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ORIGINAL ARTICLE

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What is the best protocol for bonding resin-modified glass ionomer cement to composite resin?

Qual o melhor protocolo de união entre cimento de ionomero de vidro resina-modificado e resina composta?

Daphne Camara BARCELLOS[1], **Nicolas PETRUCELLI**[1], **Sérgio Eduardo de Paiva GONÇALVES**[1], **Milena Traversa PALAZON**[1], **Bianca Mitsue Goulart SOBUE**[1], **César Rogério PUCCI**[1]

1 – Department of Restorative Dentistry – School of Dentistry – Institute of Science and Technology – UNESP – Univ Estadual Paulista – São José dos Campos – SP – Brazil.

ABSTRACT

Objective: The objective of this study was to evaluate the bond strength of resin-modified glass ionomer cement (RMGIC) to composite resin considering the use of conventional and self-etching adhesive systems. **Material and Methods:** 60 RMGIC blocks (Riva, SDI) measuring 4 x 4 x 4 mm. were constructed. On the blocks, the application of different protocols of adhesive systems (n = 10) was carried out: Group 1 (Control) - without application of adhesive agent; Group 2 - 37% phosphoric acid + conventional adhesive agent Single Bond 2; Group 3 - conventional adhesive agent Single Bond 2; Group 4 – conventional adhesive agent Scotch Bond Multi-Purpose; Group 5 - self-etching adhesive Clearfil SE Bond; Group 6: self-etching adhesive Optibond All-in-One. Next, resin composite blocks measuring 4 x 4 x 4 mm were constructed (Venus, Heraeus Kulzer). The specimens were cut to obtain sticks which were submitted to microtensile bond strength test in a universal testing machine. The data were submitted to ANOVA and Tukey test (5%). **Results:** ANOVA showed a value of $p < 0.05$, which indicated significant differences between the groups (in Mpa): Group 2 - 32.83; Group 5 - 31.2; Group 3 - 25,15b; Group 6 - 22.92; Group 4 - 22.15; Group 1 - 13.84. The analysis of fracture mode demonstrated that there was a predominance of adhesive and mixed fractures for all groups. **Conclusion:** The protocols of acid etching + conventional adhesive system Single Bond 2 (Group 2) or self-etching adhesive system Clearfil SE Bond (Group 5) increased the bond strength of RMGIC to the composite resin. The presence of an adhesive layer between the two materials tended to improve the bonding of RMGIC to composite resin.

KEYWORDS

Glass ionomer cement; Composite resin; Dentin-Bonding Agents; Dental Cements; Tensile Strength.

RESUMO

Objetivo: O objetivo desse estudo foi avaliar a resistência de união entre cimento de ionômero de vidro resina-modificado (CIVRM) e resina composta, considerando a utilização de sistemas adesivos de condicionamento acido total e autocondicionantes. **Material e Métodos:** Confeccionaram-se 60 blocos de CIVRM (Riva, SDI) de dimensões de 4x4 mm. Sobre os blocos, variou-se o protocolo de aplicação de diferentes sistemas adesivos (n = 10): Grupo 1 (Controle) – sem aplicação de adesivo; Grupo 2 – ácido fosfórico 37% + Single Bond; Grupo 3 - Single; Grupo 4 - Bond do Scotch Bond Multi-Purpose Plus Adhesive; Grupo 5 - Clearfil SE Bond; Grupo 6: Obtibond All-in-One. Em seguida, foram confeccionados blocos de resina composta (Venus, Heraeus Kulzer) de dimensões de 4x4X4 mm. Foram realizados cortes nos espécimes para obtenção de amostras com área coesiva de 1 mm2, que foram submetidas ao teste de microtração em máquina de ensaios universal. Os dados foram submetidos aos testes ANOVA e Tukey. **Resultados:** ANOVA apresentou um valor de $p < 0.05$, o que indicou diferenças significantes entre os grupos (em Mpa): Grupo 2 – 32,83 a; Grupo 5 – 31,2 a; Grupo 3 – 25,15 ab; Grupo 6 – 22,92 ab; Grupo 4 22,15 ab; Grupo 1 – 13,84 b. **Conclusão:** os protocolos condicionamento ácido + Single Bond ou Clearfil SE Bond aumentaram resistência de união entre o CIVRM e a resina composta. A presença de uma camada de adesivo entre os dois materiais tende a melhorar a união entre CIVRM e resina composta.

PALAVRAS-CHAVE

Cimentos de Ionômeros de Vidro; Resinas Compostas; Adesivos dentários; Cimentos Dentários; Resistência à Tração.

INTRODUCTION

In restorative dentistry, glass ionomer cement (GIC) can be used, among many situations, as liner material to protect pulp-dentin complex in deep cavities by playing the role of artificial dentinal [1-3]. Such material is often associated with composite resin, which provides some advantages such as: decrease in the total volume of composite by absorbing the stress generated by polymerization contraction, responsible for possible breakages of adhesive bonds [4-7]; reduce the marginal leakage due to chemical bond to dentin and the increase of the restoration flexibility by absorbing the stresses developed during and after curing of composite resin [4-9].

With the constant evolution of direct restorative materials, resin-modified cement glass ionomer (RMGIC) was introduced in dentistry in the 80s [10]. This system, also called hybrid, shows improvements in the properties of GICs: increasing in the mechanical properties, higher bond strength to enamel and dentin, reduced syneresis/soaking and greater control in working time [10,11].

However, the protocol of acid etching with 37% phosphoric acid on RMGIC prior to the application of the adhesive agent is still very controversial. Some studies suggest doubts about the effectiveness of the acid etching on the material [12-14], while the others consider that the acid etching protocol is effective to bond the two materials [15-18].

In addition, the interaction of RMGIC with the new adhesives in the market, called self-etching adhesive systems, is still a matter to be assessed and understood. The self-etching adhesives do not require the application of phosphoric acid separately. The acidity of the self-etching comes from the ionization of radicals present in the hydrophilic monomer molecule itself, also responsible for the impregnation of the substrate [19]. Therefore, the change in the composition of self-etching adhesives can influence on the bond strength of RMGIC to composite resin.

A third clinical relevance of this bonding of RMGIC to the composite is using GIC as a liner due to difficulty in accessing the internal dentin walls, the adhesive system, regardless of the category and method of use, will always be applied on RMGIC, even if unintentionally.

Therefore, the aim of this study was to evaluate the bond strength of RMGIC used as a liner to the composite resin, considering the association with conventional and self-etching adhesive systems. The tested null hypothesis is that the different application of adhesive system techniques between RMGIC and composite resin are not different from each other regarding to the bond strength.

MATERIAL AND METHODS

Sixty RMGIC blocks (Riva light cure, SDI Limited, Bayswater, Victoria, Australia) measuring 4 X 4 X 4 mm were obtained using a silicone matrix. The material was mixed and light-cured (Curing Light XL 3000 3M ESPE, St. Paul, MN, USA) with a power density of 600 mW/cm2 according to the manufacturer's instructions.

On RMGIC blocks, different adhesive application techniques were used (n = 10):

• Group 1 (control): No adhesive system was applied;

• Group 2: Acid etching with 37% phosphoric acid for 15 s, followed by rinsing for 30 s and drying with gentle air jet for 5 seconds. Application of conventional adhesive system Single Bond 2 (3M ESPE) in accordance with the manufacturer's instructions. With the aid of a micro brush, we applied two consecutive layers of adhesive, actively, shaking the brush on the surface for 15 s, followed by drying to evaporate the solvent for 5 sec at a standard distance of 10 cm, removal of the excess and light-curing for 10 s;

• Group 3: Acid etching at 37% was not performed. Application of conventional adhesive system Single Bond 2 (3M ESPE) as described in group 2 and curing for 10 s.

• Group 4: Acid etching at 37% was not performed. Application of bonding agent of conventional adhesive system Scotch Bond Multi-Purpose Plus Adhesive (3M ESPE). With the micro brush, a layer of the bonding agent was actively applied, shaking the brush on the surface for 15 s, followed by removal of excess and light-curing for 10 s.;

• Group 5: The application of self-etching adhesive system Clearfil SE Bond (Kuraray Medical Inc., Tokyo, Japan) according to the manufacturer's instructions. With the micro brush the primer agent was actively applied for 20 s, followed by gentle air jet for 5 sec at a standardized distance of 10 cm, removing excesses, followed by the actively application of adhesive agent for 20 s, removal of excesses, applying gentle air jet for 5 sec at a standardized distance of 10 cm, and light-curing for 10 s;

• Group 6: The application of self-etching adhesive system Optibond All-in-One (Kerr Corporation, Orange, CA, USA) according to the manufacturer's instructions. With the micro brush, the first layer was applied actively for 20 s, followed by actively applying the second layer for 20 s, removing the excesses, application of gentle air jet for 5 sec at a standardized distance of 10 cm, and light-curing for 10 s;

Then, the composite resin (Vênus, Heraeus Kulzer, GmbH & Co, KG, Germany) was inserted in increments of 2 mm with aid of a Teflon matrix measuring 4 X 4 X 4 mm, followed by light-curing for 20 s. on each increment. The tradename, chemical composition and manufacturer of the materials used are shown in Table 1.

The specimens were stored for 24 h at 37 ºC and then, sections were made parallel to the long axis at the mesial-distal and cervical-occlusal directions with an approximate thickness of 1 mm. That resulted in sticks which were submitted to microtensile test in universal testing machine (DL-1000, EMIC, São José dos

Table 1 - Materials used and their compositions

Material	Manufacturer	Composition	Classification of Van Meerbeck et al. (2003)[20]
Riva Self Cure	SDI Limited Bayswater, Victoria, Australia	Fluoride Aluminum Strontium Silicate glass, dimethacrylate Triethylene Glycol, Hydroxyethyl Methacrylate, Polyacrylic Acid, Hydroxy Toluene Butyl, camphorquinone, Tetra Methyl Aniline, Water and Pigment	Resin-modified glass ionomer cement
Adper Single Bond 2	3M ESPE, St. Paul, MN, USA	HEMA, Bis-GMA, Di- methacrylates, photoinitiators, Co-polymers of polyacrylic acid, Co-polymer of itaconic acid, Photoinitiator, Water and Alcohol	Two-step conventional
Scotch Bond Multi-Purpose Plus Adhesive	3M Espe St. Paul, MN, USA	Bond: Bis-GMA, HEMA (2-hydroxyethylmethacrylate)	three-step conventional
Optibond All-in-One	Kerr, Corporation, Orange, CA, USA	Glycol Dimethacrylate phosphate, mono- and dimethacrylate, water, acetone, alcohol, camphorquinone, nanoparticles, pH = 3.0.	one-step self-etching
Clearfil SE Bond	Kuraray, Tokyo, Japan	Primer: MDP, HEMA, hydrophilic dimethacrylate, dl-camphorquinone, N, N-diethanol-p-toluidine, water, pH = 1.9. Bond: MDP, Bis-GMA, HEMA, hydrophobic dimethacrylate, dl-camphorquinone, N, N-diethanol-p-toluidine, silanized colloidal silica.	two-step self-etching

Legend: BIS-GMA = bisphenol glycidyl methacrylate; HEMA: 2-hydroxyethyl methacrylate; MDP = dihydrogen phosphate methacryloyloxydecyl.

Pinhais, PR, Brasil), with a 10 kg load cell at 0.5 mm/min speed, according to the guidelines described in ISO TR 11405. The data, expressed in Megapascal (MPa) were subjected to statistical tests of parametric analysis of variance (ANOVA) and Tukey's test using a significance level of 5%.

The fractured sticks were analyzed in stereomicroscope Stemi 2000 (Carl Zeiss NTS GmbH, Oberkochen, Germany) at 50-fold magnification, to determine the type of fracture: adhesive - the adhesive interface fracture; cohesive in RMGIC; cohesive in composite resin; mixed - part in RMGIC and part in composite resin.

RESULTS

ANOVA showed no significant differences (p = 0.0008, F = 4.81, Degree of freedom = 5) between groups. Table 2 shows the results of Tukey test for all groups. Group 1 (control - without protocol of adhesive application) presented significantly lower bond strength compared to the Group 2 (submitted to acid etching followed by the application of conventional adhesive Single Bond 2) and Group 5 (which used the self-etching adhesive system Clearfil SE Bond).

The analysis of the fracture mode showed predominance of mixed and adhesive type fractures for all groups.

Table 2 - Tukey test results for different groups

Group	Protocol	Mean(± sd)	Homogeneous groups*	
2	37% Phosphoric acid etching + Adper Single Bond 2	32.83(± 7.64)	A	
5	Clearfil SE Bond	31.20(± 7.64)	A	
3	Adper Single Bond 2	25.15(± 7.77)	A	B
6	Optibond All-in-One	22.92(± 6.41)	A	B
4	Bond agent of Scotch Bond Multipurpose	22.15(± 3.95)	A	B
1	Control	13.84(± 5.00)		B

* The means accompanied by the same letters do not present statistical differences

DISCUSSION

The glass ionomer cement is one of the best materials for using as cavity liner, because it has some advantages as: chemical bonding to dentin, coefficient of thermal expansion similar to that of the tooth, anticariogenic activity due to fluoride release and mechanical bonding to the chemical composite/dentin adhesive [5,7].

Currently, two bonding to dentin strategies exist, conventional (or total etching) and self-etching adhesive systems. The total etching system completely removes the smear layer and exposes the collagen fibers, promoting the formation of a mixed region underlying the adhesive interface, with the monomer infiltration into the interior of demineralized dentin, promoting the formation of the hybrid layer [20,21]. The self-etching adhesives are composed of monomer resin acids that promote both demineralization of dentin surface and the infiltration of adhesive resin into dentin, also resulting in the formation of the hybrid layer [19]. However, the self-etching adhesive systems follows the modern trend of simplifying clinical steps, saving the operative time and reducing the sensitivity of the technique application of dental adhesives [22,23].

The null hypothesis was rejected because the different application of adhesive system techniques between the RMGIC and composite resin differed among themselves regarding to the bond strength. The use of the acid etching on RMGIC followed by the application of Adper Single Bond 2 (Group 2) showed higher bond strength values when compared to the Group 1 (Control) that did not use adhesive agent to bond the RMGIC to the composite resin. Our results corroborate the studies of many authors [15-18], who observed that the phosphoric acid etching causes a satisfactorily rough surface in these cements, and through mechanical imbrication [24], facilitates retention of the composite resin and improves the bond strength between the two materials. Authors consider that this bonding can be comparable to that between GIC and dentin [25].

The results of this present study showed that the self-etching adhesive Clearfil SE Bond (Group 5) exhibited higher bond strength values than Group 1 (control). RMGICs have the acid-base reaction characteristic of GICs and a second activation reaction, so-called photopolymerization of free radicals of methacrylates groups of the polymer and HEMA [26,27]. Thus, there is the formation of an inhibited air layer on the surface of the material which increases the number of unsaturated carbon/carbon double bounds, which probably increases the chemical bonding of RMGIC to the adhesive and, consequently, the composite resin [28-30]. In addition, the self-etching primer Clearfil SE Bond has pH 1.9. This acidic characteristic may also have promoted a greater surface roughness of the RMGIC improving the mechanical imbrication [24], thus justifying the results obtained in the study

It can also be noted that Group 2 (self-etching adhesive + Single Bond 2 acid) and Group 5 (self-etching adhesive Clearfil SE Bond) did not differ in relation to other application techniques of the tested adhesive systems (Groups 3, 4 and 6). Our results showed that the conventional adhesive Adper Single Bond 2 (regardless of performing or not the etching), the self-etching systems Clearfil SE Bond and Optibond All-in-One or the bonding agent of Scotch Bond Multipurpose did not affect the bond strength of RMGIC to composite resin, on the contrary, the presence of an adhesive layer between the two materials tended to improve the bonding of RMGIC to composite resin.

The correct association of RMGIC with composite resin is of utmost importance for the success of the restoration because failures during the bonding stage between these two materials can cause their displacement and formation of internal cracks between RMGIC and composite resin, compromising the restoration longevity [31-33]. The results of this study demonstrate the importance of making an adhesive system application protocol on the RMGIC in order to optimize the bonding of RMGIC to composite resin, thus guiding the clinician during the restorative step In order to improve the performance of the restorations.

The fracture pattern of the sticks in all groups demonstrated predominance of adhesive and mixed type fractures. This result can be attributed to lower bond strength between two different substrates (RMGIC and composite resin), where bonding failures occur mainly on the bonding interface compared to cohesive strength of the material (cohesive failure).

However, other studies are needed to investigate the influence of conventional and self-etching adhesive systems not only on the bond strength, but also on all physical and mechanical properties of GICs. In addition, further studies should be carried out in order to observe the bonding performance of GIC to composite when using the primer agent of conventional adhesive system of three steps, as clinically this need to be applied prior to the bond agent on the inner cavity walls and often on RMGIC used as a liner.

CONCLUSION

Based on the results obtained, it can be concluded that the acid etching protocols + conventional adhesive Adper Single Bond 2 or self-etching adhesive Clearfil SE Bond increased the bond strength of RMGIC to the composite resin; the conventional adhesive system Adper Single Bond 2 without prior etching, the self-etching adhesive system Optibond All-in-One and the bonding agent of conventional adhesive system ScotchBond Multipurpose did not affect the bond strength of RMGIC to the composite resin. The presence of an adhesive layer between the two materials tended to improve the bonding of RMGIC to the composite resin.

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Cesar Rogério Pucci
(Corresponding address)
Universidade Estadual de São Paulo - UNESP, SP, Brasil.
Avenida Engenheiro Francisco José Longo, 777,
Jardim São Dimas, São José dos Campos, SP, Brasil.
12245-000.
E-mail: cesar@fosjc.unesp.br

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