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Microleakage of class V resin composite restorations after conventional and Er:YAG laser preparation

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SUMMARY This *in vitro* study compared the microleakage of Class V resin composite restorations at bevelled enamel/composite and dentin/composite interfaces following Er:YAG laser (pre-treatment modalities: laser-etching and/or acid-etching) or conventional preparation and acid-etch, in association with two resin composite formulations and their three-step adhesive system. Class V cavities with conventional bevel produced on the lingual and buccal surfaces of eighty extracted caries- and restoration-free human teeth, were assigned to eight groups: cavities were or Er:YAG-lased and acid-etched (groups 1 and 5); or Er:YAG-lased, laser-etched and acid-etched (groups 2 and 6); or Er:YAG-lased and only laser-etched (groups 3 and 7); or cut by dental drill at high-speed and acid-etched (groups 4 and 8). The specimens were restored with Optibond FL + Herculite XRV (groups 1, 2, 3 and 4) or with Scotchbond MP + Z 100 (groups 5, 6, 7 and 8), stored in distilled water at 37 °C for 24 h, thermocycled 1500 times between 5 and 55 °C, placed in a 2% aqueous solution of methylene blue for 24 h at 37 °C, embedded in resin and sectioned. Microleakage was assessed according to the depth of dye penetration along the restoration. There were statistically significant differences between occlusal and cervical regions for all groups ($P < 0{\cdot}01$) except for groups 3 and 7. Pair-wise comparison of groups showed that acid-etch is advocated when using resin composite in Er:YAG-lased Class V cavities; the seal at enamel margins in Er:YAG-lased and laser-etched cavities depended on the resin composite formulation and corresponding adhesive ($P < 0{\cdot}05$).

KEYWORDS: microleakage, acid-etch, Er:YAG, laser, resin composite

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Introduction

Despite improvements to resin composite formulations over the years, polymerization shrinkage of the resin matrix is still considered highly relevant in unsuccessful resin composite direct restorations (1). Therefore, pre-treatment of the tooth surface is essential to establish a strong bond between resin and both enamel and dentine.

Since the report of Buonocuore (2), the standard approach for enamel pre-treatment has been acid-etching. Effective adhesion to enamel has been achieved with relative ease and has repeatedly proven to be a durable and reliable clinical procedure for routine applications in modern adhesive restorative dentistry (3). The formation of a hybrid layer and resin tags is essential to the establishment of a strong bond at dentine level (4–6). One way of achieving this is by a complete dissolution of the smear layer and the demineralization of intertubular and peritubular dentine by means of acid-etching, resulting in an exposed collagen matrix that is infiltrated by resin that polymerizes *in situ*.

With the introduction of the Er:YAG laser, in contrast to other available lasers, it became possible to remove dentine and enamel more effectively and efficiently (7–9). Thermal damage was reduced, especially in conjunction with water spray (10, 11). Moreover, cavity pre-treatment with Er:YAG laser (laser-etching) was proposed by some as an alternative to acid-etching of enamel and dentine: laser irradiation of enamel and dentine has been reported to yield an anfractuous surface (fractured and uneven) and open tubules, both apparently ideal for adhesion (12). Roughened dentine surfaces with open dentinal tubules without smear layer production were also reported by others (13–17). Next to cavity preparation, the ablative effect of Er:YAG laser light in healthy enamel and dentine could also be used for modifying the dental surfaces and eliminating the need for acid-etching. Some researchers have explored the use of lasers to modify the surfaces of teeth intentionally, to improve bonding of restorations (18–22).

Data on the quality of the margins of composite fillings in relation to the use of Er:YAG laser for hard tissue preparation have been discussed. Controversial results regarding the quality of the margins of composite restorations conditioned conventionally by acid-etching, those remaining unconditioned after Er:YAG-lasing and those conditioned after Er:YAG-lasing by acid-etching or by laser-etching have been reported (14, 16, 20–28). Laser-etching as an option for cavity conditioning prior to resin composite adhesion was investigated in a limited number of studies (20, 21, 25).

The aim of the present study was to asses the degree of marginal leakage of at least two resin composite formulations and associated three-step total-etch adhesive system in Class V cavities prepared by high-speed dental bur and then acid-etched, or prepared by Er:YAG laser with or without laser-etching and with or without additional acid-etching. The majority of the previously mentioned studies have in common that there was no bevelling of the enamel margins of the Er:YAG-lased cavities. A bevel should not only be made to expose the enamel rods to the adhesive (29) but is also important for aesthetic reasons: the preparation of a bevel results in a more gradual colour change from tooth surface to restoration (30). The influence of an Er:YAG laser-conditioned bevel on the composite/enamel interface and subsequent microleakage, apparently, has been investigated in only one study (21). Therefore it was opted to bevel the enamel margins of all cavities in this study and to assess the degree of marginal leakage in association with the previously mentioned experimental cavity pre-treatment modalities.

Materials and methods

Tooth selection

Eighty extracted caries- and restoration-free permanent human molars were stored in distilled water at 4 °C for a maximum of 1 month. The teeth were scaled with a scalpel and/or scaling instruments to remove residual tissues and calculus, polished with Zircate Prophy Paste*, rinsed thoroughly with tap water and examined macroscopically using magnification for defects in enamel and dentine. These teeth were randomly assigned to eight groups of 10 teeth each.

Cavity preparation and restoration

Class V cavities were prepared on both buccal and lingual surfaces of each tooth with the occlusal margins in enamel and the cervical margins located 1·5 mm apical to the cemento-enamel junction. Cavity dimensions were standardized using a template of 4·0 mm width and 3·0 mm height. The depth of the cavity was *c.* 1·5 mm which was measured and controlled for depth by a pre-marked periodontal probe.

For groups 1, 2, 3 and 5, 6, 7 the cavities were prepared by a short-pulsed Er:YAG laser (Fidelis Plus)[†] emitting a wavelength of 2·94 μm. The laser beam was delivered by a series of mirrors in an articulated arm. The non-contact delivery tip (source: RO2-F-125) was used under abundant water spray coolant. The laser treatment was carried out moving the hand piece continuously above the tooth surface at a distance of 7 mm (in focus) in order to obtain a pattern of rows and columns that overlapped. The laser parameters were chosen according to the manufacturer's instructions and the parameters listed in an indicative table provided by European Laser Users and Research Association (ELURA) (31) i.e. enamel: 400 mJ at 12 Hz; dentine: 300 mJ at 10 Hz. The pulse duration was 100 μs (very short pulse). An enamel bevel with a width of 1·0 mm was prepared using a diamond bur (Komet ISO No 806 314)[‡] at high-speed with air/water spray. The width of the bevel was controlled by means of a pre-marked periodontal probe. In groups 1 and 5 the cavities were acid-etched (group 1: Gel Etchant[§] – group 5: Scotchbond etching gel[¶]) for 30 s, rinsed for 20 s and gently air dried. For groups 2 and 6, the cavities were additionally treated/conditioned by Er:YAG laser (enamel: 250 μs-short pulse-SP, 100 mJ at 10 Hz;

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[§]Kerr Corporation, Orange, CA, USA.
[¶]3M Dental Products, St Paul, MN, USA.

Table 1. Adhesives investigated in this study

Product name	Manufacturer	Composition*
Optibond FL	Kerr, Orange, CA, USA	Etchant: 37·5% phosphoric acid, silica thickener Primer: HEMA, GPDM, PAMM ethanol, water, photoinitiator Adhesive: TEGDMA, UDMA, GPDM, HEMA, Bis-GMA, filler, photoinitiator
Scotchbond MP	3M Dental Products Division, St-Paul, MN, USA	Etchant: 35% phosphoric acid, silica thickener Primer: HEMA, polyalkenoic acid copolymer, water Adhesive: HEMA, Bis-GMA

*Composition as provided by respective manufacturer: HEMA, hydroxyethylmethacrylate; GPDM, glycerol phosphate dimethacrylate; PAMM, phthalic acid monoethyl methacrylate; TEGDMA, triethylene glycol dimethacrylate; UDMA, urethane dimethacrylate; Bis-GMA, bisphenol-glycidil methacrylate.

dentine: 250 μs short pulse-SP, 80 mJ at 10 Hz) and acid-etched as previously described. For groups 3 and 7 the cavities were only laser-etched.

For groups 4 and 8, the cavities were prepared with a cooled high-speed hand piece (Kavo Supertorque 630B)** and a diamond bur [Komet ISO 806 314 110524 012 (836)]‡, which was changed after each four preparations. The occlusal margin was bevelled at 45 ° [bur: Komet ISO No 806 314 257524 016 (368)]‡. The width of the bevel was 1·0 mm.

In this study, two different composite resins were used to restore the teeth: Herculite XRV (A3 shade) and associated adhesive: Optibond FL (groups 1–4) and Z100 (A3 shade) and associated adhesive: Scotchbond Multi-Purpose (groups 5–8) (Table 1). A new brush tip¶ was used for each primer and bonding application. Each three-step bonding system was used according to the manufacturer's instructions. Light curing was performed using the Optilux 400††. The composite resins were applied in three increments: the first against the gingival wall and the second against the occlusal wall. The final increment was placed flush with the contour of the tooth and covered with a transparent matrix strip (Ruwa Matrix Strips)‡‡. Each increment was light-cured for 40 s. Immediately after filling, excess materials were removed using polishing burs (Shofu SF 201 Ra)§§ and polished with the Sof-lex disk system¶.

Storage and thermocycling

The restored teeth were stored for 24 h in distilled water at 37 °C. Then they were thermocycled (Willytec Thermocycler V2.9)¶¶ for 1500 cycles between 5 ± 1 and 55 ± 1 °C, with a dwell time of 30 s and a 10-s transfer time between baths.

Microleakage assessment

Microleakage was evaluated using a dye penetration technique. The teeth were superficially dried after thermocycling. The root apices were sealed with sticky wax (Kemdent)*** and the specimens were coated with two layers of transparent nail varnish (Nailslicks)††† leaving a 1-mm window around the cavity margins. They were then immersed in a 2% aqueous solution of methylene blue for 24 h at 37 °C. The teeth were brushed (Oral B)‡‡‡ thoroughly under tap water for 30 s and the wax removed with a wax knife. If signs of methylene blue were found underneath the wax or nail varnish layer, the tooth was excluded. The teeth were embedded in a chemically activated acrylic resin (Tempron)§§§ and sectioned longitudinally in a buccolingual direction through the centre of both cavities with a water-cooled diamond saw (D46 No.1821913)¶¶¶. The separated halves were once more sectioned in buccolingual direction, providing two cuts of 1·0-mm thick for each tooth.

These sections were carefully fixed on microscopic slides and analysed for leakage by viewing them under a ×10 operation microscope (Pico S 100)****. The depth of the cavity preparation (distance between the tooth surface and the axial wall of the cavity) and the depth

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††Demetron Research Co, Danburry, CT, USA.
‡‡Austenal Dental Products Ltd, Harrow, England.
§§Shofu Inc, Kyoto, Japan.
¶¶Thermo Haake, Karlsruhe, Germany.
***Kemdent Associated Dental Products Ltd, Wilthshire, UK.
†††Procter & Gamble, Cincinnati, USA.
‡‡‡Gilette Group, South Boston, USA.
§§§GC Co., Tokyo, Japan.
¶¶¶Diamant Boart SA, Brussels, Belgium.
****Carl Zeiss, Oberkochen, Germany.

Table 2. Mean (%) of tracer agent penetration at occlusal and gingival margins according to different conditioning techniques

Composite formulation	Margin	Er:YAG-lased No laser-etch Acid-etch (percentage)	Er:YAG-lased Laser-etched Acid-etch (percentage)	Er:YAG-lased Laser-etched No acid-etch (percentage)	Conventional Preparation Acid-etch (percentage)
Herculite XRV + Optibond FL	Occlusal	Group 1 1·60 (±2·95)	Group 2 5·00 (±8·82)	Group 3 8·80 (±10·51)	Group 4 0·30 (±0·67)
	Gingival	Group 1 22·84 (±14·83)	Group 2 26·15 (±18·47)	Group 3 15·76 (±18·72)	Group 4 20·83 (±19·91)
Z 100 + Scotchbond MP	Occlusal	Group 5 1·60 (±3·24)	Group 6 2·00 (±6·32)	Group 7 16·94 (±10·90)	Group 8 0·00 (±0·00)
	Gingival	Group 5 15·83 (±15·72)	Group 6 11·29 (±4·76)	Group 7 22·74 (±20·51)	Group 8 12·50 (±15·17)

of the dye penetration along this occlusal/enamel and gingival/dentine margin towards the axial wall were measured. The percentage of infiltration was calculated. The scores for all sections per test specimen were compared and the worst score for each margin was chosen to represent the specimen for statistical analysis. Examination of the specimens was undertaken blindly by two observers who were unaware of the exact nature of the restorative treatment evaluated. Consensus was obtained between observers if there were conflicts in scores. The staining of the tooth restoration interfaces was then divided according to the following groups (0%, 0·1% up to 10%, 10·1% up to 20%, …).

SEM analysis of the lased cavities

As there is substantial information on the morphologic changes as a result of etching of enamel and dentine surfaces in the literature, scanning electron microscophic (SEM) analysis in this study was limited to enamel and dentine surfaces that had been subjected to laser preparation (A), laser preparation and laser-etching (B), laser preparation and acid-etching (C), laser preparation and laser-etching and acid-etching (D). For each group (A–D) cavities were prepared in three different teeth. The 12 cavities were then subjected to the SEM procedure as described by Delmé *et al.* (17). Photographs were taken at ×3000 and ×7000 magnification.

Statistical analysis

All data were gathered using SPSS 11.0.1 for Windows statistical package[††††]. The data were submitted to statistical analysis using the Kruskal–Wallis and Mann–Whitney *U*-tests.

Results

Microleakage

The majority of the procedures tested in this study did not completely eliminate microleakage. The data showing the extent of microleakage are listed in Tables 2 and 3.

Kruskal–Wallis one-way ANOVA indicated significant differences among the four different procedures for occlusal scores in the Z100 sample (groups 5, 6, 7 and 8) ($P < 0·001$). There were no statistically significant differences in the Herculite group. On the gingival wall, the Kruskal–Wallis test did not show statistically significant differences in microleakage among the four different treatments ($P > 0·05$) in both the Herculite and the Z100 group.

Matched analysis by the Mann–Whitney *U*-test was undertaken (Table 4): statistically significant differences ($P < 0·05$) in microleakage (L) were found in the Herculite group between groups 1 and 3 (L1 > L3), and groups 2 and 3 (L2 > L3) at the gingival margins; in the Z100 group between groups 7 and 8 (L7 > L8) at enamel level, and between groups 5 and 7 (L7 > L5), and groups 6 and 7 (L7 > L6) at both enamel and gingival margins. Comparing Herculite XRV and Z100 statistically significant differences were seen between groups 1 and 5 (L1 > L5), groups 2 and 6 (L2 > L6) and groups 3 and 7 (L7 > L3) at gingival level; and between groups 3 and 7 (L7 > L3) at enamel level.

When comparing occlusal and gingival leakage in each procedure, the Mann–Whitney *U*-test indicated a statistically significant greater leakage at the gingival

[††††]SPSS Inc, Chicago, IL, USA.

Table 3. Microleakage scores obtained for each experimental group ($n = 10$)

	Occlusal margin							Gingival margin							
Resin composite + three step adhesive system	0%	10%	20%	30%	40%	50%	60%	0%	10%	20%	30%	40%	50%	60%	70%
Herculite XRV + Optibond FL															
Er:YAG laser – no laser-etch – acid-etch (group 1)	9	1	0	0	0	0	0	1	1	4	2	1	0	1	0
Er:YAG laser – laser-etch – acid-etch (group 2)	7	1	1	1	0	0	0	0	2	3	2	1	1	1	0
Er:YAG laser – laser-etch – no acid-etch (group 3)	4	4	1	0	1	0	0	5	2	2	0	0	1	0	0
Conventional preparation + acid-etch (group 4)	8	2	0	0	0	0	0	3	0	3	2	0	0	2	0
Z 100 + Scotchbond Multipurpose															
Er:YAG laser – no laser-etch – acid-etch (group 5)	9	1	0	0	0	0	0	4	0	2	3	0	1	0	0
Er:YAG laser – laser-etch – acid-etch (group 6)	9	0	1	0	0	0	0	0	6	4	0	0	0	0	0
Er:YAG laser – laser-etch – no acid-etch (group 7)	3	0	2	5	0	0	0	1	1	5	0	1	1	0	1
Conventional preparation + acid-etch (group 8)	10	0	0	0	0	0	0	5	0	3	1	0	1	0	0

Table 4. Comparison between the different experimental groups for occlusal and gingival scores (Mann–Whitney *U*-test)

	Group 1		Group 2		Group 3		Group 4		Group 5		Group 6		Group 7	
	O	G	O	G	O	G	O	G	O	G	O	G	O	G
Group 1														
O			N		N		N		N		N		S	
G				N		S		N		S		N		N
Group 2														
O					N		N				N			
G						S		N				S		
Group 3														
O							N						S	
G								N						S
Group 4														
O														
G														
Group 5														
O	N										N		S	
G		N										N		S
Group 6														
O													S	
G														S
Group 7														
O														
G														

Herculite XRV + Optibond FL: Er:YAG laser – no laser-etch – acid-etch (Group 1), Er:YAG laser – laser-etch – acid-etch (Group 2).
Er:YAG laser – laser-etch – no acid-etch (Group 3), conventional preparation + acid-etch (Group 4).
Z100 + Scotchbond MP: Er:YAG laser – no laser-etch – acid-etch (Group 5), Er:YAG laser – laser-etch – acid-etch (Group 6).
Er:YAG laser – laser-etch – no acid-etch (Group 7), conventional preparation + acid-etch (Group 8).
O, occlusal margin; G, gingival margin; N, no statistically significant difference; S, statistically significant difference.

wall in groups 1 ($P = 0{\cdot}001$), 2 ($P = 0{\cdot}003$), 4 ($P = 0{\cdot}001$), 5 ($P = 0{\cdot}006$), 6 ($P = 0{\cdot}001$) and 8 ($P = 0{\cdot}004$). There were no statistically significant differences in groups 3 and 7 ($P > 0{\cdot}05$). The latter groups consisted of samples which were only laser-etched and not acid-etched.

Scanning electron microscopy

Laser treatment of the enamel surfaces revealed an irregular surface with the typical keyhole shaped enamel prisms or rods (Fig. 1). Laser-etching rounded off the sharp edges (Fig. 2). Acid-etching of laser-

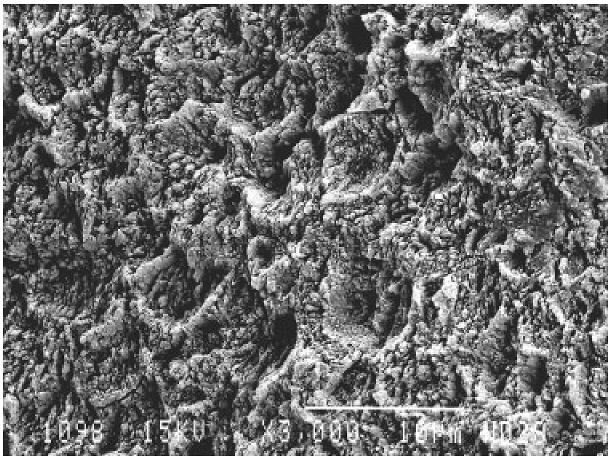

Fig. 1. Scanning electron microscopic picture of an enamel surface after laser preparation showing keyhole shaped enamel prisms or rods (×3000) (bar = 10 μm).

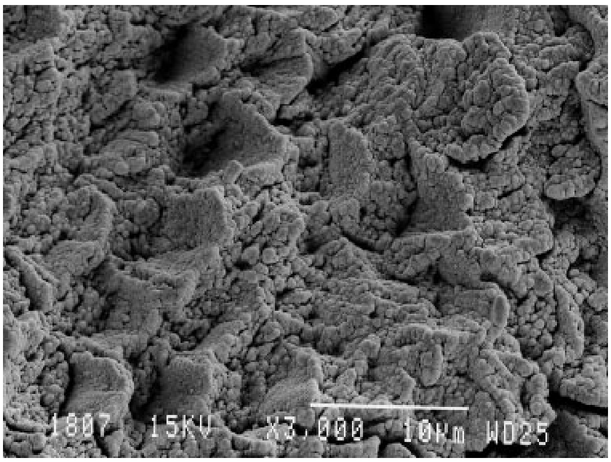

Fig. 2. Scanning electron microscopic picture of an enamel surface after laser preparation and laser-etching. The edges of the keyholes (Fig. 1) were rounded off (×3000) (bar = 10 μm).

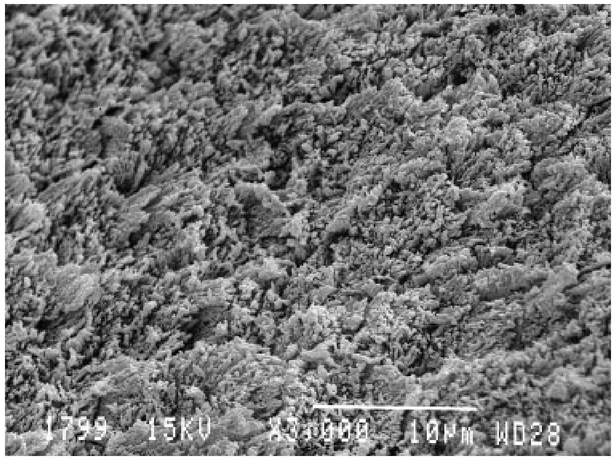

Fig. 3. Scanning electron microscopic picture of an enamel surface after laser preparation and acid-etching (3M). Acid-etching resulted in a more retentive surface (as compared with Fig. 1) (×3000) (bar = 10 μm).

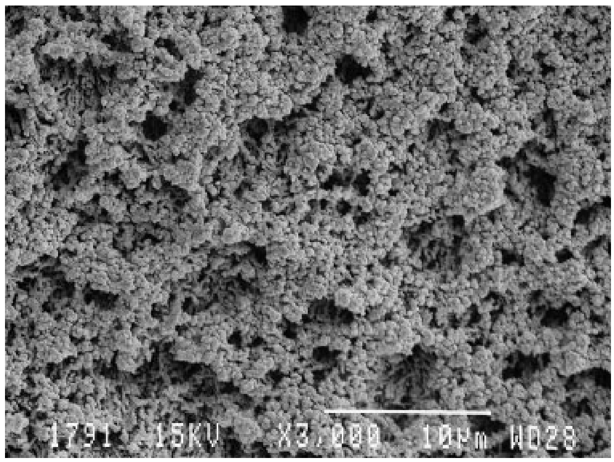

Fig. 4. Scanning electron microscopic picture of an enamel surface after laser preparation and acid-etching (Kerr). A rather granular aspect of the surface was observed (×3000) (bar = 10 μm).

prepared enamel (lased–lased and laser-etched) was characterized by a rather granular surface, especially in samples treated with Kerr acid-gel (Figs 4 and 6) as compared with those treated with 3M acid-gel (Figs 3 and 5).

Volatilization of dentine as a result of laser irradiation (Fig. 7) showed an irregular surface without smear layer exposing the orifices of the dentinal tubules. Intertubular dentine was selectively ablated more than the peritubular dentine, showing a protrusion of dentinal tubules, with a cuff-like appearance. Laser-etching of the laser-prepared dentine rounded off the surface structures (Fig. 8). Acid-etching resulted in surfaces with a rather granular aspect, the samples treated with 3M acid-gel (Figs 9 and 11) showing more open tubules than the surfaces etched with Kerr acid-gel (Figs 10 and 12).

Discussion

In the present investigation, all groups showed higher leakage on the gingival than on the occlusal walls when acid-etching was used. In this respect, it has been demonstrated that bonding to dentine is more technique- and substrate-sensitive than bonding to enamel

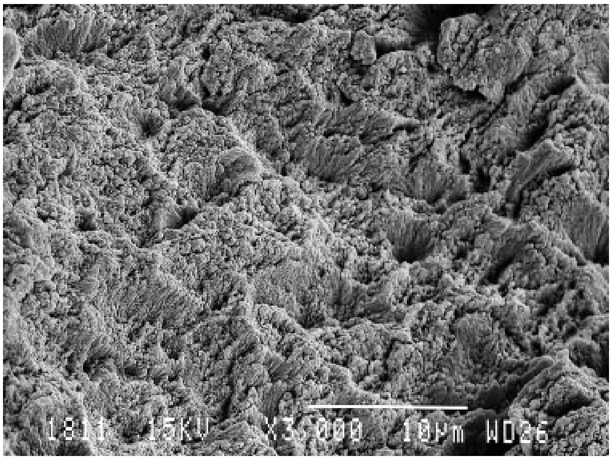

Fig. 5. Scanning electron microscopic picture of an enamel surface after laser preparation, laser-etching and acid-etching (3M). The combination of laser-etching and acid-etching resulted in a less retentive surface than shown in Fig. 3 (×3000) (bar = 10 μm).

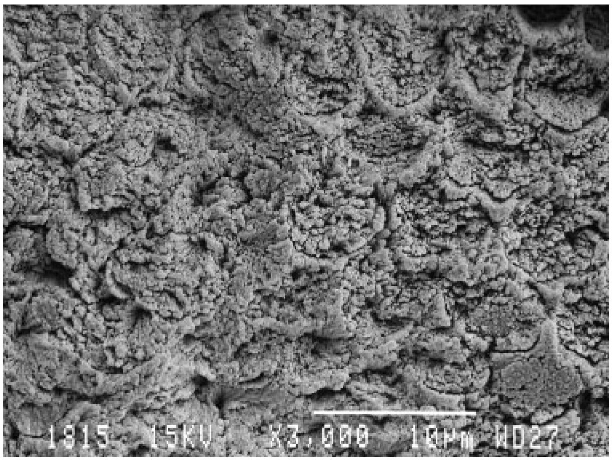

Fig. 6. Scanning electron microscopic picture of an enamel surface after laser preparation, laser-etching and acid-etching (Kerr). Keyhole shaped enamel prisms were observed. A rather granular aspect of the surface was also seen (×3000) (bar = 10 μm).

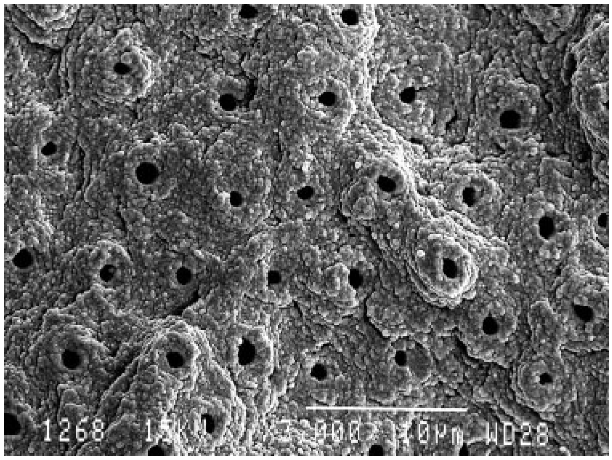

Fig. 7. Scanning electron microscopic picture of a dentine surface after laser preparation showing a cuff-like irregular surface without smear layer exposing the orifices of the dentinal tubules (×3000) (bar = 10 μm).

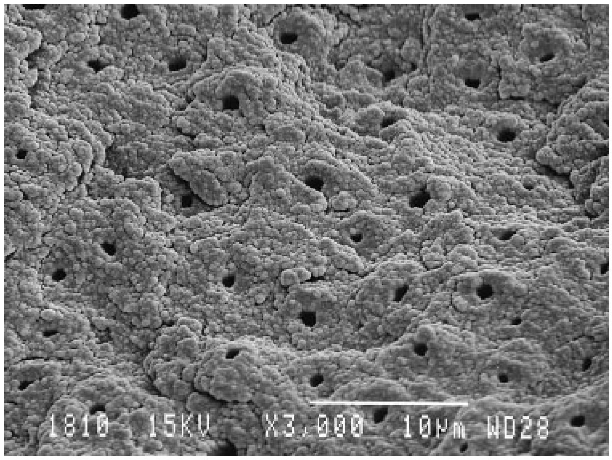

Fig. 8. Scanning electron microscopic picture of a dentine surface after laser preparation and laser-etching. The irregular surface structures (Fig. 7) were rounded off (×3000) (bar = 10 μm).

(3). However, no statistically significant differences in microleakage between the occlusal and gingival walls were found in the groups where cavities were Er:YAG-lased and laser-etched, and no acid-etching was used.

Keller and Hibst (27) reported that treatment with Er:YAG laser would create surfaces that appear similar to acid-etched surfaces, which was confirmed in our study (Figs 1 and 7). Other investigations (12, 31) have shown that when bonding composite to tooth structure, the Er:YAG laser alone or combined with acid-etching produces a surface with bond strength equal or better than that produced by acid-etching alone. The latter finding has been contradicted by a number of investigators: Eduardo *et al.* (32) observed that composite resin shear bond strength to enamel was superior for acid-etched groups compared with the group prepared by Er:YAG laser, because the morphological alterations created on enamel surface by laser irradiation were not sufficient to effectively bond composite to dental surface. More recently, De Munck *et al.* (33) showed that the micro-tensile bond strength of a three-step

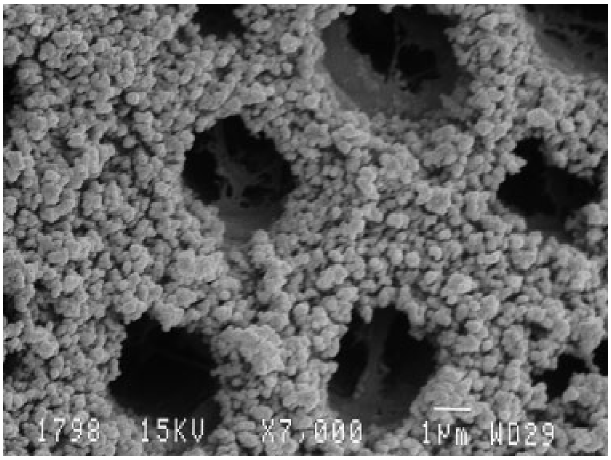

Fig. 9. Scanning electron microscopic picture of a dentine surface after laser preparation and acid-etching (3M) resulting in a surface with a rather granular aspect (×7000) (bar = 1 μm).

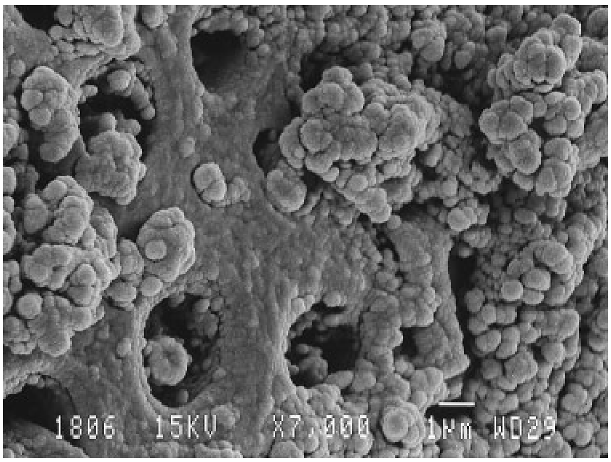

Fig. 10. Scanning electron microscopic picture of a dentine surface after laser preparation and acid-etching (Kerr). More tubules are blocked as compared with Fig. 9 (×7000) (bar = 1 μm).

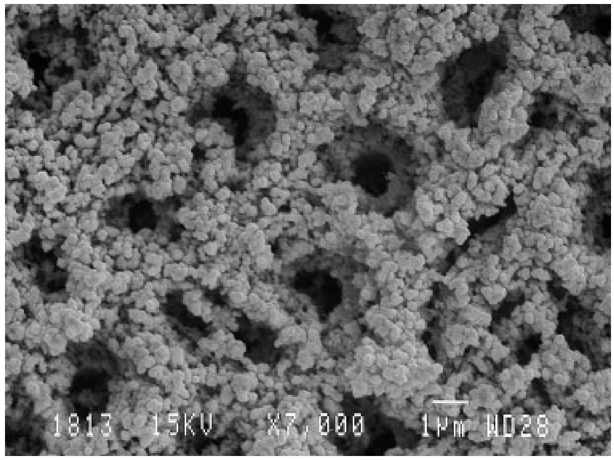

Fig. 11. Scanning electron microscopic picture of a dentine surface after laser preparation, laser-etching and acid-etching (3M). A granular surface and open tubuli were observed (×7000) (bar = 1 μm).

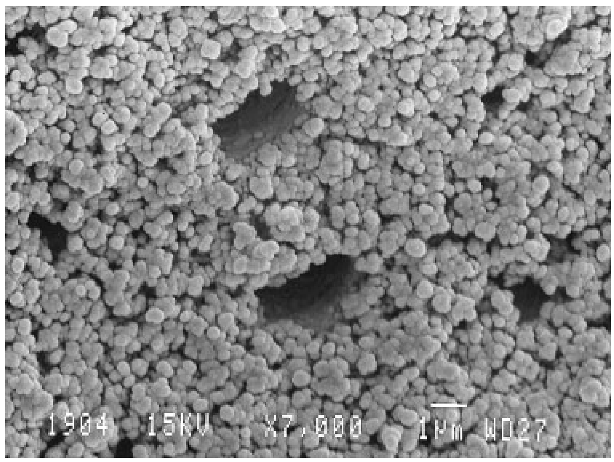

Fig. 12. Scanning electron microscopic picture of a dentine surface after laser preparation, laser-etching and acid-etching (Kerr). Less open tubuli were seen compared with Fig. 11 (×7000) (bar = 1 μm).

total-etch adhesive was significantly lower to Er:YAG-lased versus bur-cut enamel and dentine; laser-conditioning was clearly less effective than acid-etching.

For as far as leakage studies were considered, it was also demonstrated that laser irradiation seemed to be associated with more leakage than acid treatment at enamel margins (in bur-cut as well as in Er:YAG-prepared cavities) and was not advised for promoting a bond between resin composite materials and enamel in cavities without bevel (25–27) as well as in cavities with bevel (21). This finding was confirmed in the present study (Table 2). The SEM analysis of the enamel surfaces demonstrated that laser irradiation as well as additional laser-etching rounded off the enamel irregularities, resulting in a less retentive surface as provided by acid-etching (Figs 1 and 2). This may explain the less tight adhesive seal. A similar effect on the surface of lased dentine samples was also noted (Figs 7 and 8).

At the gingival wall, none of the procedures tested completely eliminated microleakage irrespective of the composite formulation and associated adhesive system.

There were no statistically significant differences among the four different bonding procedures and this is consistent with the results of other researchers (14, 20, 22). Matched analysis, however, revealed statistically significant differences in microleakage for the Er:YAG-lased cavities (irrespective of laser-etching) with and without acid-etching. Less leakage was found when phosphoric acid-conditioning was accomplished in Er:YAG-lased cavities in the Z100 group. In the Herculite group, however, less leakage was found in Er:YAG-lased cavities when no phosphoric acid-conditioning was accomplished. Apparently, a product (resin composite formulation/adhesive system) related difference was found. In this study, two resin composite formulations and adhesive systems were used: an ethanol–water based system (Optibond FL) and a water based system (Scotchbond Multi-Purpose) (Table 1). It is known that leakage is influenced by the composite and adhesive nature. For both adhesive systems a good penetration capability has been described, although, remaining water in the water based system (Scotchbond Multi-Purpose) may hamper resin penetration/polymerization (3). When comparing microleakage in association with Optibond FL and Scotchbond Multi-Purpose, a trend towards less leakage at gingival margins was found when Optibond FL was used in acid-etched bur-cut cavities (34). Examination of the SEM images, showed that dentine samples treated with 3M acid-etch showed more open tubules compared with the samples treated with Kerr acid-gel. This can explain the better results at the gingival margin for cavities treated with Scotchbond Multipurpose. Areas with a granular aspect of the dentine surface after acid-etching were also found. Van Meerbeek *et al.* (29) described similar cases on etched dentine samples: etchant thickened with silica left residual silica particles deposited on the surface, despite it having being thoroughly rinsed off. These silica particles did not appear to plug the intertubular microporosities (35).

The results of this *in vitro* study may not be directly extrapolated to the clinical situation. Additional clinical studies, evaluating the margins of composite fillings in Class V cavities, have to be performed to verify the clinical value of the present *in vitro* results.

Conclusions

Based on the findings of this study and, given the limitations of an *in vitro* study, the following conclusions were drawn:

– enamel margins provided better marginal sealing than dentine/cementum margins in association with phosphoric acid-conditioning irrespective of Er:YAG-lased or classical bur-cut cavities;
– comparable microleakage values were found for both occlusal enamel/resin composite and gingival dentin/resin composite margins in non-acid-etched Er:YAG-lased Class V cavities;
– the quality of the marginal seal of resin composites in non-acid-etched Er:YAG-lased Class V cavities appeared to be dependent on the resin composite and associated three-step adhesive system.

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