65,8% da resistência coesiva da resina. Em conclusão, o uso de adesivo universal contendo silano aumenta a resistência de união de reparo quando comparado ao adesivo convencional. No entanto, seu uso não dispensa a aplicação prévia de silano no protocolo de reparo de resina composta direta.

Palavras-chave: Resistência à Tração. Reparação de Restauração Dentária. Restauração Dentária Permanente.

ABSTRACT

The aim of this study was to evaluate the effect of a silane-containing universal adhesive used with and without a silane agent on the repair bond strength between old and new composites. Forty blocks of nanohybrid composite resin (Z350 XT, shade A1E; 3M ESPE) were stored in distilled water for 14 days and thermo-cycled. After aging, the blocks were abrasioned with 320-grit sandpaper and etched with 37% phosphoric acid gel for 30 seconds, followed by washing and drying. Then, specimens were randomly assigned into four experimental groups: conventional adhesive system - Adper Single Bond Plus (3M ESPE) and silane-containing universal adhesive system - Scotchbond Universal Adhesive (3M ESPE) with and without previous silane (RelyX Ceramic Primer; 3M ESPE) application. After the surface treatments and adhesive protocols, the blocks were repaired with the same composite resin (Z350 XT, shade A3B; 3M ESPE). The specimens were sectioned in sticks after 24 hours of storage in distilled water and submitted to microtensile test. Ten blocks of non-aged composite resin were used as a reference group to determine the cohesive strength of the material. The obtained data were submitted to two-way Analysis of Variance and Tukey's Test. One-way Analisys of Variance and Dunnet Test were used to compare the values of cohesive strength with the bond strength values of the repaired groups ($\alpha = 0.05$). The bond strength values with Scotchbond Universal Adhesive (42.3 $\pm$ 7.4 MPa) were higher than those obtained with Adper Single Bond Plus (31.6 $\pm$ 10.0 MPa). The silane application increased the repair bond strength (with silane: 40.8 $\pm$ 9.8 MPa; without silane: 33.1$\pm$ 9.3 MPa). Repair bond strength ranged of 39.3% to 65.8% of cohesive strength of the substrate material. In conclusion, the use of universal silane-containing adhesive improves the repair bond strength of composite resin compared to conventional adhesive. However, its use does not dispense prior application of silane in the direct composite resin repair protocol.

Keywords: Tensile Strength. Dental Restoration Repair. Dental Restoration, Permanent.

SUMÁRIO

1 INTRODUÇÃO

Restaurações diretas de resina composta são amplamente realizadas na clínica odontológica para restabelecimento estético e funcional de dentes acometidos por lesão de cárie, trauma ou defeitos de desenvolvimento de esmalte. A taxa de falha anual dessas restaurações tem variado entre 0 a 4,1% e 1 a 3% para dentes permanentes anteriores (DEMARCO *et al.*, 2015) e posteriores (DEMARCO *et al.*, 2012), respectivamente. Na dentição decídua, a taxa de falha anual varia entre 4 e 18,8% (BÜCHER *et al.*, 2014; PEDROTTI *et al*., 2017). Fratura do dente e/ou da restauração e presença de lesão de cárie adjacente são os principais motivos de falhas em dentes posteriores (DEMARCO *et al.,* 2012; PEDROTTI *et al*., 2017), enquanto que motivos estéticos, como alteração de cor, forma anatômica e pigmentação, levam à reintervenção de restaurações anteriores (DEMARCO *et al.*, 2015).

A substituição da restauração tem sido a conduta comumente adotada pelos clínicos, especialmente quando a restauração está associada com fratura (GORDAN *et al.*, 2014). Já o reparo de restaurações é uma abordagem minimamente invasiva que implica em adição de um material restaurador com ou sem preparo na restauração e/ou nos tecidos dentários (HICKEL; BRÜSHAVER; ILIE, 2013). Tem sido demonstrado que o reparo pode aumentar a sobrevida das restaurações (CASAGRANDE *et al.*, 2017), minimizando as chances de tratamentos mais agressivos, como tratamento endodôntico, ou extração do elemento acometido (GORDAN *et al.*, 2014).

No entanto, não há nenhum protocolo padrão ouro para tratamento da superfície da resina composta envelhecida previamente ao reparo. Alguns tratamentos tem sido estudados, como tratamentos físicos da superfície, que tem o objetivo de melhorar a união mecânica entre a resina envelhecida e a nova (reparo), enquanto que os agentes químicos são usados visando melhorar a união entre os materiais resinosos na interface adesiva (VALENTE *et al.*, 2016).

A asperização da superfície a ser reparada com pontas diamantadas, jateamento com óxido de alumínio ou sílica e uso de silano previamente à aplicação de sistemas adesivos tem sido alvo de pesquisas nos últimos anos, tendo seus mecanismos de ação comparados entre si. Tem sido evidenciado que o jateamento parece não aumentar a resistência de união de reparo de resinas compostas

(VALENTE *et al.*, 2016). Por outro lado, a associação de tratamentos de superfície físicos e químicos parece ser benéfica no aumento da resistência de união de reparo (VALENTE *et al.*, 2016).

Silanos são moléculas organofuncionais que promovem a união entre dois materiais. Em procedimentos de reparo, essa molécula promove a união da fase inorgânica do substrato com a fase orgânica da resina do reparo (ÇAKIR *et al.*, 2018). Além disso, os silanos possuem maior capacidade de molhamento, facilitando a penetração do adesivo nos defeitos da superfície da resina composta (BRENDEKE; OZCAN, 2007). Assim, os silanos poderiam ser efetivos no aumento da resistência de união em reparos. Todavia, ainda não está elucidado na literatura seu efeito na resistência de união de reparo de resinas compostas (VALENTE *et al.*, 2016).

Estudos recentes sobre protocolos de reparo (ELIASSON; DAHL, 2017; FORNAZARI *et al.*, 2017) tem investigado a utilização de sistemas adesivos atuais que contém silano na composição, como o Single Bond Universal (3M ESPE). Seu uso no protocolo de reparo parece promissor, uma vez que visa a simplificação da técnica, com redução do número de passos operatórios e tempo clínico. Todavia, os resultados obtidos na literatura ainda não são consensuais. Enquanto um estudo demonstrou que o uso de adesivo contendo silano dispensa a aplicação prévia de silano (FORNAZARI *et al.*, 2017), o outro reportou que o uso de silano aumenta a resistência de união de reparo de resina composta mesmo quando da utilização de adesivo contendo silano (ELIASSON; DAHL, 2017). Sendo assim, parece relevante a realização de um estudo que investigue o efeito de um sistema adesivo universal contendo silano com e sem aplicação prévia de silano na resistência de união de reparo de resina composta.

2 ARTIGO CIENTÍFICO

Does use of silane-containing universal adhesive eliminate the silane application for direct composite repair?

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Abstract

Purpose: To evaluate the effect of a silane-containing universal adhesive used with and without a silane agent on the repair bond strength between old and new composites. **Materials and Methods:** Forty blocks of nanohybrid composite resin (Z350 XT) were stored in distilled water for 14 days and thermo-cycled. Sandpaper ground, etched and rinsed specimens were randomly assigned into four experimental groups: Adper Single Bond Plus and Scotchbond Universal Adhesive with and without previous silane (RelyX Ceramic Primer) application. Blocks were repaired with the same composite. After 24h of water storage, the blocks were sectioned and bonded sticks were subjected to microtensile testing. Ten fresh and non-repaired composite blocks were used as reference group to evaluate the cohesive strength of composite. The μTBS means were analyzed by two-way ANOVA and Tukey's tests. One-way ANOVA and Dunnet *post-hoc* tests were used to compare the cohesive strength values and bond strength obtained in repaired groups ($\alpha = 0.05$). **Results:** The μTBS values obtained for Scotchbond Universal Adhesive were higher than those obtained for Adper Single Bond Plus. Silane application improved the repair bond strength. Repair bond strength ranged of 39.3% to 65.8% of cohesive strength of the substrate material. **Conclusion:** Use of a silane-containing universal adhesive does not dispense the application of a silane agent in the protocol for direct composite repair.

Keywords: aged surface; composite repair; silane; universal adhesive.

Introduction

The management of failed restorations usually includes replacement of the entire restoration, while repair involves partial removal of defective restoration, followed by restoration of the prepared defect[12]. It is not obvious in which clinical situation one must choose repair or replacement of defective restorations[19,20]. Nevertheless, the current evidence suggests that the repair should be preferable, whenever possible, rather than restoration replacement in order to preserve more dental structure and reduce treatment costs[13].

While most dentists state to perform repair, and this approach has been adopted by most dental schools, the proportion of truly repaired restorations is still low[14]. Although the repair may increase the survival of restorations placed in both primary and permanent teeth[5,18], there is no gold standard protocol or materials established for treating the aged composite surfaces before repair.

Successful repair procedure requires a durable bond between the old restoration and the new composite resin. New composite can possibly be retained to aged composite either through micromechanical interlocking to irregularities in the prepared surface or through chemical bonding to the filler particles and the organic matrix[21]. A recent systematic review showed that application of silane coupling agents and adhesives play a role in improving the repair bond strength when physical treatments such as the use of burs are applied to the aged composite[21].

Silanising agent has been incorporated in adhesive systems such as Scotchbond Universal Adhesive (3M ESPE, St. Paul, EUA). In this sense, the use of a silane-containing universal adhesive could eliminate the need to apply silane as a separate step in the clinical protocol for composite repair. Evidence about effect of a silane-containing universal adhesive associated or not with a silane agent on the repair bond strength of composite is limited and the results are contradictory[8,11].

This study therefore sought to evaluate the effect of a silane-containing universal adhesive used with and without a silane agent on the repair bond strength between old and new composites.

Materials and Methods

For this study, a silane coupling agent (RelyX Ceramic Primer, 3M ESPE, St. Paul, MN, USA) and two adhesive systems were tested: a two-step etch-and-rinse adhesive system (Adper Single Bond Plus, 3M ESPE, St. Paul, MN, USA), and a silane-containing universal adhesive system (Scotchbond Universal Adhesive, 3M ESPE, St. Paul, MN, USA). The nanohybrid composite resin (Filtek Z250 XT, 3M ESPE, St. Paul, MN, USA) was used in the A1E and A3B shades. A detailed description of the materials is presented in Table 1.

Preparation of aged composite blocks

A total of 40 blocks of composite resin (Z350 XT, A1 shade; 3M ESPE, St. Paul, MN, USA) measuring 8x8 mm with 4 mm height were fabricated using a metallic mold (8x8x8 mm). The mold was fixed on a glass slab and composite was packed into the mold in two increments and light cured for 20 seconds each with a light emitting diode curing unit (Radii-cal; SDI, Victoria, AUS) with a light output of at least 1250 mW/cm^2. Light intensity output was monitored with a Demetron Curing Radiometer (Kerr, Orange, CA, USA). The composite was carefully condensed with a clean filling instrument in order to avoid contamination and/or entrapment of voids.

After setting, composites were gently removed from the mold and the thickness of each block was confirmed with a digital caliper (Absolute Digimatic, Mitutoyo, Tokyo, Japan). The specimens were stored in distilled water at 37°C for 14 days[7] previously to aging. The blocks were further aged by thermal cycling 5000 times between 5°C and 55°C, with a dwell time of 20 seconds and transfer time of 3 seconds[7]. The aged surfaces of the specimens were wet-ground with 320-grit silicon carbide grinding paper for 5 seconds in order to remove the superficial resin-rich layer and create standardized repair surfaces[1,7]. The surfaces of all the specimens were then etched with 37% phosphoric acid for 30 seconds, washed with air/water spray for 60 seconds, and dried with a blast of air for 60 seconds[11].

Bonding procedures

The 40 aged blocks were randomly assigned (Random Allocation software, Iran, version 1.0) into four experimental groups (n=10) according to repair protocol: silane + Adper Single Bond Plus, Adper Single Bond Plus, silane + Scotchbond Universal Adhesive and Scotchbond Universal Adhesive. All materials were applied according to the manufacturer's recommendations (Table 1).

The aged composite blocks were carefully placed over the original mold and then repaired using composite resin (Z350 XT, A3B shade; 3M ESPE, St. Paul, MN, USA), in two incremental layers light cured for 20 seconds each, the same way as the original specimens, resulting in 8-mm high specimens. Specimens were stored in distilled water at 37º C for 24 h. A single trained operator carried out all procedures.

*Microtensile bond strength (*µTBS)

To guarantee the blinding of the operator of the testing machine, each composite block was numbered according to the sequence of the randomization. Blocks were sectioned in sticks with a cross-sectional area of approximately 0.8 mm^2 using a water-cooled diamond saw in a cutting machine (Isomet, Buehler, Lake Bluff, IL, EUA). The cross-sectional area of each stick was measured with a digital caliper (Absolute Digimatic, Mitutoyo, Tokyo, Japan) to calculate the bond strength values (in MPa). The sticks were carefully examined with a stereomicroscope (HMV-2, Shimadzu Corp., Kyoto, Japan) at 40× magnification and those interfacial flaws, gaps, bubbles, or other defects were discarded. The bonded sticks were attached to a device for microtensile testing with cyanoacrylate resin and subjected to the microtensile test on a universal testing machine (EZ-SX series, Shimadzu Corp., Kyoto, Japan) at a crosshead speed of 1mm/min. The µTBS (MPa) was obtained by dividing the load at failure (N) by the cross-sectional area (mm^2) of each stick.

Failure mode

The fracture surfaces were examined under a stereomicroscope (HMV-2, Shimadzu Corp., Kyoto, Japan) at 40× magnification to determine if the failure region was within the adhesive zone or out of it. The adhesive zone was defined as the

interphase between the old and the new composite. The failures were reported as cohesive or adhesive. Fracture in the adhesive zone was classified as adhesive failure. A blind examiner to experimental groups evaluated the failure mode.

Cohesive strength of non-aged composite – Reference group

Ten blocks of composite resin (Z350 XT, A1E shade; 3M ESPE, St. Paul, MN, USA) measuring 8x8 mm with 8 mm height were fabricated using a metallic mold. The mold was fixed on a glass slab and composite was packed into the mold in four increments and light cured for 20 seconds each with a light emitting diode curing unit. After the insertion of the last increment, the Mylar strip were pressed down over the mold and left for 30 seconds, and the specimen was light-cured through the strip. The thickness of each specimen was also measured with a digital caliper. Specimens were stored in distilled water at 37°C for 24 hours and then prepared to be subject to tensile test. Figure 1 summarizes the experimental design.

Statistical Analysis

The experimental unit in the current study was the resin block. Thus, the mean of the μTBS values of all of the sticks from the same block were averaged for statistical analysis. The μTBS means for every test group was expressed as the mean of the ten blocks used per group. The sample size of ten blocks per group was estimated previously considering an 80% power, a coefficient of variation of 20% and assuming a two-sided 5% significance level for comparisons.

The normal distribution of the data was confirmed using Kolmogorov-Smirnov test. The μTBS means were analyzed by two-way ANOVA and Tukey's *post hoc* tests. One-way ANOVA and Dunnet *post-hoc* tests were used to compare the cohesive strength values and bond strength obtained in repaired groups. The significance level was set at $p<0.05$. Statistical analyses were performed using the Minitab18 software (Minitab Inc., State College, PA, USA).

Results

The microtensile bond strength means (MPa), standard deviations, and distribution of the failure mode for all experimental groups are shown in Table 2. Only the main factors “adhesive system” (p=0.002) and “silane coupling agent” (p=0.03) were statistically significant.

The μTBS values obtained for Scotchbond Universal Adhesive (42.3 ± 7.4 MPa) were higher than those obtained for Adper Single Bond Plus (31.6 ± 10.0 MPa). Previous silane application improved the repair bond strength (with silane: 40.8 ± 9.8 MPa; without silane: 33.1± 9.3 MPa). Cohesive strength values of non-aged specimens (69.9 ± 17.8 MPa) were highest than bond strength obtained in all repaired groups (p=0.000). Repair bond strength ranged of 39.3% to 65.8% of cohesive strength of the substrate material.

Discussion

Both silane coupling agents and adhesive systems seem have a role for establishing adequate bond strength between the existing composite and the new composite[21]. Considering the “universal application” idea behind these contemporary all-in-one adhesives, use of a silane-containing universal adhesive for composite repair would simplify the clinical protocol, reducing chair time and operatory errors. In our study, silane-containing universal adhesive produced higher repair bond strength values in comparison with conventional adhesive system.

Scotchbond Universal Adhesive contains 10-MDP as functional monomer that can chemically bond to zirconia surface[2]. Considering the zirconia content of fillers in Z350 XT, it could be assumed that 10-MDP monomer would be beneficial for the promotion of the repair bond strength by providing additional chemical bonding. However, silane application as a separate step improved the repair bond strength, irrespective of the adhesive.

Removing the superficial layer from an old composite and roughening with diamond bur are necessary to obtain micromechanical retention. In laboratory studies, the standardized surface roughness is obtained by the use of 320-grit silicon carbide grinding paper, simulating roughness obtained with a medium diamond

bur[1,7]. This physical treatment is able to dissolve or remove the polymer matrix covering the glass fibers or particles, creating a proper scenario for silane coupling agents to interact with silica. The degradation of dental composites upon storage can also break filler-polymer bonds, allowing surface loss of glass particles[10]. Although there is currently no consensus on an aging method completely imitating the clinical conditions, in our study, composite resin was aged by water storage for 14 days followed by thermocycling (5000 cycles)[7].

Silane coupling agents promote chemical bonding by forming siloxane bonds between silicate-containing filler particles exposed on the repair surface and the resin matrix of fresh resin layer[4]. Additionally, silanes have a higher surface wettability, facilitating the penetration of the adhesive into surface defects[3], improving the repair bond strength. Scotchbond Universal adhesive contains prehydrolyzed silane, claimed by the manufacturer to be stable up to at least one year in storage. However, amount of silane in its composition (data not informed by manufacturer) may be not sufficient to improve the repair bond strength.

A previous study[9] also found that silane surface treatment increased microtensile repair bond strength when using Scothbond Universal Adhesive. Conversely, other study[11] reported that silane-containing universal adhesive on its own was as effective as any combination of silane and adhesive. It is important to highlight that in the latter, methodological differences related to bond strength test (microshear versus microtensile) and type of composite resin (nanofilled versus nanohybrid) may be explain contradictory findings with our study. Differently of the composite resin Z350XT, Filtek Supreme Ultra Restorative composite (3M ESPE) contains silane-treated ceramic, silane-treated silica and silane-treated zirconia. It has been reported that incorporation of silanized filler particles in the resin matrix improves the physical and mechanical properties of resin composites in terms of mechanical strength and hydrolytic stability[16] and it may have an influence in the surface treatment for repair.

Repair strength is force measured when the specimens fracture. If large percentage of specimens is cohesively fractured, little or no conclusion can be drawn from the results on repair strength. In our study, the majority of the failures were adhesive for all experimental groups. We used the cohesive strength of the non-aged composite as a reference for the desired or optimal repair strength. It is unrealistic to reach the cohesive strength of new material, since composite gradually

loses strength as it ages[9]. Repair bond strength ranged of 39.3% to 65.8% of cohesive strength of the substrate material, being the association of silane with silane-containing universal adhesive the repair protocol that provided bond strength closer to the cohesive strength of the substrate composite. Thus, the probability of failures at the composite–repair interface such as fractures could be minimized.

It is relevant to emphasize that in most clinical situations, repair procedure of direct composite involves dental structure. It has been evidenced satisfactory bonding of the Scotchbond Universal Adhesive to dental substrates[6]. Therefore, the bonding of the silane-containing universal adhesive to enamel and dentin could help to ensure effective adhesion between old and new composite, minimizing the need for prior application of silane to composite surface.

The possibility of obtaining chemical bond to a composite substrate decreases slowly over time due to post-curing and water uptake, leading to hydrolysis of available double bonds, leaving few carboxyl groups for chemical bonding to new composite[15]. Furthermore, one-bottle prehydrolyzed silane solutions, such as RelyX Ceramic Primer, have a relatively short shelf life and gradually become less reactive after opening of the bottle, preventing optimal adhesion[17]. Further studies evaluating the effect of use of silane as pretreatment or incorporated to adhesive on the durability of repair procedures are necessary in order to consolidate the recommendation of a universally applicable repair protocol.

Conclusion

Use of a silane-containing universal adhesive improves the repair bond strength between old and new composites compared to conventional adhesive. However, it does not dispense the application of a silane agent in the protocol for direct composite repair.

Clinical relevance

Clinicians should use silane coupling agent plus silane-containing universal adhesive for repair of direct composite restorations not involving dental structure.

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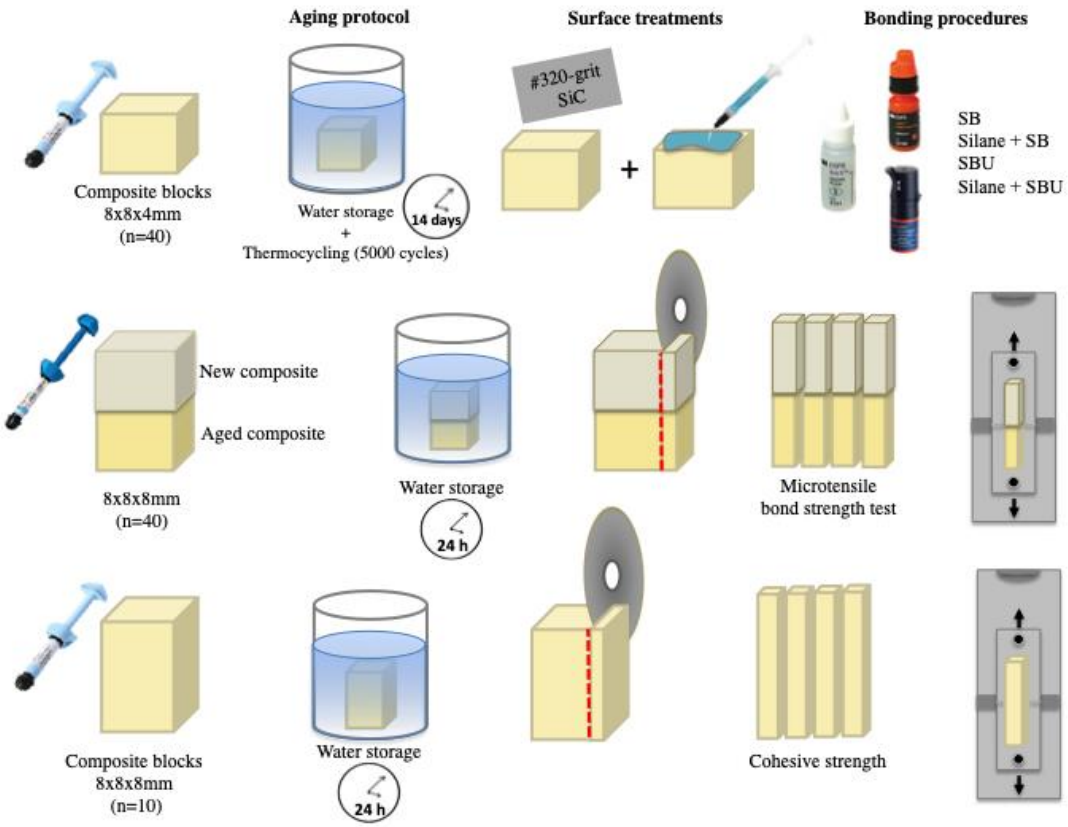

Figure 1. Experimental design of the study.

Abbreviations: SB: Adper Single Bond Plus, SBU: Scotchbond Universal Adhesive.

Table 1. Composition and application mode of the materials tested.

Material	*Main components*	*Application mode*
RelyX Ceramic Primer (3M ESPE, St. Paul, MN, USA) #Batch number 1720700505	Methacryloxypropyl trimethoxysilane; water; ethyl alcohol 3-(trimetoxysilyl methacrylate)	Apply one coat of silane Gently air dry for 5 s
Scotchbond Universal Adhesive (3M ESPE, St. Paul, MN, USA) #Batch number 1809600708	Etchant: 37% phosphoric acid, MDP phosphate monomer, dimethacrylate resins, HEMA, methacrylate-modified polyalkenoic acid copolymer, filler, ethanol, water, initiators, silane	Apply the adhesive for 20 s with vigorous agitation Gentle air thin for 5 s Light-cure for 10 s
Adper Single Bond Plus (3M ESPE, St. Paul, MN, USA) #Batch number 1812300361	Etchant : 37% phosphoric acid HEMA, water, ethanol, Bis-GMA, dimethacrylates, amines, metacrylate-functional copolymer of polyacrylic and polyitaconic acids, 10% by weight of 5 nanometer-diameter spherical silica particles	Apply 2 consecutive coats of adhesive for 15 s with gentle agitation Gently air dry for 5 s Light-cure for 10 s
Z350 XT A1E e A3B Shades (3M ESPE, St. Paul, MN, USA) #Batch numbers 1729300455, 1732800739	Bis-GMA, UDMA, TEGDMA, Bis-EMA, non-agglomerated/non-aggregated 20 nm silica filler, non-agglomerated/non-aggregated 4 to 11 nm zirconia filler, and aggregated zirconia/silica cluster filler	Insert the composite in 2 mm increments Light-cure for 20 s

Abbreviations: MDP: 10-methacryloyloxydecyl-dihydrogen-phosphate; Bis-GMA: bisphenyl-glycidyl methacrylate; HEMA: 2-hydroxyethyl methacrylate ; TEGDMA: triethylene glycol dimethacrylate; Bis-EMA: ethoxylated bisphenol-A dimethacrylate; UDMA: urethane dimethacrylate

Table 2. The microtensile bond strength means (MPa), standard deviations, and distribution of the failure mode for all experimental groups.

		Failure mode	
Experimental groups	**Bond strength**	**Adhesive**	**Cohesive**
Adper Single Bond Plus	27.5 ± 10.5	90.6%	9.4%
Silane + Adper Single Bond Plus	35.7 ± 3.7	87.7%	12.3%
Scotchbond Universal Adhesive	38.7 ± 10.5	93.7%	6.3%
Silane + Scotchbond Universal Adhesive	46.0 ± 8.4	83.0%	17.0%

3 CONCLUSÃO

Considerando a ideia de “aplicação universal” dos sistemas adesivos atuais de frasco único disponíveis no mercado, o uso de um adesivo universal contendo silano poderia simplificar o protocolo de reparo de resina composta direta, reduzindo tempo clínico e erros operatórios. Com base nos resultados do presente estudo, o uso de adesivo contendo silano aumenta a resistência de união de reparo quando comparado ao adesivo convencional. Entretanto, seu uso não dispensa a aplicação prévia de silano no protocolo de reparo de resina composta direta.

É importante enfatizar que em muitas situações clínicas, os procedimentos de reparo de resina composta envolvem estrutura dentária. Tem sido evidenciada satisfatória adesão do sistema adesivo universal testado (Single Bond Universal; 3M ESPE) aos substratos dentais (CUEVAS-SUÁREZ *et al.*, 2019). Sendo assim, a adesão do adesivo universal contendo silano ao esmalte e dentina poderia auxiliar na promoção de efetiva adesão entre as resinas compostas envelhecida e nova, minimizando a necessidade de aplicação prévia do silano. Estudos clínicos futuros são necessários para consolidar a recomendação de um protocolo para reparo de resina composta direta.

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ANEXO A – Aprovação da COMPESQ

Projeto de Pesquisa na Comissão de Pesquisa de Odontologia

rodrigoarthur.ufrgs@gmail.com
Qua 10/10/2018, 19:28
Para: tathilenzi@hotmail.com <tathilenzi@hotmail.com>

Prezado Pesquisador Tathiane Larissa Lenzi,

Informamos que o projeto de pesquisa O USO DE ADESIVO CONTENDO SILANO AUMENTA A RESISTENCIA DE UNIAO DE REPARO DE RESINA COMPOSTA ENVELHECIDA? encaminhado para análise em 13/09/2018 foi aprovado quanto ao mérito pela Comissão de Pesquisa de Odontologia com o seguinte parecer:

O presente trabalho visa avaliar a influência de um sistema adesivo contendo silano na resistência de união de reparo de resina composta envelhecida. Para isso, 50 corpos de prova (8 mm x 8 mm x 8mm) de resina composta (Z350 XT, 3M ESPE) serão divididos aleatoriamente em 5 grupos experimentais: controle negativo (nenhum tratamento de superfície químico), silano + adesivo convencional (Adper Single Bond 2, EM ESPE), adesivo convencional, silano + adesivo contendo silano (Single Bond Universal, 3M ESPE) e adesivo contendo silano. Os corpos de prova serão submetidos a envelhecimento por meio de ciclagem térmica (5000 ciclos de imersão em água destilada a 5o e 55o C) e abrasionados com lixa de granulação 320 para simular a asperização da superfície com ponta diamantada. Após os tratamentos de superfície, os corpos de prova serão reparados com resina composta (Z350 XT, 3M ESPE). Após 24 horas de armazenamento em água destilada, os corpos de prova serão seccionados para obtenção de espécimes com área de secção transversal de aproximadamente 1mm2. Metade dos espécimes serão submetidos imediatamente ao teste de microtração e a outra metade após 6 meses de armazenamento em água destilada a 37o
C. Adicionalmente, 10
corpos de prova (8mm x 8mm x 8mm) serão confeccionados para serem submetidos ao ensaio de tração (ultimate tensile strength) após 24 horas de armazenamento em água destilada ? grupo controle positivo (resistência coesiva). Os dados obtidos serão submetidos à análise estatística apropriada.

O projeto apresenta-se bem delineado e o parecer dessa comissão é favorável à aprovação.

Devido as suas características este projeto foi encaminhado nesta data para avaliação por .

Atenciosamente, Comissão de Pesquisa de Odontologia

ANEXO B – Normas do periódico The Journal of Adhesive Dentistry

The Journal of Adhesive Dentistry

GUIDELINES FOR AUTHORS

The Journal of Adhesive Dentistry is a bi-monthly journal that publishes scientifically sound articles of interest to practitioners and researchers in the field of adhesion to hard and soft dental tissues. The Journal publishes several types of peer-reviewed original articles:

1. ***Clinical and basic science research reports*** – based on original research in adhesive dentistry and related topics.
2. ***Reviews topics*** – on topics related to adhesive dentistry
3. ***Short communications*** – of original research in ad-hesive dentistry and related topics. Max. 4 printed pages, including figures and references (max. characters 18,000). High priority will be given to the review of these papers to speed publication.

4a. ***Invited focus articles*** – presenting a position or hypothesis on a basic science or clinical subject of relevant related topics. These articles are not intended for the presentation of original results, and the authors of the articles are selected by the Editorial Board.

4b. ***Invited commentaries*** – critiquing a focus article by addressing the strong and weak points of the focus article. These are selected by the Editorial Board in consultation with the focus article author, and the focus article and the commentaries on it are published in sequence in the same issue of the Journal.

5. ***Invited guest editorials*** – may periodically be solicited by the Editorial Board.
6. ***Proceedings of symposia, workshops, or conferences*** – covering topics of relevance to adhesive dentistry and related topics.
7. ***Letters to the Editor*** – may be submitted to the editor-in-chief; these should normally be no more than 500 words in length.

SUBMISSION INSTRUCTIONS

Submission of manuscripts in order of preference:

Submission via online submission service (www.manuscriptmanager.com/jadd). Manuscript texts should be uploaded as PC-word files with tables and figures preferably embedded within the PC-word document. A broad range of file formats are acceptable. No paper version required but high resolution photographs or illustrations should be sent to the editorial office (see below). Online submissions are automatically uploaded into the editorial office's reviewer assignment schedule and are therefore processed immediately upon upload.

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The Journal of Adhesive Dentistry
Ifenpfad 2–4, D–12107 Berlin, Germany

Illustrations that cannot be sent electronically will be scanned at the editorial office so that they can be sent to reviewers via e-mail along with the manuscript to expedite the evaluation process.
Resubmitted manuscripts should also be submitted in the above manner. Please note that supplying electronic versions of your tables and illustrations upon resubmission will assure a faster publication time if the manuscript is accepted.

Review/editing of manuscripts. Manuscripts will be reviewed by the editor-in-chief and at least two reviewers with expertise within the scope of the article. The publisher reserves the right to edit accepted manuscripts to fit the space available and to ensure conciseness, clarity, and stylistic consistency, subject to the author's final approval.
Adherence to guidelines. Manuscripts that are not prepared in accordance with these guidelines will be returned to the author before review.

MANUSCRIPT PREPARATION

- The Journal will follow as much as possible the recommendations of the International Committee of Medical Journal Editors (Vancouver Group) in regard to preparation of manuscripts and authorship (Uniform requirements for manuscripts submitted to biomedical journals. Ann Intern Med 1997;126: 36-47).
- **Title page.** The first page should include the title of the article (descriptive but as concise as possible) and the name, degrees, job title, professional affiliation, contribution to the paper (e.g., idea, hypothesis, experimental design, performed the experiments in partial fulfillment of requirements for a degree, wrote the manuscript, proofread the manuscript, performed a certain test, consulted on and performed statistical evaluation, contributed substantially to discussion, etc.) and full address of all authors. Phone, fax, and e-mail address must also be provided for the corresponding author, who will be assumed to be the first listed author unless otherwise noted. If the paper was presented before an organized group, the name of the organization, location, and date should be included.
- **3-8 keywords.**
- **Structured abstract.** Include a maximum 250-word structured abstract (with headings *Purpose, Materials and Methods, Results, Conclusion*).
- **Introduction.** Summarize the rationale and purpose of the study, giving only pertinent references. Clearly state the working hypothesis.
- **Materials and Methods.** Present materials and methods in sufficient detail to allow confirmation of the observations. Published methods should be referenced and discussed only briefly, unless modifications have been made. Indicate the statistical methods used, if applicable.
- **Results.** Present results in a logical sequence in the text, tables, and illustrations. Do not repeat in the text all the data in the tables or illustrations; emphasize only important observations.
- **Discussion.** Emphasize the new and important aspects of the study and the conclusions that follow from them. Do not repeat in detail data or other material given in the Introduction or Results section. Relate observations to other relevant studies and point out the implications of the findings and their limitations.
- **Acknowledgments.** Acknowledge persons who have made substantive contributions to the study. Specify grant or other financial support, citing the name of the supporting organization and grant number.
- **Abbreviations.** The full term for which an abbreviation stands should precede its first use in the text unless it is a standard unit of measurement.
- **Trade names.** Generic terms are to be used whenever possible, but trade names and manufacturer should be included parenthetically at first mention.
- **Clinical Relevance.** Please include a very brief (2 sentences or 3 lines) clinical relevance statement.

REFERENCES

- **All references must be cited** in the text, according to the alphabetical and numerical reference list.
- **The reference list** should appear at the end of the article, in alphabetical and numerical sequence.
- **Do not include unpublished data** or personal communications in the reference list. Cite such references parenthetically in the text and include a date.
- **Avoid using abstracts** as references.
- **Provide complete information** for each reference, including names of all authors. If the reference is part of a book, also include title of the chapter and names of the book's editor(s).

Journal reference style:

1. Turp JC, Kowalski CJ, Stohler CS. Treatment-seeking patters of facial pain patients: Many possibilities, limited satisfaction. J Orofacial Pain 1998;12:61–66.

Book reference style:

1. Hannam AG, Langenbach GEJ, Peck CC. Computer simulations of jaw biomechanics. In: McNeill C (ed). Science and Practice of Occlusion. Chicago: Quintessence, 1997:187–194.

ILLUSTRATIONS

- All illustrations must be numbered and cited in the text in order of appearance.
- Submitted figures should meet the following minimum requirements:
  – High-resolution images should have a width of 83 mm and 300 dpi (for column size).
  – Graphics (bar diagrams, schematic representations, drawings) wherever possible should be produced in Adobe Illustrator and saved as AI or EPS files.
  – All figures and graphics should be separate files – not embedded in Word or Power Point documents.

Upon article acceptance, high-resolution digital image files must be sent via one of the following ways:

1. As an e-mail attachment, if the files are not excessively large (not more than 10 MB), to our production department
2. Online File Exchange Tool: Please send your figures with our Online File Exchange Tool. This web tool allows you to upload large files (< 500 MB) to our server. Please archive your figures with a maximum size of 500 MB first. Then upload these archives with the following link: http://files.qvnet.de/JAD/, password: IAAD. Please name the archive with your name and article number so we can identify the figures.

Line drawings – Figures, charts, and graphs should be professionally drawn and lettered large enough to be read after reduction. Good-quality computer-generated laser prints are acceptable (no photocopies); also provide electronic files (eps, ai) if possible. Lines within graphs should be of a single weight unless special emphasis is needed.
Legends – Figure legends should be grouped on a separate sheet and typed double-spaced.

TABLES

- Each table should be logically organized, on a separate sheet, and numbered consecutively.
- The title and footnotes should be typed on the same sheet as the table.

MANDATORY SUBMISSION FORM

The Mandatory Submission Form, signed by all authors, must accompany all submitted manuscripts before they can be reviewed for publication. Electronic submission: scan the signed form and submit as JPG, TIF or PDF file.

PERMISSIONS & WAIVERS

- Permission of author and publisher must be obtained for the direct use of material (text, photos, drawings) under copyright that does not belong to the author.
- Waivers must be obtained for photographs showing persons. When such waivers are not supplied, faces will be masked to prevent identification. For clinical studies the approval of the ethics committee must be presented.

PAGE CHARGE

The first 8 printed pages in an article are free of charge. For excess pages, the charge is €140 per printed page. The approximate number of characters on a printed page is approximately 6,800. Please also consider the number and size of illustrations.

Fonte: The Journal Of Adhesive Dentistry ([201-]).