

EVALUATION OF THE MICROLEAKAGE OF DIFFERENT CLASS V CAVITIES PREPARED BY USING ER:YAG LASER, ULTRASONIC DEVICE AND CONVENTIONAL ROTARY INSTRUMENTS WITH TWO DENTIN BONDING SYSTEMS : AN *IN VITRO* STUDY

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Abstract

The aim of this study was to evaluate the extent of microleakage in class V cavities prepared with bur, Er:YAG laser and ultrasonic, hybridized with two different bonding agents ("Single bonding" and "Swiss TEC SL bond"). Thirty freshly extracted human premolars were divided into three groups of ten teeth each. On each tooth, two cavities were prepared, one on the buccal surface and one on the lingual surface. Each group was subdivided into two subgroups of 5 teeth each according to the bonding system used. Cavities were restored with a micro-hybrid composite resin. After thermocycling, the specimens were immersed in 2% methylene blue solution for four hours and then sectioned in the buccolingual direction. Dye penetration was scored using a stereomicroscope. No statistically significant differences among the methods of preparation (conventional, laser and ultrasonic). However, statistical differences were found between the adhesives tested.

Based on the results of this study it can be concluded that the Er:YAG laser and ultrasonic device are as effective as the conventional method in preparing cavities. The extent of microleakage depends on the type of the bonding agents.

Keywords: Er:YAG laser – ultrasonic device - Single bonding – Swiss TEC SL bond – microleakage.

IAJD 2013;4(3):103-108.

EVALUATION DE LA MICROPERCOLATION DE DIFFÉRENTES CAVITÉS DE CLASSE V PRÉPARÉES PAR UTILISATION DU LASER ER:YAG, DU DISPOSITIF À ULTRASON ET D'INSTRUMENTS ROTATIFS CONVENTIONNELS AVEC DEUX SYSTÈMES DE COLLAGE DENTINAIRE: UNE ÉTUDE *IN VITRO*

Résumé

Cette étude visait à évaluer l'ampleur de micro-infiltration dans les cavités de classe V préparées conventionnellement par fraisage, par irradiation au laser Er: YAG ou par les ultrasons, hybridées avec deux adhésifs (« Single bonding » et « Suisse TEC SL bond »). Trente prémolaires humaines fraîchement extraites ont été réparties en trois groupes de dix dents chacun suivant la modalité de préparation des cavités. Sur chaque dent, deux cavités ont été préparées, l'une au niveau de la face vestibulaire et l'autre sur la face linguale. Chaque groupe a été subdivisé en deux sous-groupes de 5 dents chacun selon l'adhésif utilisé. Les cavités ont été restaurées avec une résine composite microhybride. Après thermocyclage, les échantillons ont été immergés dans une solution de bleu de méthylène à 2% pendant quatre heures, puis sectionnés dans le sens bucco-lingual. L'infiltration

du colorant a été évaluée à l'aide d'une loupe binoculaire. Aucune différence statistiquement significative n'a été démontrée entre les méthodes de préparation des cavités. Toutefois, des différences statistiquement significatives ont été observées entre les adhésifs testés, le "Single bonding" avait

des valeurs de micro-infiltrations inférieures à celles du "Swiss TEC SL Bond". En se basant sur les résultats de cette étude, on peut conclure que le laser Er :YAG et le dispositif à ultrasons sont aussi efficaces que la méthode conventionnelle de préparation des cavités. L'étendue de la micro-infiltration dépend du type des adhésifs appliqués.

Mots- clés : Laser Er :YAG – adhésif - micro-infiltration.

IAJD 2013;4(3):103-108.

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Introduction

Numerous devices have been suggested for cavity preparation and finishing in an attempt to further preserve tooth structures and benefit from new bonding systems [1].

The Erbium: Yttrium-Aluminum Garnet (Er:YAG) laser ablates hard dental tissues effectively due to its highly efficient absorption in water and in hydroxyapatite [2]. It produces minimal thermal damage to the surrounding tissues [3]. When dental hard tissues were irradiated by the Er:YAG laser accompanied with fine water mist, the temperature was controlled and the cutting efficiency was increased [2].

Effective ablation of dental tissues by means of an Er:YAG laser system has been reported and its application in the removal of carious tissues or cavity preparations for restorations has been described. The ability of this laser to remove dentine and enamel was found comparable to that achieved with the conventional dental drill [4].

Ultrasonic instrumentation was described in 1847. Its use in the dental field was suggested in 1934 and implemented in the 1950's by Nielsen et al. [5]. The stainless steel tips are adaptable to the handpiece of any ultrasonic instrument commonly used in dental offices for calculus removal [1, 6].

Microleakage refers to very small or microscopic openings between the margins of the composite restoration and the tooth structure through which fluid and bacteria can penetrate [7]. The microleakage is considered a major problem that may hinder the longevity of dental restorations [8].

Dentin bonding agents are composite resins with very low viscosity containing a minimal percentage of filler particles, capable of forming a hybrid layer between the resin and tooth structures [9].

Since a variety of dentin bonding systems have been developed for clinical use and the debate on the impact of lasers and ultrasonic for cavity pre-

paration continues, it is necessary to evaluate the composite filling margins in laser and ultrasonic prepared cavities with different bonding systems. This in vitro study aimed to compare and assess:

- The effect of different methods of cavity preparation (Er:YAG laser, ultrasonic and conventional methods) on the microleakage.
- The effect of two types of dentine bonding systems (Single bonding (SB) and Swiss TEC SL bond, Coltène Whaledent) on the microleakage.

Materials and Methods

Sample selection

A total of thirty extracted human premolars free of caries, restorations, cracks or obvious defects had been cleaned and restored in 50% ethanol at 8°C for a maximum of one month following their extraction in order to avoid microbial contamination. This storage medium was chosen because it produces little change in dentin permeability. Prior to the experiments, the teeth were placed in water for 24 hours at 20°C [10].

Cavity preparation

Standardized class V cavities were prepared on the buccal and lingual surfaces (3mm height, 3mm width and 2mm depth) about 1mm occlusal to the cemento-enamel junction. The outline of the cavity was drawn on the tooth surface with a 0.5 mechanical pencil using a matrix band with a pre-cut hole of 3x3 mm which was fixed on the tooth with a retainer. The depth of the cavity was calibrated using a pre-marked periodontal probe. The cavities were prepared with a butt-joint in accordance with the international guidelines and the margins were not beveled [11].

Sample grouping

Group 1

Twenty cavities were prepared using an Er:YAG laser system (TwinLight laser, Fotona, Italy) with a wave length

of 2.94µm, laser handpiece R02F. The laser irradiation was performed in a non-contact mode to remove the dental hard tissue with a focused beam of 500 mJ energy, with a repetition rate of 10 Hz, under a continuous water mist (6 ml/min). The spot size was 1mm. The laser beam was kept perpendicular to the target during irradiation and the delivery kept within 12mm from the target area by adapting the hand piece to the horizontal arm of a surveyor.

Energy density = Energy per pulse / Area..... (J/cm²) [12].

Energy density= 63.69 J/cm²

Group 2

Twenty cavities were prepared using ultrasonic scaler (Dentsply, USA) with a stainless steel tip and a Steri-Mate Handpiece under a water spray cooling (water flow rate 20ml/min to 30ml/min) [13]. The tip was operated at 60Hz oscillation frequency; it was adapted to the horizontal arm of the surveyor so that it can be kept perpendicular to the tooth surface (buccal or lingual).

Group 3

Twenty cavities were prepared using a high speed turbine under water cooling and a straight, flat end, standard grain size bur n. 109/010 ISO oriented perpendicularly to the buccal or lingual surfaces of the tooth [11]. The bur was renewed after the preparation of 10 cavities.

Conditioning of the enamel and dentin

All cavities were acid-etched with a 37% phosphoric acid gel (Ivoclar - Vivadent, Germany) for 15 seconds, washed with water spray for 30 seconds, air dried for 20 seconds and divided into two subgroups:

- Subgroup 1a (10 cavities): Single bonding (DMP, USA) was applied to enamel/dentine surfaces with light brushing motion for 15 seconds and cured with halogen light for 30 seconds (according to the manufacturer's instructions).

			N	Mean
Swiss TEC SL bond (alcohol-based bonding system)	Er:YAG cavity preparation	occlusal	10	1.30 ± 0.923
		gingival	10	2.25 ± 0.639
	Ultrasonic cavity preparation	occlusal	10	1.20 ± 0.410
		gingival	10	1.55 ± 0.605
	Conventional cavity preparation	occlusal	10	1.50 ± 0.513
		gingival	10	2.45 ± 0.510

Table 1: Means of microleakage for Er:YAG laser, ultrasonic and conventional cavity preparations treated with "Swiss TEC SL bond" bonding system.

			N	Mean
Single bonding (solvent-free bonding system)	Er:YAG laser cavity preparation	occlusal	10	0.60 ± 0.754
		gingival	10	2.45 ± 0.605
	Ultrasonic cavity preparation	occlusal	10	1.10 ± 1.165
		gingival	10	2.00 ± 1.026
	Conventional cavity preparation	occlusal	10	0.45 ± 0.605
		gingival	10	2.20 ± 0.951

Table 2: Means of microleakage for Er:YAG laser, ultrasonic and conventional cavity preparations treated with "Single bonding" system.

- Subgroup 1b (10 cavities): Swiss TEC SL bond (Coltene, Germany) was applied directly from the syringe onto a disposable brush, massaged into the cavity for 20 seconds and cured with halogen light for 30 seconds (according to the manufacturer's instructions).

Restoration procedure

After application of the adhesive systems, all the cavities were filled with a microhybrid composite resin (Tetric® Ceram, Ivoclar- Vivadent, Germany), in one layer (using a plastic instrument) and light cured for 30 seconds. All the restored teeth were stored in distilled water at 37°C for one week using an electrical incubator.

Thermocycling and dyeing step

To simulate clinical stress, the samples were thermocycled for 700 cycles. Each cycle consisted of a water bath at 5°C ± 2°C and 55°C ± 2°C with 60 seconds of dwell time [12].

After thermocycling, the apices of the samples were sealed with sticky wax to prevent dye penetration. The samples were also coated with two coats of waterproof nail varnish except for the 1mm rim of the margins of restoration. They were then immersed in 2% buffered methylene blue solution at pH 7 and stored for 4 hours.

Following storage, the samples were rinsed with tap water for 5 minutes and prepared for sectioning. They were sectioned in the bucco-lin-

gual direction through the center of the restoration vertically, using a low speed water-cooled diamond disc in order to assess the degree of microleakage [12].

Scoring

The sectioned teeth were examined under a stereomicroscope (power x40) and classified according to the dye penetration to the following grades [14]:

Grade 0: No leakage.

Grade 1: Leakage between cavo-surface and dentino-enamel junction.

Grade 2: Leakage between dentino-enamel junction and axial wall.

Grade 3: Leakage involve or beyond the axial wall.

Results

By using stereomicroscope (x40), two readings of dye penetration were done by two examiners for all the specimens. These readings corresponded to the microleakage of tooth restoration interfaces occlusally and gingivally.

Descriptive statistics including means and standard deviations (SD) for the scores of dye penetration of all the treatments combination for restoration according to the type of bonding agents and the cavity preparation modality are shown in tables 1 and 2.

When the cavities were treated with “Swiss TEC SL bond” bonding system, the conventional cavity preparation gave the highest value of microleakage (1.50) and the ultrasonic cavity preparation gave the lowest value (1.20) on the occlusal surface. On the gingival surface, the lowest value (1.55) of microleakage was observed for the ultrasonic cavity preparation while the highest value (2.45) was obtained with the conventional cavity preparation.

When the cavities were treated with “Single bonding” bonding system, on the occlusal surface, the highest value of microleakage was observed for ultrasonic cavity preparation (1.10); the lowest value (0.45) was obtained with the conventional cavity preparation.

However, on the gingival surface, the lowest microleakage value was obtained with the ultrasonic cavity preparation (2.00) whereas the Er:YAG laser cavity preparation gave the highest value (2.45).

The two-way ANOVA test did not indicate a statistically significant difference in the occlusal and the gingival microleakage among the three groups (Er:YAG laser, ultrasonic and conventional cavity preparations) for the “Single bonding” system ($p > 0.05$).

However when the “Swiss TEC SL bond” was applied on the gingival wall, the ANOVA test showed a highly significant difference among the three modes of cavity preparation ($p < 0.01$).

Discussion

The ability of a dentin bonding agent to minimize the extent of microleakage at the tooth/restoration interface is an important factor in predicting clinical success. Failure of the restoration may contribute to marginal staining, adverse pulpal response, postoperative sensitivity and recurrent caries [15].

Therefore, the search for a material or technique that ensures appropriate adhesion of the restoration material to the tooth structure in order to minimize potential leakage is constant [4].

Our study examined the quality of composite filling margins in Er:YAG laser and ultrasonically prepared cavities compared to conventionally prepared restorations; all cavities were treated with either “Single bonding” or “Swiss TEC SL bond” bonding agents.

The mean of occlusal microleakage of the restorations placed in the cavities treated with “Single bonding” system was the highest for the ultrasonically prepared cavities and the lowest for the conventionally prepared cavities.

Several studies have reported a higher degree of microleakage around composite restorations when cavity preparation was done or treated by Er:YAG laser [16]. Furthermore, shear bond strength studies showed that Er:YAG laser created a laser-modified layer that adversely affected adhesion to dentin [16].

De Munck et al. [17] in 2002 observed that cavities prepared by laser appeared less receptive to adhesive procedures than conventionally prepared cavities. The authors stated that after acid-etching the laser-conditioned dentin, the hybridization effectiveness is compromised because of the selective ablation of organic tissue, leading to less exposed collagen and consequently less hybridized. These findings diverge from those of the present study in which laser-prepared cavities showed similar results to conventionally prepared ones. This might be explained by the fact that in the past studies, acid treatment was

not performed in laser-prepared cavities [17].

Several studies [18-21] stated that enamel and dentine surfaces treated with the Er:YAG laser are capable of decreasing microleakage of composite resin restorations; no significant differences between the laser and conventionally prepared cavities were found.

In the study of Visuri et al. [22], laser-irradiated samples had improved bond strengths compared with acid-etched and handpiece controls. Er:YAG laser preparation of dentin left a suitable surface for strong bonding or an applied composite material.

When evaluating the microleakage in the occlusal wall, its value was statistically the highest when the “Swiss TEC SL bond” bonding system was applied in the Er:YAG laser irradiated cavities and conventionally prepared cavities. However, no statistically significant difference was observed between the two bonding systems in the ultrasonically prepared cavities.

On the other hand, in the gingival microleakage, no statistically significant difference was found between the “Single bonding” and “Swiss TEC SL bond” systems in Er:YAG laser and conventional cavity preparations; however, a significant difference was observed in cavities prepared with ultrasonic device.

Primer has been used to improve the bonding between the composite resin and the cavity walls. Current adhesive systems contain hydrophilic primers that utilize acetone, alcohol and/or water as solvent. These solvents carry the resin primers into the demineralized dentin by displacing water from the collagen network. Resin penetration into the collagen network and its occupation of the demineralized dentin is responsible for forming the interdiffusion zone or hybrid layer.

HEMA is a hydrophilic monomer that penetrates into the collagen network. Its molecules are usually dissolved in different solutions with acetone, alcohol and/or water which work as chasers. These chasers compete with water present at the dentin sur-

face by promoting a union of the water molecules and displacing water when compressed air is applied, permitting the penetration by the monomer [23].

Since “Single bonding” system contains special chemical components composed of HEMA with no other solvent, the water remnant in the dentin substrate would bend to HEMA within the “Single bonding”.

Jacobsen et al. [24] showed that adhesive systems with alcohol are less sensitive to the technique utilized. Requirements for an effective dentin adhesive system include the ability of the system to thoroughly infiltrate the collagen network and the partially demineralized zone, to commingle and encapsulate the collagen and the hydroxyapatite crystallites at the surface of the demineralized dentin and to produce a well-polymerized durable hybrid layer [24].

In the present investigation all groups showed higher leakage on the gingival than on the occlusal walls with a highly significant statistical difference. The reason for this difference between gingival and occlusal leakage scores might be due to the fact that bonding to dentin is much more technique- and substrate-sensitive than bonding to enamel. There is no guarantee that bonding to dentin is as durable as to enamel. These results came in agreement with the results of Cagidiaco et al. [25] who suggested that the leakage observed at the cervical margins may be related to the relatively limited number of tubules and to the mainly organic nature of the dentin substrate. Enamel, when present at the cervical margin, is usually thin, prismatic and bonds less well to resins. When polymerized, the resin composite shrinks towards the stronger bond at the occlusal margin and pulls away from the weaker bond at the gingival margins [25-27].

Conclusion

The modality of cavity preparation didn't have any effect on the microleakage values. The type of the bonding

agents was the major factor that affected the results.

Within the confines of this *in vitro* study, it may be concluded that the “Single bonding” system, the solvent-free bonding agent, showed lower microleakage values than the “Swiss TEC SL bond” system, the alcohol-based bonding agent.

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