

# Assessment of marginal sealing in indirect resin composite restorations cemented with 3 different types of cement

## *Avaliação do selamento marginal em restaurações indiretas de resina composta cimentadas com 3 diferentes tipos de cimentos*

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### **ABSTRACT**

The aim of this study was to evaluate the sealing of indirect resin restorations cemented with three different luting agents. Thirty bovine teeth were used. Box type cavities preparations were made in the middle third of the buccal face. The cavities were restored with inlay restorations by the direct/indirect technique using resin composite Resilab (Wilcos, Petrópolis, RJ, Brazil). The teeth were randomly divided into three groups: Group 1: etched with 37% phosphoric acid for 30 seconds, adhesive system Prime Bond 2.1 and Enforce resin cement (Dentsply, Petrópolis, RJ, Brazil); Group 2: etched with 37% phosphoric acid for 30 seconds, adhesive system Single Bond and RelyX ARC resin cement (3M ESPE, St Paul, MN, USA); and Group 3: resin-modified glass ionomer cement RelyX Unicem Aplicap (Dentsply, Petrópolis, RJ, Brazil). The indirect restorations were cemented with the respective cements and thermal cycled for 800 cycles. The specimens were stored in 50% silver nitrate dye for 24 hours, after this procedure the teeth were sectioned in the bucco-lingual direction into 3 slices of 1 mm thick, fixed on a glass slide and then analyzed by a stereomicroscope were was coupled a digital camera to register the images. From these pictures, the marginal leakage areas were measured by the software Image Tool 3.0. The data obtained were submitted to the ANOVA and Tukey tests. ANOVA showed that there was no significant difference ( $p=0.73$ ) among groups (mean values( $\pm$ SD): Group 1=0.96( $\pm$ 0.71); Group 2: 1.10( $\pm$ 0.63) and Group 3: 0.99( $\pm$ 0.35) . It was concluded that the 3 luting agents presented no significance regarding marginal microleakage, demonstrating similar performance in the proposed research situation.

### **UNITERMS**

Microleakage; marginal sealing; indirect restorations.

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### **INTRODUCTION**

With the growing concern about esthetic, patients are increasingly requesting alternatives to conventional metallic restorations.<sup>22</sup> Direct resin composites could

be considered an alternative<sup>25</sup>, however they still show many limitations like polymerization shrinkage, which produces inadequate marginal adaptation, consequently leading to microleakage, bacterial

invasion, and possible formation of recurrent caries<sup>1</sup> and; low wear resistance in areas of masticatory contact with the antagonist dental structure. Discoloration and dentinal hypersensitivity are factors that contribute to making the direct use of resin composite unfeasible.<sup>15</sup>

Looking for minimizing these problems, indirect restorations have been developed, and showed good esthetic results and satisfactory physical-mechanical properties<sup>5</sup>, thus becoming a good alternative for making restorations<sup>6</sup>. Indirect restorations offer better wear resistance and better polishing, and then less bacterial plaque retention, less susceptibility to pigment accumulation and consequently less discoloring. They also present better marginal adaptation, because, when making the restoration indirectly, one can have a better visualization of margins. Moreover, because the quantity of cementing material used is small, there is less polymerization shrinkage, which minimizes the chance of marginal leakage.<sup>22</sup>

The luting technique applied for these restorations has great importance for their success, because its correct use will provide adequate marginal sealing and guarantee the characteristics required for good clinical performance of the restorations. To enable this to occur, there must be compatibility among the restoration/cement/dental structure, in order to preserve the qualities that indirect restorations offer, and to take advantage of the remaining dental structure without producing injuries.

Several different types of materials may be used for luting these restorations, the most appropriate being glass ionomer (GI) based and resin cements. Glass ionomer cements have the characteristic of releasing fluoride ions, which inhibit the formation of secondary caries, but their physical properties, such as mechanical resistance, solubility in oral fluids, and bacterial plaque retention are not fully satisfactory. On the other hand, resin cements present better adhesiveness, compatibility and esthetics, in addition to better mechanical properties, but they may generate greater post-operative sensitivity.<sup>21</sup> There are also resin-modified glass ionomer cements, which combine the characteristics of the two materials, and present fluoride ion release, less incidence of post-operative hypersensitivity, bactericidal activity, greater resistance to dissolution, greater strength and are not susceptible to the physical-mechanical properties related for glass ionomer cements<sup>4</sup>.

The above-mentioned cements have different forms of polymerization, being: light polymerization,

by visible light appliances, chemical polymerization, by mixing base and catalyst materials, or also dual polymerization, which is a combination of the two previously mentioned forms; initial activation occurs by means of light polymerization and is finalized chemically<sup>4</sup>.

This research was developed with the aim of evaluate marginal leakage in box-type cavities restored with resin inlay simulating microleakage occurring in indirect restoration, using 3 different types of luting agents: two dual resin cements: Enforce (Dentsply) and RelyX ARC (3M ESPE), and a resin-modified glass ionomer cement: RelyX Unicem Aplicap (3M ESPE).

## MATERIAL AND METHODS

Thirty bovine teeth were selected and sectioned in the apical third. The teeth were fixed in an acrylic resin matrix, randomly divided into three groups (n=10) and received box type preparations in the middle third of the vestibular face, with expulsive walls. The cavities measured 3x4x2mm, and were made with diamond tips #4137 (KG Sorensen, Rio de Janeiro, RJ, Brazil) at high speed, coupled to a modified optic microscope, in order to standardize the cavity preparations.

The cavity preparations received prophylaxis with Herjos paste (Vigoden, Rio de Janeiro, RJ, Brazil) and were cleaned with Tergestesin anionic detergent solution (Degussa, Catanduva, SP, Brazil), washed with water and air jets for 20 seconds and dried with absorbent paper.

Inlay restorations were made by the direct/indirect technique. This technique was made with Resilab indirect composite (Wilcos, Petrópolis, RJ, Brazil) inserted in a single increment and light cured with a Curing Light XL 3000 (3M ESPE, St. Paul, MN, USA) in accordance with the manufacturer's instructions. To complement light polymerization, the inlay restorations were taken to a specific oven Resilab Master Fotoceram (Fotoceram Indústria e Comércio, Goiânia, GO, Brazil) for 4 minutes. The parts were internally roughened with airborne aluminum oxide particle abrasion (50 microns) Microetcher Erc (Danville Engineering, San Ramon, CA, USA).

For groups 1 and 2, the enamel and dentin were etched with 37% phosphoric acid, 30 seconds to enamel and 15 seconds to dentin, and washed with air/water jet for 20 seconds and dried with absorbent paper. The first group received 2 layers of adhesive Prime&Bond 2.1 (Dentsply, Petrópolis, RJ, Brazil) used in accordance with the manufacturer's

instructions. Excess adhesive was removed with an air jet for 2 seconds and light cured for 10 seconds. The parts were cemented with dual cure resin cement Enforce (Dentsply, Petrópolis, RJ, Brazil), composed of a catalyst paste and a matized base paste in shade A3. The pastes were mixed, put into the cavities, the indirect restorations placed in position, the excess cement removed and light cure done in accordance with the manufacturer's instructions.

The Group 2 received 2 layers of Adper Single Bond adhesive system (3M ESPE, Saint Paul, MN, USA) used in accordance with the manufacturer's instructions, and the same steps followed as for Group 1. The resin indirect restorations were cemented with Rely X ARC (3M ESPE, Saint Paul, MN, USA) dual cure resin cement, presented in a specific dosing flask, which provides base and catalyst pastes in a suitable manner. The pastes were manipulated, placed in the cavities and the indirect restorations positioned.

After this, a standard pressure of 2 kg was applied perpendicularly on the indirect resin block and the excess were removed with brush. Each face of the resin blocks was light polymerized for 40 seconds.

The Group 3 received the self-adhesive glass ionomer cement Rely X Unicem Aplicap (3M ESPE). This cement is presented in capsules that are placed in a device that promotes mixture of the liquid and powder. The capsules were transferred to a capsule mixer Astronmix (Dabi Atlante/ Ribeirão Preto, SP, Brazil) and mixed for 8 seconds. The capsules were taken to an applicator that enables the cement to be inserted into the cavity, then the indirect restorations were positioned into the cavities. A standard pressure of 2 kg was applied perpendicularly on the indirect resin block and the excess cement was removed and light cure realized for 40 seconds. The characteristics of cements, adhesives and acids like manufacturers, lots and compositions are available in Box 1.

#### Box 1 – Materials used, manufacturers, lots and compositions.

Cement	Manufacturer	Lot	Composition
Enforce	Dentsply, Petrópolis, RJ, Brazil	43650	Bis-GMA(Bisphenol A-Glycidyl Methacrylate), BHT(2,6 di-tert-butyl-p hydroxyl toluene), EDAB (ethyl-4-dimethylaminobenzoate), BDMA(Benzyl Dimethyl Amine), HEMA(2-hydroxyethyl methacrylate), TEGDMA(triethyleneglycol dimethacrylate), fumed silica, silanized barium, aluminum bore-silicate glass (66 wt%).
Rely X ARC	3M ESPE/ St. Paul, MN, USA	20000630	Bis-GMA, TEGDMA, silica and zirconium glass (67.5%wt).
Rely X Unicem	3M ESPE/ ST Paul, MN, USA	150125	Powder: Glass powder, Silica Initiator, Substituted pyrimidine, Calcium hydroxide, Peroxy compound, Pigment. Liquid: Methacrylated phosphoric ester, Dimethacrylate, Acetate, Stabilizer, Initiator.
Single Bond	3M ESPE/ St. Paul, MN, USA	7 KX	Water, alcohol, HEMA, Bis-GMA, dimethacrylate, photoinitiator, copolymers of the acid and poly(itaconic) acid.
Prime & Bond 2.1	Dentsply, Petrópolis, RJ, Brazil	48890	Elastomeric resins, PENTA (Pentaerythritol), acetone, cetylamine hydrofluoride.
Magic acid	Vigodent/ Rio de Janeiro, RJ, Brazil	00406	Phosphoric acid 37%.

The specimens were stored in a bacteriologic autoclave at 37° C for 24 hours. After this period, they were placed in a thermal cycling machine with temperature ranging from 5°C to 55°C (Ética Miltex Instrument Co Inc.) for 800 cycles. A distance of

2 mm beyond the restorations was delimited, which was sealed with 3 coats of nail varnish.

The dye used was a 50% silver nitrate solution, to clearly delimit the leakage areas. The samples were immersed in the solution at room temperature for

24 hours. After the immersion period had elapsed, the specimens were removed from the solution and washed under running water for 5 min. Next, they were placed in a radiographic developer solution for 6 hours, under the action of a halogen lamp to produce the completely fixation of the silver ions entire dye leakage area. After this stage, the teeth were washed under running water for 20 min and kept at room temperature to dry.

Next, the teeth were sectioned longitudinally in the vestibular-lingual direction, in a low speed saw Labcut 1010 (Extel, Enfield, CT, USA) with diamond disks, resulting in three slices of approximately 1.0 mm thick each one, for each tooth. The slices were fixed onto glass slides and taken for observation under a Stemi/2000C Stereomicroscope (Carl Zeiss, Jena, Germany) at 25X magnification, coupled with a digital camera (Cybershot, Sony, Tokyo, Japan). The images were analyzed with the Image Tool 3.0 software to measure the dye penetration area. The data obtained were submitted to the analysis of variance ANOVA and Tukey's test at a 5% level of significance.

## RESULTS

The ANOVA test showed a value of  $p=0.73$ , which indicated that there was no significant difference among the groups. Group 1 in which the resin cement Enforce (Dentsply, Petrópolis, RJ, Brazil) was used presented a mean of  $0.96(\pm 0.7)$ , Group 2 in which the resin cement RelyX ARC (3M ESPE) was used presented a mean of  $1.10(\pm 0.63)$  and Group 3 in which the resin-modified glass ionomer cement RelyX Unicem Aplicap (3M ESPE) was used, presented a mean of  $0.99(\pm 0.35)$ . The results are showed in Table 1.

**Table 1 – Mean ( $\pm$  standard deviation) values for the different groups.**

GROUP	CEMENT	MEAN ( $\pm$ S-D)*
01	Enforce	$0.96(\pm 0.7)^A$
02	Relyx ARC	$1.10(\pm 0.63)^A$
03	Rely X Unicem Aplicap	$0.99(\pm 0.35)^A$

Means accompanied by the same letters (Homogeneous Sets) do not present statistically significant differences by the Tukey test ( $p=7.3$ ).

## DISCUSSION

Microleakage is defined as the seepage of oral fluids containing bacteria and debris between a tooth and its restoration or cement layer. The process of microleakage can affect the tooth-cement interface associated with an indirect restoration as well as the tooth foundation<sup>3</sup>. The esthetic properties of luting agents are considerable important with the increasing demand for ceramic restorations, especially in anterior teeth. Nevertheless, the marginal adaptation of these indirect restorative materials is a fundamental question in the longevity of the esthetic restorative treatment. Marginal openings and microleakage are important causes of the failure of indirect restorations<sup>3</sup>. Considering the importance of adequate marginal sealing to prevent microleakage and consequent failure of restorations, many materials and luting techniques are available, but when the clinical and laboratory results are evaluated, there is no consensus about which material and luting technique is closest to the ideal.

Adhesive luting agents present physical properties of bonding between indirect restorations and the dental structure and play a pivotal role in sealing the margins and prevent marginal leakage. However, most of the dental cements available cannot guarantee continual impermeability<sup>3,17</sup>.

Another important factor to assure adequate physical and biologic properties is the proper cure of resin cements. The difficulty the light source has in penetrating the deeper areas of indirect restorations also created the potential for marginal leakage and bacterial penetration, due to the partial conversion between the resin cement/dental structure interface<sup>20</sup>. This frequently leads to marginal discoloration, secondary caries and post-operative sensitivity.<sup>25</sup>

Dual cure resin cement was introduced to overcome a disadvantage of light cure cements, that was restricted by the depth of conversion of the luting agent, in which transmission of light is diminished between the tooth and the prosthetic part. Light cured materials can reach a rate of conversion of approximately 90%, while in these same luting agents isolated from light activation, the conversion was approximately 10% less in all cases.<sup>8</sup> The dual cure resin cements reduce the stress polymerization shrinkage, resulting in a better marginal adaptation and sealing of the indirect restoration<sup>11</sup>.

RelyX Unicem Aplicap is a self-adhesive resin-modified glass ionomer cement that present adhesive properties both to dentin and to enamel<sup>27</sup>, provides

a chemical bond with the calcium of the dental structure<sup>5</sup>, releases fluorides<sup>10</sup>, has antibacterial action<sup>14,23</sup>, flexibility<sup>12,28</sup>, increased resistance to salivary dissolution<sup>19</sup> and problems related to the physical properties of syneresis and imbibitions are reduced.<sup>13</sup> The commercial presentation of this resin-modified glass ionomer cement also offers triple cure or triple activation: the acid-based reaction of glass ionomer, light activation of the resin and the third reaction of chemically activated cure of the resin.

Another important factor to consider is the ease of application of the self-adhesive glass ionomer cement, which does not use previous treatment of the dental structure (acid etching, primer and adhesive application) and has a predetermined proportion for manipulation in capsules. Ilie<sup>9</sup> related that mechanically manipulated capsule cementation systems, used in units, have superior mechanical properties when compared with hand manipulated systems, due to the homogeneity of the proportion of the encapsulated material being more precise than that of the powder-liquid proportion system, diminishing the insertion of bubbles and maintaining its physical properties and the clinical success of the restorations.

The three luting agents used in this study presented a small difference among them, but without statistical significance, demonstrating similar behaviors in the proposed research situation. Enforce, Rely X ARC and RelyX Unicem Aplicap shown to have similar values of microleakage and marginal sealing. Motta et al.<sup>16</sup> compared the microleakage of the resin cements Enforce and Rely X ARC, and concluded that there

were similar behaviors between the cements analyzed, confirming the results of the present study. However, Piwowarczyk et al.<sup>18</sup> compared Rely X Unicem with Rely X ARC and observed greater microleakage both in enamel and dentin of the dual resin cement Rely X ARC in comparison with the resin-modified glass ionomer cement Rely X Unicem. The basis of this result could be the presence of methacrylate in the composition of the cement RelyX Unicem, making it capable of interacting with the tooth surface, forming complex combinations with the calcium ions, resulting in bonding to enamel and dentin, thus obtaining better sealing at the tooth/cement interface.

The results are based only on the efficiency of marginal sealing of each tested system, and does not take into consideration the other properties the luting agents offer, since the professional's choice of which technique and luting agent are closest to the ideal for use must be based on the individual clinical history of each patient<sup>24</sup>. Thus one can consider the ease of using resin modified glass ionomer cement as another important factor for cementation, because being self-adhesive, it has the advantage of eliminating pre-treatment of the tooth, and the proportion of cement is predetermined in capsules.

## CONCLUSION

It was concluded that the 3 luting agents presented no statistical significance regarding the marginal microleakage, demonstrating similar behaviors in the proposed research situation.

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## RESUMO

O objetivo deste estudo foi avaliar o selamento de restaurações indiretas de resina cimentadas com três diferentes agentes de cimentação. Foram empregados 30 dentes bovinos onde foram realizados preparos cavitários tipo caixa no terço médio da face vestibular. As cavidades foram restauradas com resina composta indireta Resilab. Aleatoriamente, os dentes foram separados em três grupos: Grupo 1: condicionamento com ácido fosfórico a 37% por 30s, sistema adesivo Prime Bond 2.1 (Dentsply) e cimento resinoso Enforce (Dentsply); Grupo 2: condicionamento com ácido fosfórico a 37% por 30s, sistema adesivo Single Bond (3M ESPE) e cimento resinoso RelyX ARC (3M ESPE) e Grupo 3: cimento de ionômero de vidro resino modificado RelyX Unicem Aplicap (3M ESPE). As peças foram cimentadas com os respectivos cimentos e os espécimes termociclados por 800 ciclos. Para avaliação de infiltração utilizou-se o corante nitrato de prata a 50 % por 24h. Os dentes foram seccionados no sentido vestibulo-lingual em 3 fatias de 1 mm, fixados em lâmina de vidro e avaliados em estereomicroscópio, onde havia uma câmera digital acoplada e as imagens foram registradas e áreas de infiltração marginal posteriormente mensuradas pelo software Image Tool 3.0. Os dados obtidos foram submetidos aos testes estatísticos ANOVA e Tukey. ANOVA demonstrou não haver diferenças estatísticas entre os grupos ( $p=0,73$ ). As médias (desvio padrão) foram: Grupo 1=0,96( $\pm 0,71$ ); Grupo 2: 1,10( $\pm 0,63$ ) e Grupo 3:0,99( $\pm 0,35$ ). Concluiu-se que os 3 agentes de cimentação apresentaram entre eles uma pequena diferença, porém não estatisticamente significativa, em relação a microinfiltração marginal, demonstrando comportamentos semelhantes diante proposição desta pesquisa.

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Microinfiltrações; selamento marginal; restaurações indiretas.

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