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Original

Preparation time and sealing effect of cavities prepared by an ultrasonic device and a high-speed diamond rotary cutting system

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Abstract: The purpose of this study was to compare a high-speed handpiece to an ultrasonic device regarding the time taken for cavity preparation in bovine incisor teeth (n = 12), and to evaluate microleakage after the restorations. Two cylindrical cavities each were prepared on the labial surfaces of 12 teeth. One of them was made with a diamond tip in group 1 (G_1 = 12) coupled with a high-speed handpiece, and the other with a chemical vapor deposition (CVD) tip in group 2 (G_2 = 12) coupled with an ultra-sound device (n = 24). The time taken for each preparation was measured with a stopwatch. The cavities were treated with adhesive (Scotchbond Multipurpose, 3M), restored with composite (Filtek Z250, 3M), finished and polished, and then the prepared teeth were immersed in a 50% silver nitrate solution. The samples were cut in the mesio-distal direction and evaluated for microleakage. Data were analyzed using the Wilcoxon test ($P < 0.01$). The results revealed that the time taken to prepare cavities was 7.9 times shorter in G_1. There was no microleakage in 100% of the samples indicated by the absence of dye penetration in G_1, and 46% in G_2. It was concluded that the performance of the high-speed handpiece was better than that of the oscillatory system, in terms of both the time taken for preparation and the microleakage. (J. Oral Sci. 49, 207-211, 2007)

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Introduction

Rotary instruments have been used in dentistry for over two hundred and fifty years and advances in technology have enabled efficient cavity preparation (1). The first dental drills, made of steel, were superseded by tungsten carbide. However, diamond drills were the first to be featured in the dental market (2). The technology which can be applied to improve conventional diamond drills is somewhat limited due to the heterogeneous shape of diamond granules, and their short-term durability (3,4). Added to that, they remove a good part of the sound portion of the tooth structure (5).

Current cavity preparation procedures demand a more cautious approach than the traditional procedures, with conservative removal of the carious tissue and use of adhesive restorations. This approach to the treatment is known as Minimally Invasive Dentistry (6).

As a solution to the above-mentioned problems, chemical vapor deposition (CVD) diamond tips were launched. A CVD diamond tip coupled with an ultrasound piece makes cavity preparations minimally invasive (7,8). The efficiency of this instrument can be attributed to an improved capacity of removing tooth structure within a minimum period of time and with minimum effort. Once this has been established, it will be easier to compare it with the efficiency of other instruments and standardize the time taken for the procedure.

Therefore, the aims of this in vitro study were to compare the time taken by a rotary cutting instrument (high-speed rotation) and an oscillatory one (ultrasonic, CVD) for cavity preparation in bovine teeth, and to evaluate how the use of these instruments affects microleakage in restorations.

Materials and Methods

This study was approved by the institutional ethics committee (#355/04). Twelve bovine teeth free of faults, cracks or critical wear were selected after microscopic evaluation (40×). The teeth were stored in saline solution, which was renewed every seven days, before embedding them in resin blocks for cavity preparation and restoration. The material was all handled in compliance with biosafety norms (9).

On the labial surfaces of each tooth, two class V cavities were prepared manually, one on the mesial side (AR) and the other on the distal side (US), with 2.0 mm width and 2.0 mm depth and without a cavosurface bevel. In order to standardize their depths, a groove was made on the active tip of each bur, equivalent to their depths and the width was measured with the aid of a digimatic caliper.

An operator, who was trained prior to the experiment, carried out all preparations and restorations. While the cavities were being prepared, a second researcher, using a stopwatch (Technos®, Manaus, Brazil) recorded the time taken for the preparations on a spreadsheet. The time taken for each cavity preparation was tabulated in the SPSS 11.0 statistical software and analyzed by the Wilcoxon test, with a significance level of 1%.

The samples were separated into two groups as described below.

Group 1 (High-speed diamond rotary instrument)

Twelve cavity preparations were performed using a high-speed rotating handpiece (Kavo Extra Torque® 605, Joinville, Brazil) with four cooling holes and a flat inverted cone short-shafted (1.60 mm) diamond tip number 1061 (KG Sorensen®, Alphaville, Brazil). The high-speed handpiece was operated for 10 sec, and then applied to the labial surface, under continuous air/water cooling (10). The diamond tip was replaced after every fifth preparation (11).

Group 2 (Ultrasonic device with CVD diamond tip)

The cavity preparations (n = 12) were performed using an ultrasonic device (Laxys Easy DMC®, São Carlos, Brazil) with a flat inverted cone CVD diamond tip UTP0525 (CVD®, São José dos Campos, Brazil) of diameter 0.5 mm and diamond powder of 2.5 µm. The ultrasound device was regulated to 70% of its maximum potency, and the CVD tip was not replaced (12). For the preparation, the ensemble was moved in the direction of the vibration generated by the ultrasound device, that is, backwards, which allowed cuts to be made by 'oscillation'. The water flow was adjusted so that the vibratory movement of the tip formed a cloud of spray around it.

Restoration (Etching procedure)

All teeth were submitted to the total etch technique using phosphoric acid gel at 35% for 15 sec, washed with water for 30 sec (13) and dried for 5 sec. The adhesive agent (Scotchbond Multiuso, 3M®, St. Paul, USA) was applied to the enamel and dentine, and polymerized for 10 sec with a photocuring unit (CL-K200 Kondortech®, São Carlos, Brazil) having a light intensity of 500 mw/cm^2 (14).

The composite (Z-250, 3M®, St. Paul, USA) (color A1) was inserted into the cavities using the bulk technique with the aid of a Centrix (DFL®, Rio de Janeiro, Brazil) syringe, accommodated with a spatula and polymerized for 40 sec (14). The specimens were stored in distilled water at 37°C for 7 days.

After finishing and polishing with Sof-Lex® (3M®, St. Paul, USA) disks, in the graded sequence indicated by the manufacturer, the teeth received two coatings of red nail enamel all over the external surface and on the crowns, except in the area adjacent to the restorations, 1 mm from their borders. After one hour, when the nail varnish was dry, the specimens were removed from the resin block and immersed in an aqueous solution of 50% silver nitrate for 24 h. They were then washed in running water (15) and immersed in an X-ray developer (KODAK®, São José dos Campos, Brazil) for one hour and, in the next step, each fragment was washed and dried for one minute (16).

Microleakage evaluation

The roots were removed and rectangular fragments containing both preparations were cut out from the crown of the bovine teeth. These fragments were cut into halves with two-sided diamond disks, which made it possible to visualize the internal part of the restorations prepared with high-speed rotary ultrasound device, and to evaluate the penetration of the dye (Fig. 1). A trained examiner checked the leakage of the dye with the aid of a stereoscopic magnifying lens (×25).

Microleakage levels were determined by the penetration of silver nitrate through the border of the restoration towards the pulpal wall, at the enamel dentine/composite interface. In order to grade the microleakage levels, the following scoring system was followed (17):

0: Without dye penetration.

1: Penetration into the cavosurface up to 1/3 of the depth of the cavity wall.

2: Penetration up to between 1/3 and 2/3 of the depth of the cavity walls.

3: Penetration of over 2/3 of the depth of the cavity wall.

The data were analyzed using the Wilcoxon test in the SPSS 11.0 statistical program, with a significance level of 1%.

Results

The time taken for the preparation of G_1 was 7.9 times shorter than G_2 (Table 1). A statistically significant difference was observed between the two groups in terms of the time taken for the preparation ($P < 0.01$).

Considering the frequency of the microleakage scores in the two groups (Table 2), it is possible to conclude that G_1 performed better, presenting no penetration of the dye in 100% of the samples analyzed ($P < 0.01$).

Discussion

Bovine teeth are commonly used for research on microinfiltration due to the difficulties in obtaining human permanent and deciduous teeth. The use of bovine teeth in this study is justified by the fact that all mammalian teeth are similar (18) there being no statistically significant differences between human and bovine teeth regarding their adhesive characteristics (19).

According to Myaki et al. (20), there are no studies correlating *in vitro* microleakage with clinical performance, however, laboratory tests have been used in order to predict it.

Unlike the conventional high-speed rotary drills which wear very quickly (4) and demand replacement after every fifth cavity preparation (11), CVD tips have a long-term durability because the diamond is chemically broken down into a single piece, eliminating the need for replacement during preparation (7,12). The replacement of the high-speed rotary drills used in this study, as well as the maintenance of the CVD drills throughout the dental cutting procedures, seem to have rendered more reliable results, especially concerning the time taken for the preparations. However, the efficiency of a cutting instrument is defined as the capacity of this instrument in removing as much as possible from the dental structure, within the shortest possible period of time, and demanding the least possible effort from the operator (2).

The superior cutting capacity of the rotary instrument compared to the ultrasonic one was previously described by Wicht et al. (21). According to Street (22), the cutting

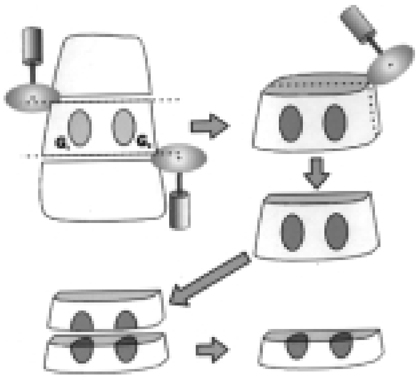

Fig. 1 Diagram representing the fragments containing the restorations of G_1 and G_2, and the cut made for microleakage evaluation.

Table 1 Mean and standard deviation of the time taken in the high-speed (G_1) rotary and the ultra-sound (G_2) groups

Instrument	Time taken (Sec)
(G_1) A	36.50 ± 2.71
(G_2) B	287.67 ± 38.26

Distinct letters differ statistically from the 1% significance level (P< 0.01), Wilcoxon test.

Table 2 Distribution of the frequency (%) of the microleakage scores in the high-speed rotary (G_1) and the ultra-sound (G_2) groups

Instrument	Microleakage scores			
	0	1	2	3
(G_1) A	100%	0.00%	0.00%	0.00%
(G_2) B	46%	9%	27%	18%

Distinct letters differ statistically from the 1% significance level (P< 0.01), Wilcoxon test.

speed of an ultrasonic tip, coupled with an ultra-sound handpiece, was equivalent to half the cutting speed of a conventional instrument. The results of the present study agree with the previous ones, since it was observed that the performance of the CVD ultrasonic tip, regarding the time taken, was inferior (7.9) to that of the high-speed rotary device. However, another study by Conrado et al. (7), in which a CVD ultrasonic tip was coupled with a high-speed rotary device, demonstrated that the CVD tip presented the same cutting capacity as the conventional diamond drill, suggesting that the time taken for preparation depends more on the instrument used than on the tip itself.

In the present study, preparation with the ultrasonic tips took longer than that with the conventional high-speed rotary instrument. The manipulation of the ultrasonic instrument differs from the conventional one (the rotary system). Although it is not difficult to handle this instrument, it demands practice. The attempts to use it in the same way as the conventional ones are rather disappointing and more often than not, result in failure (23). Bearing this in mind, the operator in this study received training prior to the study in order to perform the experimental procedures.

It is suggested that the mechanism of action of these instruments is responsible for the microleakage that occurred in this study. The action of the ultra-sound via piezoelectric ultrasonic movements (24) covers a continuous spectrum of bubbling activity within a liquid and results in shock waves that break the biological tissue wearing it (23). In contrast, the high-speed rotating mechanism cuts the enamel or dentine (25) in much shorter time.

The angled shape of the shaft of CVD drills facilitates access to the site, allowing a better view of the site (10). However, in the present study it was observed that this design did not make it any easier. Apart from that, the formation of a cloud of spray around the active ultrasonic tip (26) does not occur when the high-speed handpieces are used because they have cooling orifices pointing in the direction of its active tip on a continuous basis, not blocking the view and therefore, not presenting any factor that affects its cutting capacity.

In addition, the greater the water flow from the cutting equipment onto the surface, the greater the cutting efficiency (2). In the present study, a 4-hole high-speed handpiece was used, which, according to the author above, is considered a relevant factor that contributes to improving the quality of the cutting.

Marginal adaptation is affected by the following factors: cavity preparation, conditioning technique, acid in the enamel, use of the adhesive, insertion technique, finishing procedures and also the restorative material (27). In the present study, a single protocol was used in the different restorative stages. Given that, it is possible to conclude that the different types of instruments used in the preparation of cavities were the main factors contributing to the statistically significant differences in the microleakage scores observed in the present study.

According to Vieira and Vieira (12), the microleakage scores of the restorations performed in the cavities prepared with the CVD were superior to those performed with the high-speed rotary instrument. The reason for that could be the reduced production of dentin mud when the former system is used, which improves the adhesive quality between the tooth and the restorative material. However, such findings were not observed in this study. According to Dyson and Darvell (28), the cooling system of high-speed rotary instruments acts as a lubricant, in addition to controlling thermal damage. In this study, there was no microleakage in the restorations performed with high-speed rotary instruments when compared to the restorations performed with CVD tips. It is suggested that the cooling system acting as a lubricant might have increased the cutting efficiency, reducing the accumulation of residues during cavity preparation, and consequently, microleakage.

In conclusion in this study, the diamond tips coupled with a high-speed rotary device demonstrated a better performance than the ultrasonic CVD tip, in terms of both the time taken for cavity preparation and the quality of the tooth-restoration interface. Very few laboratory studies have compared the cutting efficiency of CVD tips, which culminates in a shortage of quantitative laboratory data capable of backing the use of the system.

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