UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
FACULDADE DE ODONTOLOGIA

CASSIANE GONÇALVES DE OLIVEIRA DA SILVA

REPARO DE RESTAURAÇÕES DE CIMENTO IONÔMERO DE VIDRO MODIFICADO POR RESINA ENCAPSULADO: ESTUDO *IN VITRO*

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

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RESUMO

O objetivo deste estudo foi avaliar a resistência de união do reparo de restaurações com cimento ionômero de vidro modificado por resina encapsulado reparadas com o mesmo material ou com resina composta. Vinte e quatro blocos (8 x 8 x 4 mm) de cimento ionômero de vidro modificado por resina encapsulado (Riva Light Cure, cor A1, SDI, Bayswater, Vitória, Austrália) foram submetidos a envelhecimento por meio de armazenamento em água destilada a 37°C por 14 dias, seguido de ciclagem térmica (5.000 ciclos). Após o envelhecimento, os blocos foram abrasionados com lixa de granulação #320 por 5 segundos e divididos aleatoriamente de acordo com o protocolo de reparo: cimento ionômero de vidro modificado por resina encapsulado (Riva Light Cure, cor A3, SDI, Bayswater, Vitória, Austrália), sistema adesivo universal (Single Bond Universal, 3M Oral Care, Saint Paul, Minnesota, EUA) no modo convencional + resina composta (Filtek Z350 XT, cor A3, 3M Oral Care, Saint Paul, Minnesota, EUA), sistema adesivo universal (Single Bond Universal, 3M Oral Care, Saint Paul, Minnesota, EUA) no modo autocondicionante + resina composta (Filtek Z350 XT, cor A3, 3M Oral Care, Saint Paul, Minnesota, EUA). Após 24 horas de armazenamento em água destilada a 37º C, os blocos reparados (8 x 8 x 8 mm) foram seccionados em palitos com área de secção transversal de aproximadamente 0,8 mm^2. Os espécimes foram submetidos imediatamente ao teste de microtração e o padrão de fratura foi avaliado em estereomicroscópio com aumento de 40x. Os dados obtidos foram submetidos à Análise de Variância de um fator e teste de Tukey (α=0,05). O padrão de fratura foi analisado descritivamente**.** Os maiores valores de resistência de união foram obtidos quando o cimento de ionômero de vidro modificado por resina foi reparado com o mesmo material (34,6 ± 7,3 MPa). Além disso, o modo de aplicação do sistema adesivo universal influenciou na resistência de união do reparo. Maiores valores de resistência de união foram observados quando o adesivo universal foi usado no modo convencional (21,2 ± 7,7 MPa) em comparação ao modo autocondicionante (11,6 ± 4,5 MPa) ($p<0,001$). Fraturas adesivas/mistas prevaleceram em todos os grupos. Em conclusão, o reparo de restaurações de cimento de ionômero de vidro modificado por resina encapsulado com o mesmo material parece ser a melhor opção para aumentar a resistência de união.

Palavras-chave: Cimentos de Ionômeros de Vidro. Reparação de Restauração Dentária. Resinas Compostas. Resistência à Tração.

ABSTRACT

The aim of this study was to evaluate the repair bond strength of encapsulated resin-modified glass ionomer cement restorations repaired with the same material or with resin composite. Twenty-four blocks (8 x 8 x 4 mm) of encapsulated resin-modified glass ionomer cement (Riva Light Cure, A1 shade, SDI, Bayswater, Victoria, Australia) were stored in distilled water at 37°C for 14 days, followed by thermal cycling (5,000 cycles). After aging, the blocks were abrasioned with #320-grit sandpaper for 5 s and randomly assigned according to the repair protocol: encapsulated resin-modified glass ionomer cement (Riva Light Cure, A3 shade, SDI, Bayswater, Vitória, Australia), universal adhesive system (Scotchbond Universal Adhesive, 3M Oral Care, Saint Paul, Minnesota, USA) in etch-and-rinse mode + resin composite (Filtek Z350 XT, A3 shade, 3M Oral Care, Saint Paul, Minnesota, USA), universal adhesive system (Scotchbond Universal Adhesive, 3M Oral Care, Saint Paul, Minnesota, USA) in self-etch mode + resin composite (Filtek Z350 XT, A3 shade, 3M Oral Care, Saint Paul, Minnesota, USA). After 24 h of storage in distilled water at 37°C, the repaired blocks (8 x 8 x 8 mm) were sectioned into sticks with a cross-sectional area of approximately 0.8 mm^2. The specimens were immediately subjected to the microtensile test and the fracture pattern was evaluated in a stereomicroscope at 40x magnification. The data obtained were submitted to One-way Analysis of Variance and Tukey's test (α=0.05). The fracture pattern was analyzed descriptively. The highest bond strength values were obtained when the resin-modified glass ionomer cement was repaired with the same material (34.6 ± 7.3 MPa). Moreover, the application mode of the universal adhesive system influenced on the repair bond strength. Higher bond strenght values were observed when the universal adhesive was used in the etch-and-rinse mode (21.2 ± 7.7 MPa) in comparison with self-etch mode (11.6 ± 4.5 MPa) ($p < 0.001$). Adhesive/mixed fractures prevailed in all groups. In conclusion, the repair of encapsulated resin-modified glass ionomers restorations with the same material appears to be the preferred option to improve bond strength.

Keywords: Glass Ionomer Cements. Dental Restoration Repair. Composite Resins. Tensile Strength.

SUMÁRIO

1 INTRODUÇÃO

Lesões de cárie cavitadas na dentição decídua representam um problema global que ainda afeta milhões de crianças (URIBE; INNES; MALDUPA, 2021). Procedimentos restauradores são realizados como parte do tratamento da doença cárie, auxiliando no controle de biofilme e restabelecendo a integridade dental, sendo possível recuperar função e estética de maneira conservadora (SCHWENDICKE *et al.,* 2016).

A literatura não é unanime ao afirmar qual é o melhor ou mais indicado material restaurador para ser utilizado no tratamento de lesões de cárie na dentição decídua (YENGOPAL *et al.*, 2016). Nesse sentido, a escolha do material a ser utilizado depende, entre outros fatores, da exigência estética dos pais, do comportamento do paciente, do controle de umidade, do tipo de cavidade a ser restaurada e das preferências do operador (WAGGONER, 2015; PIRES *et al.*, 2018).

Materiais adesivos têm sido amplamente utilizados em Odontopediatria uma vez que possibilitam a realização de preparos cavitários conservadores, preservando estrutura dentária (INNES *et al.*, 2016), além de resultarem em estética satisfatória. O cimento de ionômero de vidro apresenta boas propriedades, como coeficiente de expansão térmica similar aos dentes, capacidade de liberação e reincorporação de fluoretos e biocompatibilidade (HATTAB; AMIN, 2001; PASCHOAL *et al.,* 2011), sendo um material restaurador bem aceito e extensamente utilizado pelos profissionais (BURKLE *et al.,* 2005).

Entretanto, a literatura tem demonstrado que o cimento de ionômero de vidro convencional, quando comparado a outros materiais restauradores, apresenta um maior risco de falha de restaurações oclusais e ocluso-proximais em dentes decíduos (PIRES *et al.*, 2018), devido especialmente a uma menor resistência mecânica. Neste sentido, cimentos de ionômero de vidro modificado por resina foram desenvolvidos, apresentando modificações na sua composição com o intuito de melhorar suas propriedades físicas e minimizar possíveis falhas (CROLL *et al.,* 2002). Ademais, versões encapsuladas do material estão disponíveis com o intuito de eliminar erros de proporcionamento e manipulação do pó e líquido pelo operador (NOMOTO *et al.*, 2004).

Tem sido evidenciado que o cimento de ionômero de vidro modificado por resina apresenta comportamento similar ao compômero, amálgama e resina composta (PIRES *et al.*, 2018), sendo uma opção viável para restaurar dentes decíduos. A taxa de falha de restaurações de cimento de ionômero de vidro modificado por resina em dentes decíduos varia de 0,6 a 16,9% (CHISINI *et al.,* 2018). Falhas decorrentes de fratura e perda parcial ou total do material tem sido observadas (QVIST; MANASCHER; TEGLERS, 2004).

Frente à necessidade de reintervenção, os clínicos podem optar pela substituição ou reparo. O reparo é uma abordagem minimamente invasiva que implica adição de um material restaurador, com ou sem preparo da restauração ou da estrutura dentária (HICKEL *et al*., 2013). Embora tenha sido tradicionalmente considerado como "*bad dentistry*", atualmente o reparo é considerado como "estado de arte". Isso porque reparo pode aumentar a sobrevida das restaurações (RUIZ *et al*., 2019; CASAGRANDE *et al.*, 2017), preservando estrutura dentária e minimizando o risco de complicações pulpares (GORDAN *et al*., 2015). Além disso, essa abordagem implica em redução de tempo clínico e desconforto ao paciente. Neste contexto, a realização de reparo de restaurações insatisfatórias é especialmente interessante em Odontopediatria.

Embora os profissionais prefiram reparar uma restauração defeituosa com o mesmo material, os protocolos para reparo são inconsistentes, tornando a decisão de repair ou substituir, por vezes, difícil (DA COSTA *et al.,* 2021). Poucos estudos laboratoriais (YAP; LYE; SAU, 2000; MANEENUT; SAKOOLNAMARKA; TYAS, 2010) têm avaliado o potencial de reparo de restaurações de cimento de ionômero de vidro modificado por resina com o mesmo material ou resina composta.

Um estudo laboratorial (MANEENUT; SAKOOLNAMARKA; TYAS, 2010) investigou a resistência de união do reparo de dois cimentos de ionômero de vidro modificado por resina (Fuji II LC, GC e Ketac N100, 3M Oral Care) com o mesmo material ou resina composta. Os resultados foram material-dependente, indicando que o reparo de Ketac N100 com o mesmo cimento de ionômero de vidro modificado por resina pode ser clinicamente imprevisível. No entanto, o reparo de Fuji II LC com o mesmo material ou com resina composta parece ser aceitável.

Outro estudo *in vitro* (YAP; LYE; SAU, 2000) verificou que a resistência de união do reparo de restaurações de cimento de ionômero de vidro modificado por resina diminui significativamente após 3 meses de armazenamento em água, independente do ácido utilizado para condicionamento de superfície (ácido maleico ou poliacrílico).

Tendo em vista que o cimento de ionômero de vidro modificado por resina é amplamente utilizado para restaurar dentes decíduos e frente às lacunas na literatura acerca do protocolo para reparar as restaurações que apresentem pequenas falhas, o presente estudo teve como objetivo investigar a resistência de união do reparo de um cimento de ionômero de vidro modificado por resina encapsulado com o mesmo material ou resina composta.

2 ARTIGO CIENTÍFICO

Restoration-repair potential of resin-modified glass ionomer cement

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Abstract

Objective: To evaluate the repair bond strength of resin-modified glass ionomer cement using either the same material or a universal adhesive in the etch-and-rinse and self-etch modes *plus* resin composite. **Material and Methods:** Twenty-four resin-modified glass ionomer cement blocks were stored in distilled water for 14 d and thermocycled. Specimens were randomly assigned to three experimental groups according to the repair protocol: resin-modified glass ionomer cement (Riva Light Cure, SDI) and universal adhesive (Scotchbond Universal Adhesive, 3M Oral Care) in etch-and-rinse or self-etch modes with nanohybrid resin composite (Z350 XT, 3M Oral Care). After 24 h of water storage, the blocks were sectioned, and bonded sticks were subjected to the microtensile bond strength (μTBS) test. One-way ANOVA and Tukey's test were used to analyze the data. The failure mode was descriptively analyzed. **Results:** The highest μTBS values were obtained when the resin-modified glass ionomer cement was repaired using the same material. In addition, the mode of application of the universal adhesive system influenced the repair bond strength of the resin-modified glass ionomer cement. Higher μTBS values were observed when the universal adhesive was used in the etch-and-rinse mode than in the self-etch approach ($p < 0.001$). Adhesive/mixed failures prevailed in all groups. **Conclusion:** Repair of resin-modified glass ionomers with the same material appears to be the preferred option to improve bond strength. **Clinical Relevance:** Resin-modified glass ionomer restorations should be repaired with the same material, however when repair is performed with resin composite and universal adhesive the etch-and-rinse mode is preferable.

Keywords: Dental Restoration Repair, Glass Ionomer Cements, Dental Restoration, Composite Resins.

Introduction

Resin-modified glass ionomer cements are commonly used to restore primary teeth and non-carious cervical lesions in the permanent teeth. The annual failure rate of these restorations is approximately 2.7%[1] in non-carious cervical lesions, and varies from 0.6–16.9% in primary teeth[2]. When restorative reintervention is needed, repair is considered a more conservative approach to replacement[3].

Restoration repair has gained increasing acceptance among dental practitioners, especially in cases of marginal defects, partial loss or fracture of the restoration, and margin repair due to carious lesions[4]. Most dentists reported performing resin composite restoration repairs, whereas the proportion of repaired glass-ionomer cement restorations is low[4].

Although clinicians prefer repairing a restoration with the same material[4], repair protocols are inconsistent, making decisions to replace or repair defective restorations difficult. Few studies[5-7] have assessed the repair potential of resin-modified glass ionomer cements with resin-modified glass ionomer cement or resin composite; however, the results are not conclusive.

Therefore, this study sought to evaluate the repair bond strength of resin-modified glass ionomer cement using either the same material or a universal adhesive in etch-and-rinse and self-etch modes *plus* resin composite.

Material and Methods

This study followed the CRIS Guidelines for *in vitro* studies, as discussed in the 2014 concept note[8].

The following materials were tested: encapsulated resin-modified glass ionomer cement (Riva Light Cure, A1 and A3 shades; SDI, Bayswater, Victoria, Australia), nanohybrid resin composite (Filtek Z350 XT, A1B shade; 3M Oral Care, Saint Paul, Minnesota, USA), and a universal adhesive system (Scotchbond Universal Adhesive, 3M Oral Care, Saint Paul, Minnesota, USA) in etch-and-rinse and self-etch modes. A detailed description of the materials used is provided in Table 1.

Preparation of aged resin-modified glass ionomer cement blocks

Twenty-four blocks of encapsulated resin-modified glass ionomer cement (Riva Light Cure, A3 shade; SDI, Bayswater, Victoria, Australia), measuring 8 × 8 mm in depth and width and 4 mm in height, were fabricated using a metallic mold (8 × 8 × 8 mm). The mold was fixed to a glass slab. First, the capsule was activated by pushing the plunger until it was flush with the body. It was then immediately placed in an amalgamator (Ultramat 2, SDI, Bayswater, Victoria, Australia) and mixed for 10 s. The capsule was removed and placed in a Riva applicator (SDI; Bayswater, Victoria, Australia). The trigger of the applicator was pressed, and encapsulated resin-modified glass ionomer cement was inserted into the metallic mold in two increments, each of which was light-cured for 20 s using a light-emitting diode curing unit (Radii-cal; SDI, Victoria, Australia) with a light output of at least 1250 mW/cm2. Light intensity was measured using a radiometer (Demetron Curing, Kerr, Orange, California, USA). After setting, the resin-modified glass ionomer cement blocks were gently removed from the mold, and the thickness of each block was confirmed using a digital caliper (Absolute Digimatic, Mitutoyo, Tokyo, Japan). The specimens were coated with petroleum jelly and stored in distilled water at 37 °C for 14 d prior to aging[9]. The blocks were further aged by thermal cycling 5000 times between 5 °C and 55 °C, with a dwell time of 20 s and a transfer time of 3s[9]. The aged specimen surfaces were wet-ground with 320-grit silicon carbide grinding paper for 60 s to create standardized repair surfaces, corresponding to those obtained by medium diamond bur grinding[9] (Figure 1).

Bonding procedures

The 24 aged blocks were randomly assigned (Random Allocation software, version 1.0, Iran) into three experimental groups according to the repair protocol (n = 8): use of encapsulated resin-modified glass ionomer cement, use of universal adhesive in the self-etch mode + nanohybrid resin composite, or universal adhesive in the etch-and-rinse mode + nanohybrid resin composite. Randomization was performed by a staff member who was not involved in any of the laboratory phases. Allocation concealment was guaranteed by using sequentially numbered individual containers that prevented the operator from seeing the blocks before treatment.

The aged blocks were carefully placed over the original mold and repaired using encapsulated resin-modified glass ionomer cement (A1 shade) or nanohybrid composite resin (A1B shade). Both materials were applied in two incremental layers, each light-cured for 20 s. This process resulted in 8-mm high specimens. After removal from the mold, the specimen surfaces covered by the mold were cured for 20 s. The repaired blocks were stored individually in distilled water at 37 °C for 24 h before testing. A single trained operator performed all procedures.

Microtensile bond strength (μTBS)

Each composite block was numbered according to the randomization sequence to ensure the blinding of the testing machine operator. Blocks were sectioned into 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, USA). The sticks were carefully examined under a stereomicroscope at 40× magnification, and those with interfacial flaws, gaps, bubbles, or other defects were excluded. The cross-sectional area of each stick was measured using a digital caliper (Absolute Digimatic, Mitutoyo, Tokyo, Japan) to calculate the bond strength values, measured in MPa.

The bonded sticks were attached to a universal testing machine for microtensile testing (EZ-SX series, Shimadzu Corp., Kyoto, Japan) with cyanoacrylate, and tested at a crosshead speed of 1 mm/min. μTBS, measured in MPa, was obtained by dividing the load at failure (N) by the cross-sectional area (mm^2) of each stick.

Failure mode

A blinded examiner evaluated the mode of failure. The fracture surfaces were examined under a stereomicroscope at 40× magnification to determine the failure mode: mixed/adhesive (failure at the adhesive interface) or cohesive (failure exclusively within the aged resin-modified glass ionomer cement or repair material). Representative specimens from each group were gold-sputtered and analyzed using scanning electron microscopy (SEM) in the secondary electron mode at 10 kV. Premature failure was considered a pre-testing failure owing to specimen preparation.

Statistical analysis

A resin block was used as the experimental unit. The μTBS values from every stick from the same block were averaged for statistical analysis. The mean μTBS for every testing group was expressed as the average of the eight blocks used per group. Specimens with cohesive failures were excluded from the data analysis. Premature failures were included in the statistical analysis with a value of 4.0 Mpa[10]. Assuming a mean difference of 25% among groups and expecting a variation coefficient of 20%, a minimum of eight blocks per group was required to achieve a power of 0.8 and an α-error probability of 5%.

Normal data distribution was confirmed using the Kolmogorov-Smirnov test. μTBS means were analyzed using one-way ANOVA and Tukey's *post-hoc* tests. The significance level was set at 5%. Statistical analyses were performed using Minitab18 software (Minitab Inc., State College, USA).

Results

The μTBS means, standard deviations, and distribution of the failure modes for all the experimental groups are shown in Table 2. The highest μTBS values were obtained when the resin-modified glass ionomer cement was repaired using the same material. In addition, the mode of application of the universal adhesive system influenced the repair bond strength of the resin-modified glass ionomer cement. Higher μTBS values were observed when the universal adhesive was used in the etch-and-rinse mode than in the self-etch approach ($p < 0.001$).

Mixed/adhesive failures prevailed in all the groups. This pattern was further confirmed by SEM images (Figure2). A higher frequency of cohesive failures was observed when repair was performed with resin-modified glassionomer cement. Premature failures occurred only for repair with resin composite and were more frequent whena universal adhesive was used inthe self-etch mode

Discussion

A recent survey[4] showed that clinicians prefer repairing defective glass ionomer cement restorations with the same material, followed by resin composites. Therefore, in this study, we investigated the repair potential of resin-modified glass ionomer cement using different adhesive materials. Repair of the resin-modified glass ionomer with the same material resulted in higher μTBS values than those with the resin composite.

A previous study[5] measured the repair bond strength of two resin-modified glass ionomer cements (Fuji II LC and Ketac N100), using either the same resin-modified glass ionomer cement or resin composite as the repair material. The results were material-dependent, indicating that the repair of Ketac N100 with additional Ketac N100 may be clinically unpredictable. However, the repair of Fuji II LC with either Fuji II LC or resin composite would be acceptable. Ketac N100 is a nanofilled resin-modified glass ionomer with a highly packed filler composition (~69%), of which approximately two-thirds are nanofillers. The primary curing mechanism is light activation, and no redox or self-curing occurs during setting[11]. These characteristics could explain why the resin composite bonded better to the old Ketac N100 than to the same material. Conversely, Fuji II LC and the resin-modified glass ionomer cement used in this study (Riva Light Cure) have very similar compositions. However, it is important to highlight that in contrast to this study, repair procedures in the previous study were not performed in “non-aged” resin-modified glass ionomer cements.

Aging of the glass ionomer cement surface was also shown to be a significant factor influencing the repair bond strength, and increased aging reduced the repair bond strength[6,12]. Although there is no aging protocol that is considered the gold standard for mimicking the aging of dental materials that occurs in the oral environment, in this study, resin-modified glass ionomer cement was aged by water storage for 14 d followed by thermocycling[9]. All aged resin-modified glass ionomer cements were roughened using a 320-grit silicon carbide grinding paper, simulating the roughness obtained with a medium diamond bur[9], before any additional chemical treatments were performed.

It has been shown that conditioning for 20 s with phosphoric acid or roughening of the surface followed by acid etching promotes the bond between the old and new glass ionomer cement[12]. It was suggested that the exposed glass particles in the old material could react with the acid in the new material and thus establish a chemical bond[6]. Therefore, in this study, pre-repair treatment using resin-modified glass ionomer cement was performed with phosphoric acid for 20 s and not with polyacrylic acid. A previous study[7] found that the repair of an encapsulated glass hybrid restorative system (Equia Forte Fil) with the same material provided lower μTBS values compared to repair with a universal adhesive in the etch-and-rinse mode and resin composite. Polyacrylic acid was applied for 20 s before repair with Equia Forte Fil, which may explain the contradictory results of this study.

Furthermore, the mode of application of the universal adhesive system influenced the repair bond strength of the resin-modified glass ionomer cement. Higher μTBS values were obtained when the universal adhesive was used in the etch-and-rinse mode compared with the self-etch approach, reinforcing the need for acid etching to improve the repair bond strength. A higher frequency of premature failures was also observed when performing repair with a universal adhesive in the self-etch mode and resin composite.

The repair bond strength was measured as the maximum force prior to specimen fracture[13]. If a large percentage of the specimens are cohesively fractured, few conclusions can be drawn regarding the repair bond strength because the bond strength is usually lower than the cohesive strength. Cohesive failures most commonly occurred when repair was performed with resin-modified glass ionomer cement; however, these failures were not included in the mean bond strength. This finding is in line with previous studies that have tested the repair of resin-modified glass ionomer cements[5,6]. Bond strength testing of glass ionomer cement to tooth structure frequently results in cohesive failure of the material, and failure stress is probably representative of the strength of the glass ionomer cement itself.

The limitations of this study must be addressed. The results are based on immediate repair bond strength values and are limited to the materials used in this study. Further studies are required to evaluate the long-term repair potential of resin-modified glass ionomer cements using the same material or resin composite.

Conclusions

Repair of resin-modified glass ionomers with the same material appears to be the preferred option to improve bond strength. When resin composite is used for repair, it is preferable to use a universal adhesive in the etch-and-rinse mode.

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Table 1. Main composition and manufacturer's instructions of the materials used

Material	Main components	Repair protocol
Riva Light Cure A1 and A3 shades (SDI, Bayswater, Victoria, Australia)	Etchant: 37% phosphoric acid Compartment 1: Acrylic acid homopolymer (15–25%), 2-hydroxyethyl methacrylate (15–25%), dimethacrylate cross-linker (10–25%), acid monomer (10–20%), tartaric acid (5–10%) Compartment 2: Glass powder (93–100%)	Apply the etchant for 20 s Rinse thoroughly with water Remove excess water Activate the capsule by pushing the plunger until it is flush with the body Place the capsule into the amalgamator for 10 s Place the capsule into the Riva applicator Click the trigger of the applicator until glass ionomer paste is seen through the clear nozzle Insert the material in 2 mm increments Light cure for 20 s each increment Apply petroleum jelly
Scotchbond Universal Adhesive + Resin composite Z350 XT A1 shade (3M Oral Care, St. Paul, MN, USA)	Etchant: 37% phosphoric acid MDP phosphate monomer, dimethacrylate resins, HEMA, methacrylate-modified polyalkenoic acid copolymer, filler, ethanol, water, initiators, silane 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	**Self-etch mode** Apply the adhesive for 20 s with vigorous agitation Gentle air thin for 5 s Light cure for 10 s **Etch-and-rinse mode** Apply the etchant for 15 s Wash and totally dry the surface Apply the adhesive as the self-etch mode Insert the resin composite in 2 mm increments Light cure for 20 s each increment

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		
Repair protocol	**Bond strength**	**Mixed/Adhesive**	**Cohesive**	**Premature**
SBU ER+ RC	21.2 ± 7.7^{a}	69.4%	28.6%	2%
SBU SE + RC	11.6 ± 4.5^{b}	53.5%	33.6%	13.9%
RMGIC	34.6 ± 7.3^{c}	55.2%	45.8%	0%

*Different capital superscript letters indicate statistically significance differences between bond strength values of the repaired groups ($p < 0.05$).

Abbreviations: SBU: Scotchbond Universal Adhesive; ER: etch-and-rinse; SE: self-etch; RC: resin composite; RMGIC: resin-modified glass ionomer cement.

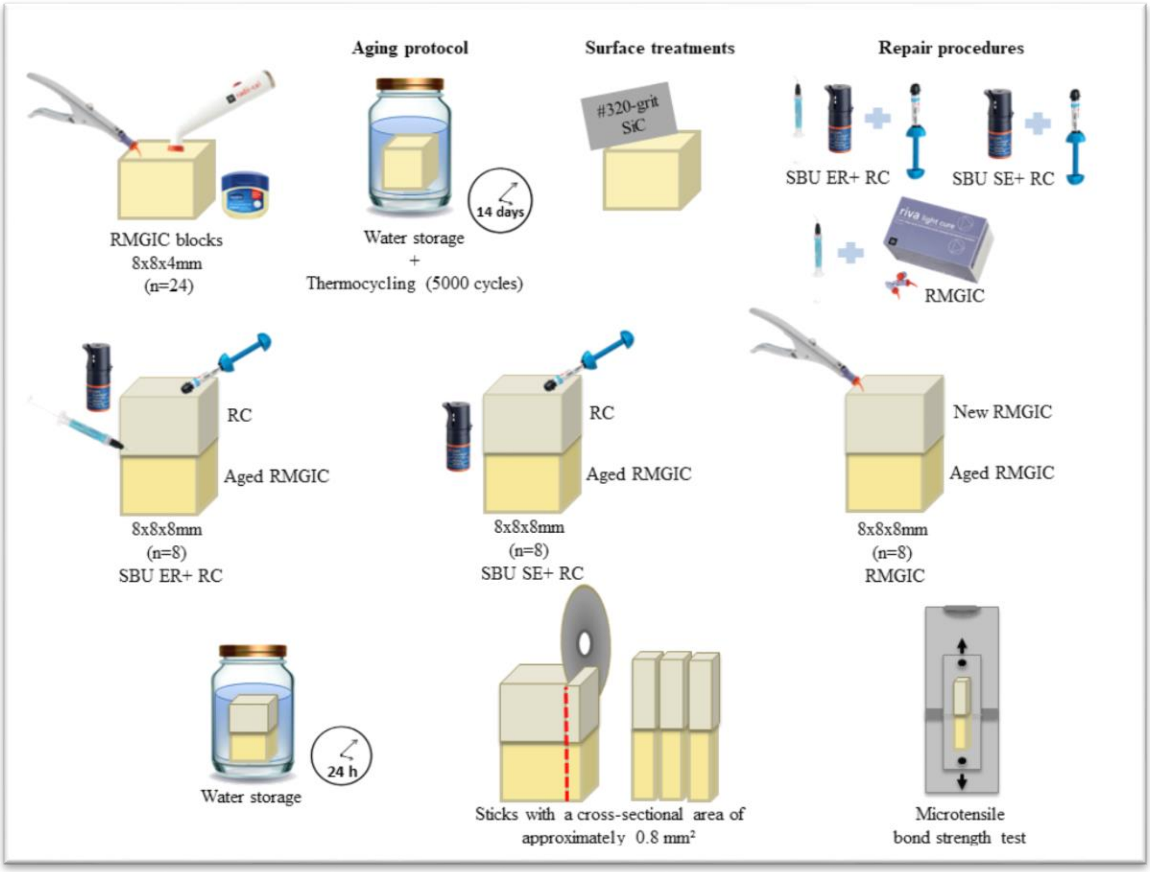

Fig.1 Experimental design of the study.

Abbreviations: SBU: Scotchbond Universal Adhesive; ER: etch-and-rinse; SE: self-etch; RC: resin composite; RMGIC: resin-modified glass ionomer cement.

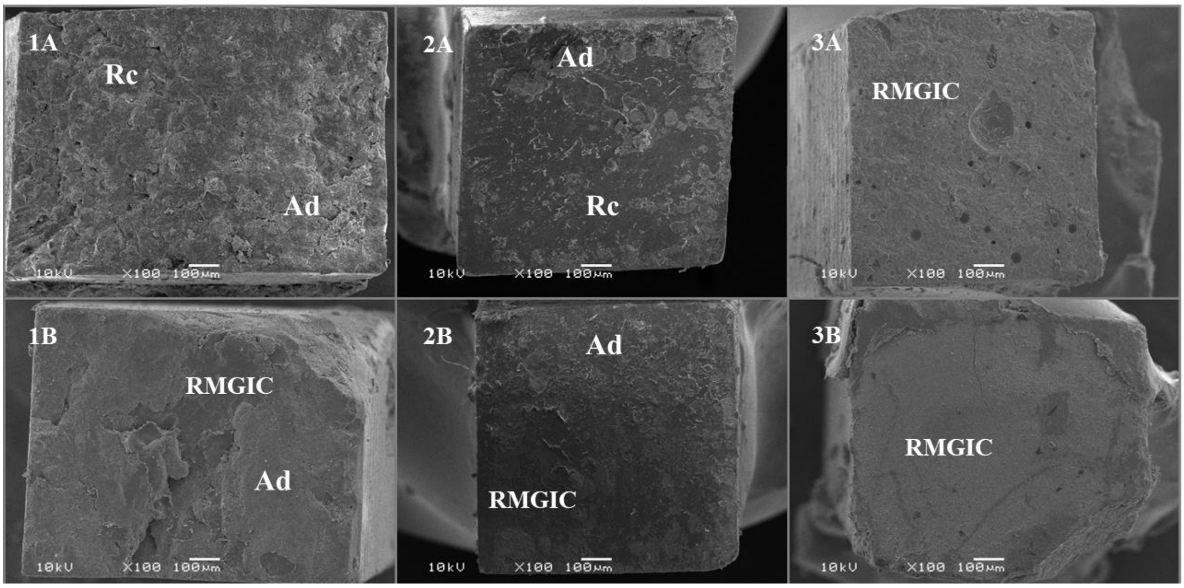

Fig. 2 SEM images of fractured specimens representative of the mixed/adhesive failure pattern from: 1A: repair with universal adhesive in the etch-and-rinse mode plus resin composite and 1B: “old” resin-modified glass ionomer cement; 2A: repair with universal adhesive in the self-etch mode plus resin composite and 2B: “old” resin-modified glass ionomer cement; 3A: repair with resin-modified glass ionomer cement and 3B: “old” resin-modified glass ionomer cement. RC: resin composite; Ad: adhesive system; RMGIC: resin-modified glass ionomer cement.

3 CONCLUSÃO

Com base nos resultados do presente estudo *in vitro*, pode-se concluir que:

O reparo de restaurações de cimento de ionômero de vidro modificado por resina encapsulado com o mesmo material parece ser a melhor opção para aumentar a resistência de união.

Caso os clínicos optem por reparar restaurações de cimento de ionômero de vidro modificado por resina com resina composta, o uso de sistema adesivo universal no modo convencional é preferível ao modo autocondicionante.

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ANEXO A – Aprovação da COMPESQ

Projeto de Pesquisa na Comissão de Pesquisa de Odontologia

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Ter, 16/03/2021 14:48

Para: tathilenzi@hotmail.com <tathilenzi@hotmail.com>

Prezado Pesquisador Tathiane Larissa Lenzi,

Informamos que o projeto de pesquisa REPARO DE RESTAURACOES DE CIMENTO IONOMERO DE VIDRO MODIFICADO POR RESINA ENCAPSULADO: ESTUDO IN VITRO encaminhado para análise em 12/03/2021 foi aprovado quanto ao mérito pela Comissão d Pesquisa de Odontologia com o seguinte parecer:

O objetivo deste estudo será avaliar a resistência de união do reparo de restaurações com cimento ionômero de vidro modificado por resina reparadas com o mesmo material ou com resina composta. Trinta blocos (8 x 8 x 4 mm) de cimento ionômero de vidro (Riva Light Cure, cor A1, SDI, Bayswater, Vitória, Austrália) serão submetidos a envelhecimento por meio de armazenamento em água destilada a 37°C por 14 dias, seguido de ciclagem térmica (5.000 ciclos). Após o envelhecimento, os blocos serão abrasionados com lixa de granulação #320 por 5 segundos e divididos aleatoriamente de acordo com o protocolo de reparo: cimento ionômero de vidro modificado por resina encapsulado (Riva Light Cure, cor A3, SDI, Bayswater, Vitória, Austrália), sistema adesivo universal (Single Bond Universal, 3M ESPE, Saint Paul, Minnesota, EUA) no modo convencional + resina composta (Filtek Z350 XT, cor A3, 3M ESPE, Saint Paul, Minnesota, EUA), sistema adesivo universal (Single Bond Universal, 3M ESPE, Saint Paul, Minnesota, EUA) no modo autocondicionante + resina composta (Filtek Z350 XT, cor A3, 3M ESPE, Saint Paul, Minnesota, EUA). Após 24 horas de armazenamento em água destilada a 37o C, os blocos reparados (8 x 8 x 8 mm) serão seccionados em palitos com área de secção transversal de aproximadamente 0,8 mm2
. Metade dos espécimes serão submetidos
imediatamente ao teste de microtração e a outra metade após 6 meses de armazenamento em água destilada. O padrão de fratura será avaliado em estereomicroscópio com aumento de 40x. Os dados obtidos serão submetidos à análise estatística apropriada com base na sua distribuição e na homogeneidade das variâncias. O nível de significância será de 5%.

O projeto apresenta mérito científico e encontra-se bem delineado. O parecer dessa Comissão é favorável à aprovação.

Atenciosamente, Comissão de Pesquisa de Odontologia