Marginal leakage in Cavity Prepared with Er:YAG Laser: Evaluation by Stereomicroscope, Scanning Electron Microscope and Energy Dispersive X-Ray

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SUMMARY

This in vitro study aimed to examine the marginal leakage in cavity prepared with Er:YAG laser. Thirty-six human third molar teeth were divided into 3 groups. Group 1 was prepared with a conventional high-speed drill and etched with 35% phosphoric acid. Group 2 was prepared with Er:YAG Laser and etched with 35% phosphoric acid and Group 3 was prepared and etched only with the Er:YAG Laser. The cavity was restored with Single bond (bonding agent - 3M) and light cure composite resin. (Z100 - 3M). The specimens were immersed in a 50% silver nitrate solution, They were sectioned and observed under Stereomicroscope, SEM and EDX. Leakage was observed in Groups 1, 2 and 3. The results were analyzed with the KruskalWallis test and was observed a significant difference in the degree of leakage at gingival margins between the 3 groups ($p=0,01$) and no significant difference in the leakage at occlusal margins between the 3 groups ($p>0,05$). The elemental distribution provide by EDX analysis of the SEM field showed more microleakage in the specimens of group 3.

INTRODUCTION

Marginal microleakage is a major cause of restorative failure. It can promote marginal discoloration, recurrent caries, hypersensitivity and the development of pulpal pathology. It is found especially at the gingival margins of Class V cavities even when adhesive restorative materials, such as composite resin with dentin bonding agents are used. Various materials and techniques have been investigated in order to minimize or eliminate microleakage around Class V restorations.

In 1988, the first description of Er:YAG laser effects on dental hard tissue indicated that effective ablation of healthy tissue, as well as carious lesions, is possible without thermal injury to surrounding hard tissues. This laser emitted wavelength of 2.94 μm and has demonstrated the ability to remove dentin and enamel, as well as restorative materials, at rates comparable with those achieved with the dental drill (Hibst and Keller, 1995). The clinical use of Er:YAG laser in Restorative Dentistry is based on the ability of this system in create irregular surface providing micromechanical retention for adhesive dental restorative material and marginal seal.

The aim of this study was to evaluate under Stereomicroscope, SEM and EDX the marginal leakage in Class V restorations prepared with Er:YAG laser.

MATERIALS AND METHODS

Thirty-six extracted human third molar teeth were used in this study. All teeth were free of carious lesions or defects. The teeth were cleaned and stored in a 0.9% NaCl solution to prevent dehydration. Cervical Class V cavities of uniform size (mesiodistal width of 3 mm, occlusogingival length of 2 mm and a depth of 2 mm) were prepared at the buccal surfaces of teeth. The occlusal cavosurface margin of each cavity was placed in enamel and the cervical margins of all preparations extended into dentin or cementum. The teeth were equally divided into 3 groups:

Group 1 (control group) - the cavities were prepared using a high speed handpiece tinder spray coolant (KaVo do Brasil S/A) with a diamond bur #1091 drill and the final preparation of the cavity surface was done with the same drill but at a low speed handpiece (KaVo do Brasil S/A). The occlusal cavosurface bevel was done with a diamond bur # 3195 F using a high speed handpiece. After the preparations, the cavities were etched using 35% phosphoric acid gel (3M Dental Products -- Brazil) for 15 seconds, washed with a water spray for 1 minute and dried with absorbent paper, promoting a moist surface.

Group 2 - the cavities were prepared using the Er:YAG laser with a focused laser light, with an energy

of 400 mJ, a frequency of 6 Hz and an energy density of 56.43 J/cm². The occlusal cavosurface bevel was done with a same laser using an energy reduced to 60 mJ, the frequency increased to 10 Hz and energy density of 8.43 J/cm² (Groth et al1, 1996) .

Afterwards, the cavities were etched with 35% phosphoric acid gel for 15 seconds, washed with a water spray for 1 minute and dried with absorbent paper, promoting a moisty surface.

Group 3 - the cavities were prepared using the Er:YAG laser with a focused laser light, with na energy of 400 mJ, a frequency of 6 Hz and an energy density of 56.43 J/cm². The occlusal cavosurface bevel was etched with a same laser using an energy reduced to 60 mJ, the frequency increased to 10 Hz and energy density of 8.43 J/cm². In this group., no acid phosphoric etching was used.

The laser used in this study was a KaVo KEY Laser II - Germany, at a wavelength of 2.94 µm, a pulse duration of 250-500ms and spot size of 0.95 µm.

After the preparations two consecutive layers of the Single Bond (bonding agent -- 3M Dental Products) was applied in the cavities of the 3 groups, dried for 5 seconds and the light cured by visible light (XL3000 - 3M do Brasil) for 10 seconds. The cavities were restored with Z100 composite resin (3 M), color A 3,5, inserted using a Centrix syringe in incremental built up in approximately 1 mm portions. Each increment was polymerized for 40 seconds with a visible light curing. Finished restorations, the specimens were stored in water for 24 hours at 37° C and polished with ultra fine diamond burs and Sof-Lex disks (3M), After that, they were thermocycled (MCT2 - AMM. Instrumental). The thermocycling regimen employed consisted of 600 cycles between baths of 5° C and 55° C with a dwell time of 1 minute in each bath and a 3 seconds transfer time between baths.

For tracer element penetration testing, the apices of all teeth were sealed with cyanoacrylate and the entire tooth received a coating of red nail varnish up to the restorations and 2 mm beyond the margins. The teeth were then immersed in a 50% aqueous silver nitrate solution for 24 hours while kept in darkness. Sequentially, the teeth were washed in tap water for 1 minute and soaked in photo developing solution and exposed to fluorescent light for 6 hours (Wu et al[4], 1983; Wieczkowski et al6, 1992)

The specimens were embedded in resin chemically activated (Redefibra) and 1 mm thick longitudinal sections in the center of the restorations were done with a diamond saw microtome under running water (Labcut 1010 - Extec). Cut surfaces were polished with sandpaper #600 under water in a variable speed grinder-polisher (Ecomet 3 - Buehler). The specimens were cleaned in an ultrasound appliance.

The degree of marginal leakage was determined by the penetration of the silver nitrate stain from the gingival and occlusal cavosurface margins toward the base of the cavity preparations. Each specimen was evaluated under Olympus zoom Stereomicroscope (Model SZ40) at x 40 magnification by two examiners. The following criteria were used to determine the degree of silver nitrate penetration in this study was: 0=no leakage; 1=Minimal (leakage less than 1/3 the length of the wall); 2=Moderate (1/3 to 2/3 the length of the wall) and 3=Extensive (greater than 2/3 the length of the wall).

After examination under a Stereormicroscope, two representative samples from each group were chosen for study under the SEM with EDX analysis for identify precisely the pathway of microleakage (Wieczkowski et al.[5], 1991). Each specimen was air dried, mounted on an aluminum stub, coated with a thin layer of gold and placed under vacuum. The specimens were examined by SEM at 25Kv (Phillips LX30 -Eindhoven/Ho) and by EDX microanalysis (EDAX - Noran Serie II).

Kendall test (Test -W) and Kruskall-Wallis test were used for statistical analysis.

RESULTS

Stereo microscope observation:

Specimens	1	2	3	4	5	6	7	8	9	10	11	12
Group 1- Oc	1	1	0	1	1	1	1	1	1	1	1	0
Group 1- Gi	2	2	2	2	2	2	3	2	3	2	3	2
Group 2- Oc	0	0	0	1	1	1	1	1	0	1	0	1
Group 2- Gi	1	3	2	2	2	2	1	2	2	2	2	2
Group 3- Oc	1	1	0	1	2	1	2	2	1	1	1	1
Group 3- Gi	3	2	3	3	3	3	3	3	3	3	3	3

The Table I indicates the results of the study, using 0 to 3 scale to demonstrate leakage degree. Oc-indicates occlusal margin and Gi- indicates gingival margin.

In all cases more leakage was found at gingival margins than occlusal margins. The statistical analysis indicat-

ed that there was significant difference in the degree of leakage at gingival margins among the 3 groups ($p=0,01$) and that there was not significant difference in the leakage at occlusal margins among the 3 groups ($p>0,05$).

SEM and EDX observation:

Elemental distribution was provided by EDX analysis of the SEM field as shown in Figs 1, 2, and 3 followed by mapping for the elements of calcium, phosphorus, silver and silicon (table 2).

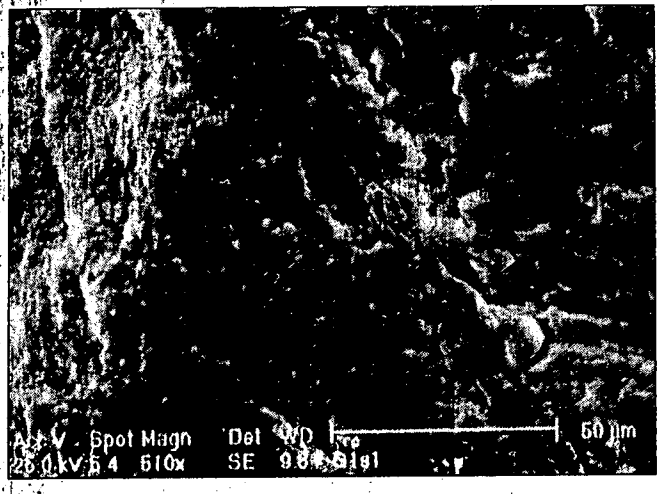

Fig. 1-SEM of the specimens of group 1 c=composite and d=dentin

Fig. 2-SEM of the specimens of group 2. b=bonding agent, c=composite d=dentin.

Fig. 3-SEM of the specimens of group 3. b= bonding agent, c = composite d = dentin

Element	Group I	Group II	Group III
Calcium (Ca)	6,76	12,75	1,16
Phosphorus (P)	19,67	31,42	6,38
Silver (Ag)	26,58	0,42	80,92
Silicon (Si)	47,00	55,40	11,54

Table 2 shows in percentage (%) the presence of the Calcium, Phosphorus, Silver and Silicon elements in the restoration/tooth interface indicted by black arrow heads in figures of the 3 groups.

The silicon map indicates the location of the filler component of the composite resin. The distribution of calcium and phosphorus confirms the locations of dentin and smear layer. Silver was used as a microleakage tracer and was evident throughout the smear layer and into the dentinal tubules, suggesting that microleakage progress along the smear layer and into the tubules.

DISCUSSION

The prevention of microleakage depends largely on the maintenance of the seal between the restorative material and tooth structure5. According Pashley and Carvalho[3], 1997, some techniques showed that leakage is not uniform along the interface while some areas may show no microleakage, others may leak from the external cavosurface margin to the pulp. This reflects the non-uniformity of bonding discussed above, which may be related to several factors such as differences in the thickness of the smear layer, different degree of etching, wetness, forces of polymerization contraction, etc.

The preparation and treatment of the tooth also influences the microspace between tooth and restorative materials. The cavosurface margin produced by the

Er:YAG laser preparation appears quite rough in comparison to the enamel margin produced by conventional high speed cutting. Consequently, the margin could result in increased microspacing and greater microleakage. On the other hand, the converse also is possible since the rougher surface might provide improved mechanical bonding (Wright et al[7]., 1993).

Each group exhibited a different microleakage pattern. More microleakage was found at the composite/tooth interface in the Group 3, with Stereomicroscope, SEM and EDX observations using the silver staining method. Probably because in this group phosphoric acid was not used. When this agent is applied to smear layer that covers dentin, it will dissolve the mineral phase of the smear layer and etch approximately 0.5-1.5 μm into the sound underlying dentine. Although this system form a very thin hybrid layers (1-20μm) providing remarkable bond strengths and very little microleakage[3].

The results indicated that in all cases the gingival margins, which well in dentin or cementum, showed higher leakage than occlusal margins, which were located in enamel. These results confirm that bonding composite resin to enamel is better than dentin and cementum, in accordance to others studies (Welsh, Hembree[4], 1985).

CONCLUSION

This study examined the extent of microleakage in cavities prepared with the Er:YAG laser. The results showed that there was a significant difference in the degree of leakage at gingival margins between tile 3 groups ($p=0,01$) and no significant difference in the leakage at occlusal margins between the 3 groups ($p>0,05$). The elemental distribution provided by EDX analysis of the SEM field showed more microleakage in the specimens of group 3.

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