IN VITRO EVALUATION OF MARGINAL MICROLEAKAGE IN RESTORATIONS CLASS V WITH COMPOSITE RESINS

AVALIACIÓN IN VITRO DE LA MICROINFILTRACIÓN MARGINAL EN RESTAURACIONES CLASE V CON RESINAS COMPUESTA

AVALIAÇÃO IN VITRO DA MICROINFILTRAÇÃO MARGINAL EM RESTAURAÇÕES CLASSE V COM RESINAS COMPOSTA

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Abstract
Objective: Evaluate the marginal microleakage in restorations with three different composite resins. Material and Methods: Thirty premolars were used, where class V cavities were made. The samples were divided into three groups: G1 (Microparticulate), G2 (Micro-hybrid), G3 (Nano-hybrid). After the restorations have been made, the samples were thermocycled for 250 cycles. The teeth were waterproofed and placed in 1% methylene blue solution for 24 hours. Results: The quantitative evaluation of the degree of dye penetration showed that all groups had marginal infiltration, however they had it in varying degrees, highlighting that the nano-hybrid composite resin presented the lowest values of marginal infiltration and the microparticulate composite resin had the highest values, and the group of micro-hybrid and nano-hybrid composite resin did not present statistically significant differences. Conclusion: All the groups evaluated have undergone infiltration to some degree.
Keywords: Materials. Dental Restoration, Permanent. Dental restoration failure.

Resumen
Objetivo: Evaluar la microfiltración marginal en restauraciones con tres resinas compuestas diferentes. Material y Métodos: Se utilizaron 30 premolares, donde se realizaron cavidades de clase V. Las muestras se dividieron en tres grupos: G1 (Microparticulado), G2 (Microhíbrido), G3 (Nanohíbrido). Después de realizar las restauraciones, las muestras se termociclaron durante 250 ciclos. Los dientes se impermeabilizaron y se colocaron en solución de azul de metileno al 1% durante 24 horas. Resultados: La evaluación cuantitativa del grado de penetración del tinte mostró que todos los grupos tenían infiltración marginal, sin embargo la tenían en grados variables, destacando que la resina compuesta nanohíbrida presentaba los valores más bajos de infiltración marginal y la resina compuesta microparticulada tenía la mayor valores, y el grupo de resina compuesta microhíbrida y nanohíbrida no presentó diferencias estadísticamente significativas. Conclusión: Todos los grupos evaluados sufrieron infiltración en algún grado.

Resumo
Objevtivo: Avaliar a microinfiltração marginal em restaurações com três diferentes resinas compostas. Material e Método: Trinta pré-molares foram utilizados, onde foram feitas cavidades classe V. As amostras foram divididas em três grupos: G1 (Microparticulada), G2 (Microhíbrida), G3 (Nanohíbrida). Após as restaurações terem sido realizadas, as amostras foram termocicladas por 250 ciclos. Os dentes foram impermeabilizados e colocados em solução de azul de metileno a 1% por 24 horas. Resultados: A avaliação quantitativa do grau de penetração do corante mostrou que todos os grupos apresentaram infiltração marginal, porém variaram em graus variados, destacando que a resina composta nano-híbrida apresentou os menores valores de infiltração marginal e a resina composta microparticulada apresentou os maiores valores, e o grupo de resina composta micro-híbrida e nano-híbrida não apresentou diferenças estatisticamente significativas. Conclusão: Todos os grupos avaliados sofreram infiltração em algum grau.
Introduction

Dentistry has undergone changes in some of its concepts, being part of the routine of the dental offices and clinics the search for treatments more aesthetic and conservative. Therefore, the resin has been the subject of intense research in order to improve the negative properties that it presents. The utilization of composite resins still requires use criteria and the unrestricted use of this restorative material will only be possible after further development and improvement of its physicochemical properties.

The formation of an effective bonding interface between the tooth and the restorative material is one of the determinant factors for the marginal microleakage control. The rupture of the adhesive interface is a failure that frequently occurs in composite resins restorations caused by polymerization shrinkage, resulting in a volumetric reduction.

The composite resin has three structural components: organic matrix (a plastic resinous material that forms a continuous phase and binds to the charge particles), inorganic particles (reinforcing particles and / or fibers dispersed in the matrix) and the bonding agent (promotes adhesion between the particles and the resin matrix).

The polymerization shrinkage occurs when the monomers (organic part) are transformed into polymers. The more inorganic fillers, the less the amount of organic matrix, the greater the modulus of elasticity. The rupture in tooth-restoration interface may present as clinical consequence the marginal discoloration, marginal fractures, secondary caries, postoperative pain and development of pulpal pathology, all of which endangered the longevity of the restoration.

The dental surgeon must know and respect the correct indications of composite resins, aiming the longer permanence of the restorative material in the cavity preparation. Follow strictly the clinical protocol and instruct the patient about how to control the etiological factors of caries disease are ethical duties of a dental professional.

Considering the intense search for aesthetics by the population, the composite resin has been the material of choice in most of the restorative procedures performed by the dental surgeon, concomitantly has presented significant rates of failure, arising the interest to investigate which type of resin has lower rates of microleakage and thus less damage to biological tissues and greater longevity. Therefore, this study aimed to evaluate in vitro the marginal microleakage in class V restorations of premolar teeth using three different composite resins as restorative material.

Material and Methods

All procedures in this study followed the ethical principles established by the legislation in force, therefore this study was submitted to Ethics Committee in Research (ECR) from State University of Piauí (UESPI), pursuant to resolution CNS 466/2012 and approved under the CAAE number 4245515.0.0000.5209.

Thirty human premolars were used from UESPI Human Teeth Bank, which were stored in water under refrigeration until the beginning of the procedure. Teeth were submitted to steam sterilization, followed by prophylaxis with prophylactic paste, powdered pumice stone and water.

Class V cavities were made on the vestibular face, with the following characteristics: 3 mm width (mesiodistal) and 2 mm tall (cervical-occlusal) and 1.5
mm depth, measures granted by millimetric probe, as well as clear cavo-superficial angles located in enamel. The cavity preparation was performed with KG Sorensen diamond drills (Cotia, São Paulo, Brasil) n°1095 with high speed handpiece. The diamond drill was replaced every 10 cavity preparations. The 30 premolars teeth were randomly divided into three groups of ten teeth each one and than they were restored with the following materials: G1: microparticulate resin - Durafill® VS (Heraeus Kulzer, Hanau, Germany), G2: microhybrid resin - Charisma® Opal (Heraeus Kulzer, Hanau, Germany) and G3: nanohybrid - Charisma® Diamond (Heraeus Kulzer, Hanau, Germany). The Gluma® 2 Bond adhesive system (Heraeus Kulzer, Hanau, Germany) was used. All materials were used as manufacturer's instructions. Previous prophylaxis has been made, washing and drying and then the acid conditioning was done for 30 seconds in enamel and 15 seconds in dentin. Cavity wash was made with water jet and dried with a light air jet. With microbrush aid (Heraeus Kulzer, Hanau, Germany) the adhesive system was applied on entire cavity surface, allowing it act for a period of 15 seconds, than dried with a gentle jet of air and photoactivated for 20 seconds. The restoration was performed by incremental technique and each layer was photoactivated for 20 seconds (Bio-Art Photopolymerizer, São Carlos, Brazil). After completion of restorations, teeth were stored in distilled water with final polishing and finishing performed after 24 hours. 

In a next step, the samples were thermocycled for 250 cycles at 5 and 55°C (Biometra Thermal Cycler, Göttingen, Germany) and immersed in saliva phosphate buffer solution (pH 7.4) at each temperature the samples remained for 30 seconds. Subsequently, the dry teeth were waterproofed with two layers of Universal Instant Adhesive Super Bonder (Loctite®, São Paulo, Brazil) and two layers of cosmetic enamel (Risqué®, Barueri, Brazil), except 1 mm around the margin of restoration. 

Afterwards, the dental elements were immersed in 1% methylene blue solution Cinética® (Jand Química, Jandira, Brazil), for a period of 24 hours. After this time the samples were taken out of the solution, washed in running water and dried. The teeth were fixed in a self-cured acrylic resin base (Clássico, São Paulo) and sectioned at the center of the restorations in the longitudinal buccolingual direction with a carborundum disk (American Burrs®, Porto Alegre, Brazil) mounted on low-speed handpiece (Kavo, Santa Catarina, Brazil) totaling 60 faces for analysis. The evaluation of dye penetration was made using a stereoscopic magnifying glass (Nova Optical Systems©, Piracicaba, Brazil) with a tenfold increase by a single examiner trained for this purpose, based on the scores: Grade 0: no infiltration; Grade 1: dye infiltration until one third of the surrounding wall; Grade 2: dye infiltration until two-thirds of the surrounding wall; Grade 3: dye infiltration until three-thirds of the surrounding wall, reaching or not the bottom wall (Figure 1). Each test piece was analyzed through the Image J program (Version 1.50) and then noted the highest degree of infiltration. And finally the findings of infiltrations were statistically analyzed using Kruskal-Wallis non-parametric test with significance level of 5%.
Results

In this study 30 restorations in premolars were evaluated, totaling 60 faces for the analysis. Of these, 3 faces were eliminated due to the occurrence of microleakage due to the rupture of the tooth-restoration interface caused by stress during thermocycling.

The number of marginal infiltration scores observed on the faces of the three groups for the different composite resins are shown in Table 1.

**Table 1. Distribution of marginal infiltration scores observed in each group.**

<table>
<thead>
<tr>
<th>Scores</th>
<th>Group 1 (Microparticulate)</th>
<th>Group 2 (Micro-hybrid)</th>
<th>Group 3 (Nano-hybrid)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>20</td>
<td>19</td>
</tr>
</tbody>
</table>

From the sample characteristics, a one-factor Kruskal-Wallis ANOVA was performed in all three groups. When analyzing the average of the posts, it is verified, according to Table 2, that the group 1 (Microparticulate) presents the highest average, followed by group 2 (Micro-hybrid) and group 3 (Nano-hybrid). The results presented a $\chi^2$ (chi-square) of 9.41 with an associated probability of 0.009. Therefore, it is concluded that there are statistically significant differences in marginal leakage observed in each group.
Table 2. Distribution of groups according to sum and average of the stations.

<table>
<thead>
<tr>
<th>Group</th>
<th>Sum of stations</th>
<th>Average of stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11.67</td>
<td>38.33</td>
</tr>
<tr>
<td>2</td>
<td>3.64</td>
<td>26.10</td>
</tr>
<tr>
<td>3</td>
<td>2.69</td>
<td>23.21</td>
</tr>
</tbody>
</table>

The comparison between groups, according to Table 3, shows that there was a statistically significant difference (*p*<0.05), between G1 x G2; G1 x G3 and that there was no difference between G2 x G3.

Table 3. Comparison between groups.

<table>
<thead>
<tr>
<th>Samples compared (two to two)</th>
<th>Difference between the averages</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 X Group 2</td>
<td>8.34</td>
<td>0.02*</td>
</tr>
<tr>
<td>Group 1 X Group 3</td>
<td>9.62</td>
<td>0.005*</td>
</tr>
<tr>
<td>Group 2 X Group 3</td>
<td>2.16</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Note: *p < 0.05 (significant)

Considering the results found in this research, it was possible to prove that none of the three resin types were able to prevent marginal microleakage, with all groups presenting values of microleakage. Separately analyzing the restorative material, it was found that while the composite nano-hybrid resin (Group 3) had the lowest values of marginal infiltration, the microparticulate (Group 1) had the highest values.

Discussion

The resin matrix often consists of Bis-GMA (bisphenol-A glycidyl methacrylate) or UDMA (urethane dimethacrylate). They constitute the chemically active part, as they will establish crosslinks at the time of polymerization, conferring resistance to the material. Due to the high molecular weight, Bis-GMA and UDMA are extremely viscous at room temperature, which makes it difficult to incorporate filler into the resin matrix. To make the material more fluid to be used clinically, the dimethacrylate based diluents TEGDMA (triethylene glycol dimethacrylate) and EDMA (ethylene glycol dimethacrylate) are included, reducing their viscosity. However, the incorporation of these diluents increases the polymerization shrinkage of the composite resins.\(^{(15)}\)

According to Gonçalves et al.\(^{(16)}\), higher amounts of inorganic fillers imply a smaller amount of organic matrix, which is subject to contraction during polymerization. Therefore, the inorganic particles content is inversely related to the percentage of contraction of the material and the tension experienced by the adhesive interface during its polymerization. Increasing inorganic particles content, the polymerization shrinkage, linear expansion coefficient and water absorption are reduced and the compressive strength, wear, traction and elasticity modulus are increased.\(^{(17)}\) In order to reduce the polymerization shrinkage, it was necessary to increase the percentage of inorganic particles of the composite resins, so it was reduced the particle size, which allows a better distribution of the inorganic particles.\(^{(18)}\)
The use of nanotechnology in composite resins allowed the size reduction of inorganic particles and allowed the reduction of the polymerization stress and increased resistance to wear.\(^\text{[19]}\)

In this study, Durafill\(^\text{®}\) VS (microparticulate) resin presented the highest marginal microleakage scores, which may be caused by the presence of TEGDMA monomer in the organic matrix composition and a low percentage of inorganic particles volume. Factors that favor the occurrence of a high polymerization contraction.\(^\text{[6,7,15]}\)

The Charisma\(^\text{®}\) Diamond composite resin presented the lowest rates of marginal microleakage. In their composition are the monomers UDMA and TCD-DI-HEA (bis- (acryloyloxymethyl) tricyclo [5.2.1.0.sup.2.6] decane. According to Suzuki et al.\(^\text{[20]}\), the TCD-DI-HEA monomer provides low polymerization shrinkage, low viscosity and higher wear resistance.

There was no statistically significant difference between Charisma\(^\text{®}\) Opal (micro-hybrid) and Charisma\(^\text{®}\) Diamond (nano-hybrid) resins \((p>0.05)\). This result may be due to the similar amount of particle volume, being 58% and 64% respectively. Mahmud et al.\(^\text{[21]}\) (2008) in a follow-up of 2 years verified a very acceptable clinical performance of the resins with nanotechnology being similar to a micro-hybrid resin.

Further research involving marginal microleakage tests should be developed to increasingly explain the performance of composite resins in cavity preparations in order to promote the better longevity of restorative procedures.\(^\text{[13]}\)

Conclusions

According to the methodology used, it is concluded that:
- None of the composite resins were able to prevent marginal infiltration;
- The nano-hybrid resin (Group 3 / Charisma\(^\text{®}\) Diamond) had the lowest infiltration scores, and the microparticulate (Group 1 / Durafill\(^\text{®}\) VS) had the highest scores;
- In the comparison between the groups, it was verified that there was a statistically significant difference \((p<0.05)\) between G1 x G2; G1 x G3 and that there was no difference between G2 x G3.

References


