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In vitro evaluation of microleakage in Class V restorations after cavity preparation with high-speed diamond bur, ultrasonic tip or laser

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ABSTRACT | *Objectives:* One of the difficulties in restorative dentistry continues to be microleakage around cavities restored with esthetic materials. Microleakage is the factor that most influences restoration durability. It is characterized by gap formation due to failure of the restorative material to bond to cavity walls. The aim of this *in vitro* study was to compare the degree of microleakage of Class V restorations when different instruments are used for cavity preparation. *Methods:* Class V cavities were performed in 30 bovine teeth divided into three treatment groups (n = 10): G1, preparation with a diamond bur; G2, preparation with an Er,Cr:YSGG laser (2.78 µm); and G3, preparation with diamond tips and an ultrasonic system (CVDentus). All cavities were restored with composite resin, according to the manufacturer's specifications. The specimens were submitted to thermal cycling (700 cycles, 5°C ± 1°C and 55°C ± 1°C) and immersed in 2% methylene blue to evaluate microleakage. The teeth were sectioned longitudinally and images were captured using a stereomicroscope at 50× magnification. Three evaluators examined the images according to the scale proposed by Retief. Data were analyzed by the Kruskal-Wallis and Dunn tests. *Results:* Statistically significant differences were observed between the treatment groups ($p = 0.0007$). The highest microleakage rates were found for G2, which differed significantly from those of the other treatment groups. There was no statistically significant difference between G1 and G3. *Conclusion:* Different cavity preparation techniques may influence microleakage in Class V restorations, and the ultrasound technique was found to be an effective alternative.

DESCRIPTORS | Dental Leakage; Dental Cavity Preparation; Ultrasonic Surgical Procedures; Laser Therapy.

RESUMO | **Avaliação *in vitro* da infiltração marginal em restaurações classe V após preparo cavitário com broca diamantada, ponta de ultrasson ou laser** • *Objetivos:* Uma das dificuldades da dentística restauradora continua a ser a microinfiltração ao redor das cavidades restauradas com material estético. A microinfiltração é o fator que mais influencia na durabilidade de uma restauração. É caracterizada pela formação de fendas devido à falha do material restaurador em aderir às paredes da cavidade. O objetivo deste estudo *in vitro* foi comparar o grau de infiltração marginal de restaurações Classe V quando diferentes instrumentos são utilizados para o preparo cavitário. *Métodos:* cavidades Classe V foram realizadas em 30 dentes bovinos divididos em três grupos de tratamento (n = 10): G1, preparo com broca diamantada; G2, preparo com laser Er,Cr:YSGG (2,78 µm); e G3, preparo com pontas diamantadas e um sistema de ultrassom (CVDentus). Todas as cavidades foram restauradas com resina composta, de acordo com as especificações do fabricante. Os espécimes foram submetidos à ciclagem térmica (700 ciclos, 5°C ± 1°C e 55°C ± 1°C) e imersos em azul de metileno a 2% para avaliar a infiltração. Os dentes foram seccionados longitudinalmente e as imagens foram captadas com uma lupa estereoscópica com ampliação de 50×. Três avaliadores examinaram as imagens de acordo com a escala proposta por Retief. Os dados foram analisados pelos testes de Kruskal Wallis e de Dunn. *Resultados:* diferenças estatisticamente significativas foram observadas entre os grupos de tratamento ($p = 0,0007$). As maiores taxas de microinfiltração foram encontrados no grupo G2, as quais diferiram significativamente daqueles encontradas nos outros grupos de tratamento. Não houve diferença estatisticamente significativa entre G1 e G3. *Conclusão:* Diferentes técnicas de preparo cavitário podem influenciar na microinfiltração em restaurações Classe V, e a técnica de ultrassom mostrou-se uma alternativa eficaz.

DESCRITORES | Infiltração Dentária; Preparo da Cavidade Dentária; Procedimentos Cirúrgicos Ultrassônicos; Terapia a Laser.

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INTRODUCTION

In the field of restorative dentistry, one of the difficulties continues to be microleakage around cavities restored with esthetic materials. Even with the advent of acid etching by Buonocore, in 1955,[1] and of the adhesive systems, which have contributed positively to improve marginal sealing, microleakage has not yet been completely eliminated.

The absence or loss of a marginal seal of restorations can result in recurrent caries, marginal discoloration, hypersensitivity and pulp injuries.[2]

Microleakage is characterized by gap formation due to failure of the restorative material to bond to cavity walls, leading to passage of molecules, ions, bacteria and fluids,[3,4] and is the factor that most influences durability of the restoration.[4,5] Several factors are reported to influence the degree of microleakage, such as the difference in the thermal expansion coefficient between the tooth and the restorative material,[6] water absorption by the restoration when exposed to the oral environment, polymerization shrinkage of the resin during the polymerization process, and shape of the cavity preparation.[7] Several methods and materials have been studied in an endeavor to obtain an adequate seal between the restorative material and the tooth structure.[4] In addition to use of the etching technique, new adhesive systems, composite resins and tools for dental structure preparation have also been proposed.

Conventional tooth-cavity preparation techniques usually involve diamond burs fitted to high-speed handpieces. However, this technique leaves a *smear layer* on the tooth surface after enamel and dentin removal. This layer is removed by acid etching, for subsequent application of an adhesive system, thus forming a hybrid layer. Studies have reported that the longer the etching time, the lower the bond strength of the restorative material to the dental substrate, leading to consequent microleakage;[7-9] therefore, the manufacturer's guidelines should be followed, and the etching time should not be longer or shorter than the recommended time. Recently, other cavity preparation methods have been introduced. Apart from causing patients less discomfort,[6] proposed techniques support the philosophy of minimally invasive dentistry and propound to preserve tooth structure and cause minimal damage to pulp tissue.[10] Among these techniques, the ultrasonic system has been widely studied. Its mechanism of action is based on the kinetic energy of water molecules, transferred to the tooth surface via an abrasive tip. This ensures an accurate and efficient cut, and facilitates access to the most difficult locations.[10,11] Considering the homogeneity and surface smoothness of cavity walls, this technique makes it easier to clean and etch the tooth surface for subsequent restorative procedures,[4] thereby contributing to reducing microleakage.

Another new method is the high power laser, such as the Er,Cr:YSGG laser, which selectively removes mineralized dental tissue (enamel and dentin) by thermo-mechanical ablation. Depending on the energy density used, it can promote enamel etching, leaving a rough, smear-layer-free surface.[6,7,12] The irregularities created on enamel and dentin surfaces as a result of irradiation are described as producing micromechanical retention that can contribute positively to the restorative material bond to the tooth surface.[6]

Several authors have evaluated the influence of cavity preparation instruments on microleakage around Class V restorations,[10,12-15] but there is still no consensus in the literature about which instrumentation technique results in the lowest degree of microleakage.

When the degree of microleakage between restorations in cavities prepared using a diamond bur and those prepared using a high-power laser were compared, some authors reported that the highest microleakage rates were found when the former technique was used.[2,10] In contrast, other studies[9,13] have found that restorations performed in cavities prepared with a high-power laser showed higher microleakage, as compared with the use of diamond tips.

Studies evaluating the difference in microleakage between preparations using high-speed drills *versus* an ultrasonic system have reported that there was no significant difference between the two preparation methods.[7,16] However, Corona (2001)[10] stated that a cavity prepared with ultrasound has a lower rate of microleakage than that prepared with a high-speed handpiece equipped with a diamond bur.

Up to the present, there is no study in the literature which assesses the degree of microleakage using these three types of instruments for cavity preparation. The aim of this *in vitro* study was to compare the degree of microleakage of Class V restorations in cavities prepared using a high-speed handpiece equipped with a diamond bur, the Er,Cr:YSGG laser and an ultrasonic system.

MATERIALS AND METHODS

In the present study, 30 intact bovine teeth were used. They were immersed in 0.9% saline solution to keep the substrate hydrated until the research began. After prophylaxis with pumice and water, the teeth were divided into three groups (n = 10):

- G1, preparation using a high-speed handpiece equipped with a diamond bur;
- G2, preparation with the Er,Cr:YSGG laser (2.78 mm); and
- G3, preparation with diamond tips coupled to an ultrasonic system.

After removing the root (about 1.0 mm beyond the cementoenamel junction), cavities were prepared in the cervical third of the tooth crown, leaving enamel margins. The cavity size was standardized at 4 mm wide × 2 mm high × 2 mm deep, with rounded margins.

The dimensions were measured with a digital caliper (Mitutoyo, Santo Amaro, Brazil) and a probe with millimeter markings (Duflex, SS White, Pinhais, PR, Brazil). Cavities were prepared using three different methods as described below:

- G1, high-speed handpiece equipped with a diamond bur: the preparations were performed with cylindrical diamond bur #1013 (KG Sorensen Ind. e Com Ltda., São Paulo, SP, Brazil) coupled to a high-speed handpiece, under water/air cooling.
- G2, Er,Cr:YSGG Laser (Waterlase Millennium; Biolase, San Clemente, CA, USA): the MPV handpiece was positioned perpendicular to the dentin surface (90°), approximately 1 mm from the tooth surface (focused mode). A sapphire tip 600 µm in diameter (G6) was used, with output power ranging from 4.5 W (enamel) to 2.5 W (dentin). Irradiation was carried out under constant cooling with water (55%) and air (65%).
- G3, CVD ultrasound tips: the cavities were prepared with cylindrical diamond tips (CVDentus® C1; Clorovale Diamond Ind. Com Ltda, Sao José dos Campos, São Paulo, SP, Brazil) coupled to the CVDent U.S. 1000 unit (Clorovale Diamond), with 70% power, cooled with water, perpendicular to the sample surface.

Following cavity preparation, all the cavities were cleaned with anionic detergent (Tergentol; Biodynamic Quim. Farm. Ibiporã, PR, Brazil) and dried with absorbent paper. Enamel and dentin etching was performed with 37% phosphoric acid (3M-ESPE, St. Paul, MN, USA), according to the manufacturer's instructions. The teeth were washed with water for 15 s, and excess water was removed with absorbent paper, giving them the appearance of having moist dentin and dry enamel. Next, two layers of adhesive (Single Bond 2, 3M-ESPE) were applied to the cavity wall surface, using a disposable microbrush (KG Sorensen), according to the manufacturer's instructions.

All cavities were filled with composite resin (Filtek Z-350; 3M-ESPE), shade A1, using the incremental layering technique in increments of approximately 1 mm. Each increment was polymerized for 20 s using a halogen light source with a power intensity of approximately 650 mW/cm² (Visilux 2; 3M-ESPE).

The specimens were polished immediately after the restorative procedures with diamond burs sizes F and FF (KG Sorensen) and the Sof-lex system (3M-ESPE). Then the teeth were kept immersed in 0.9% saline solution, at 37°C (Oneon - 502; Fanem, Sao Paulo, Brazil) for 24 h.

Thermal cycling

Before thermal cycling, the teeth were dried with absorbent paper and sealed with two layers of an acid-resistant varnish (Colorama, São Paulo, SP, Brazil), leaving the restoration surface and the area 1 mm around it exposed. All samples were submitted to thermal cycling, consisting of 700 cycles of 5°C ± 1°C and 55°C ± 1°C, and remained 1 minute in each bath.[17] Methylene blue dye (2%) was added to the thermocycling water, to keep the samples in contact with the dye throughout all the cycles. The samples were then immersed in 2% methylene blue for an additional 24 h at 37°C. After this period, the teeth were rinsed and brushed to remove excess dye, and were left to dry naturally at room temperature.[15]

Microleakage analysis

In order to facilitate sample handling, the tooth samples were embedded in acrylic cubes. Then, they were taken to the cutting machine (Labcut 1010; Extec Corp, London, England) and sectioned in the buccolingual direction, separating the mesial from the distal surfaces. The sections were observed under a stereomicroscope at 50× magnification (SZ61; Olympus America Inc., Center Valley, PA, USA), and images were captured with a camera coupled to a magnifying glass (X-42; Olympus America). Three examiners evaluated the images according to the scale proposed by Retief[18] (1991):

- 0 = no microleakage;
- 1 = microleakage up to the dentin-enamel junction;
- 2 = microleakage reaching the sidewalls of the preparation;
- 3 = microleakage reaching the axial wall of the preparation.

The three evaluations of each sample (by three different examiners—the Kappa test was performed to measure the accuracy between examiners) produced a final microleakage score. The data were subjected to statistical analysis by the Kruskal-Wallis and Dunn tests.

RESULTS

The results of microleakage according to the Retief scale are described in Table 1, and the microleakage analysis is described in Table 2. The Kruskal-Wallis test revealed that there was a statistically significant difference between the treatment groups (p = 0.0007). Group 2 (Er,Cr:YSGG laser) showed the highest levels of microleakage and differed statistically from the other treatment groups. G1 and G3 showed no statistically significant differences between each other ($p > 0.05$).

DISCUSSION

Restorative dentistry plays an important role in the mechanical, biological and social aspects of dentistry, making esthetics an appealing feature of restorations in anterior and posterior teeth. One of the main reasons for restoration failure is microleakage, caused by the passage of bacteria, fluids, molecules and/or ions between the cavity walls and the restorative material. Clinically, this can be observed by stains on restoration margins, loss of

Table 1 | Results of microleakage by the Retief scale.

Influence of the instruments used for cavity preparation	Diamond bur G1	Er:Cr:YSGG laser G2	CVD G3
1	0	1	0
1	0	1	0
1	1	1	1
2	3	2	0
2	3	2	0
2	3	3	0
3	0	1	1
3	0	1	1
3	0	3	1
4	0	1	1
4	0	2	2
4	0	1	2
5	1	1	0
5	1	1	0
5	1	1	1
6	0	1	1
6	1	1	2
6	1	2	2
7	1	2	2
7	1	1	1
7	1	1	1
8	1	1	1
8	1	2	1
8	1	1	0
9	1	3	3
9	1	3	3
9	1	3	3
10	1	2	0
10	1	3	0
10	0	2	0

marginal integrity, recurrent caries at the tooth/restoration interface, and hypersensitivity of restored teeth, in addition to the possible development of pulp pathology.[3,4] In an endeavor to minimize microleakage, several authors have studied the influence of cavity configuration, variations in restorative techniques and types of preparation, making use of the Er,Cr:YSGG laser, high-speed burs or an ultrasonic system. The literature shows that each of these instruments produces different patterns of smear layer and dentin surface morphology.[10] Considering that the surface roughness of the substrate and the thickness, composition and density of the smear layer may influence the seal between the tooth and the restoration, it is of utmost importance to have a working knowledge of these factors.[10] Yazici *et al.*[12] compared the microleakage in preparations made with Er,Cr:YSGG laser, bur and ultrasound, and found no differences in microleakage among the preparation techniques. However, this was not observed in the present study, where the highest level of leakage was found in the group of cavities prepared with the Er,Cr:YSGG laser, confirming the results reported by Borsatto *et al.* (2006)[19] and Delme *et al.* (2008),[20] who also used erbium lasers.

Table 2 | Comparative mean values of the Dunn test.

Comparisons	*p*
Group 1 versus Group 2	< 0.05
Group 1 versus Group 3	ns
Group 2 versus Group 3	< 0.05

Although studies have reported the benefits of high-power lasers for cavity preparation—including reduced post-preparation sensitivity, greater acceptance by patients and microbial reduction—the effects of laser irradiation on hard tissues continues to be questioned. Although some authors have reported the benefits of lasers as regards adhesion to enamel and dentin,[12,21] others have mentioned that Er:YAG and Er,Cr:YSGG lasers could promote surface and subsurface cracks in the irradiated substrate,[22] due to the mechanism of ablation and the parameters considered for irradiation. These cracks, in turn, could promote microleakage.[8,17] This could explain the results of the present study, in which microleakage was more evident on a laser irradiated surface.

When the microleakage found in cavities prepared with ultrasound and with high-speed burs was compared, no clinical difference was observed. This was also seen in studies by other authors[16] who evaluated the two methods by light microscopy, and concluded that there was no difference between conventional preparation using a high-speed bur, and the alternative method using ultrasound. Opdam *et al.* (2002)[16] compared the microleakage in cavity preparations (limited to enamel) performed with high-speed burs *versus* ultrasound, and found no statistical difference, corroborating the findings of Oliveira *et al.* (2009).[15] These authors used light microscopy to assess the microleakage in Class V composite resin restorations in cavities prepared with high-speed burs *versus* ultrasound and, despite the different surface characteristics found by the authors, the microleakage values were similar. This was also observed in the present study, where the lowest microleakage values were found for the groups treated with ultrasound and high-speed burs. This could be related to the fact that preparations made with an ultrasonic system can form a smooth surface with few cracks, a thin smear layer and smear plugs[10] of shorter length, thus favoring bonding and reducing microleakage.

Therefore, a good alternative to replacing high-speed burs in some clinical situations seems to be ultrasound equipment, since it presents microleakage results similar to those obtained with high-speed burs, and, in most cases, no anesthesia is required during removal of the carious tissue.

CONCLUSION

Within the limits of this *in vitro* study, it could be concluded that different tooth preparation techniques may affect microleakage in Class V restorations, and the ultrasound technique seems to be an effective alternative.

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