The effect of caries detector dyes and a cavity cleansing agent on composite resin bonding to enamel and dentin

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This study was undertaken to evaluate the effect of caries detector dyes and/or cavity cleanser on composite bonding and etching patterns of enamel and dentin. One hundred and eight non-carious premolars were divided into six groups according to the enamel and dentin pretreatment investigated. The different pretreatment were as follows: Group I: teeth with prophylaxis only, Group II: Sable seek caries detector dye, Groups III: chlorhexidine cavity cleanser, Group IV: the caries detectors dye followed by prophylaxis, Group V: the cavity cleanser followed by the caries detector dye, and Group IV: Snoop caries detector dye. The shear bond strength of composite resin bonded to enamel and dentin was evaluated by the Instron Universal testing machine while, the topographic details of enamel and dentin were examined by the SEM following the different pretreatment and acid etching. Results of the shear bond strength showed no statistically significant difference among the six groups, with no substantial differences in SEM results. It is concluded that using the caries detector dyes and/or chlorhexidine cavity cleanser before acid etching does not significantly affect composite bonding to enamel and dentin.
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INTRODUCTION

During cavity preparation conventional tactile and optical criteria are used to assess the caries status of the amelodentinal junction. Cavity preparation is considered complete when this area is hard to a sharp probe and stain free.[1] Caries detector dyes have been developed to aid the diagnosis and removal of dental caries,[2-5] by differentiating between infected, irreversibly deteriorated outer carious dentin and uninfected, but reversibly denatured inner carious dentin.[6,7] The dye stains only the infected outer carious dentin.[2,7]

Initially the caries detector included a 0.5% basic fuchsin solution in propylene glycol as a solvent,[6] however, it was replaced with 1% acid red 52 solution in the same solvent as a substitute dye because fuchsin is believed to be carcinogenic.[8] Other caries detector dyes such as Sable Seek and Snoop (using the same solvent and darker colorant) are available in the market. Their dark color contrasts with dentin and is easily distinguished from the pulp.

Bacteriological investigations showed that 15% to 40% of the carious lesions examined still contained low numbers of bacteria in the dentinal tubules after the removal of dye stained caries.[9-11] Residual bacteria, that can survive for longer than one year, have been shown to proliferate from the smear layer even in the presence of a good seal from the oral cavity allowing toxins to diffuse to the pulp resulting in irritation and inflammation of the pulpal tissue.[12,13]

Since caries is a bacterial disease, it has been proposed to use disinfectants or cavity cleanser in addition to water spray and air before tooth restoration.[14] Recently, antimicrobial cavity cleansers or phosphoric acid etchants, which contain antimicrobial additives, have been recommended to be used after tooth preparation and before tooth restoration.[15-17] It has been found that disinfectant as chlorhexidine is effective in reducing the levels of *Streptococcus mutans* located on exposed carious root surfaces.[18-20] A chlorhexidine-containing cavity liner, studied *in vivo* in the early 1970's, was found to be biocompatible and provided some antibacterial protection.[21]

A cavity cleanser, which contains 2% chlorhexidine digluconate, is available in the market. It is recommended to provide bacteriostasis and to dampen the dentin surface prior to application of the primer in an adhesive system.

Many studies have demonstrated the effect of chlorhexidine on superficial enamel. Chlorhexidine gluconate is adsorbed to hydroxyapatite and to human enamel surfaces

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in vitro with a high affinity between chlorhexidine and hydroxyapatite.[22] Diffusion of chlorhexidine through human enamel was also reported by using radioactive labeling techniques.[23] In addition, an increase in surface free energy caused by chlorhexidine adsorption to enamel was estimated by using x-ray photoelectron spectroscopy.[24]

It has been hypothesized that chlorhexidine might produce both ultra structural and chemical changes in the superficial enamel that might affect composite bond.[25] Alteration of the enamel substrate could change the efficacy of chemical etching and affect the composite bond.

The purpose of this study was to evaluate the effect of using caries detector dyes and/ or a cavity cleanser on: (1) composite resin bond strength, (2) etching patterns of enamel and dentin.

MATERIALS AND METHODS

The effect of using different enamel and dentin pretreatments was investigated in two parts. In part I, composite resin shear bond strength to enamel and dentin was evaluated. In part II, the topography of enamel and dentin after different pretreatments and after acid etching was studied using the scanning electron microscope (SEM).

One hundred and eight non-carious premolars extracted for orthodontic purposes were collected and stored in distilled water in the refrigerator. The enamel of the buccal surface was flattened, using a diamond bur in 54 teeth, while the enamel was completely removed and dentin of the occlusal surface of the other 54 teeth was flattened. For bond strength evaluation 60 teeth (30 enamel and 30 dentin surfaces) were embedded in hard stone blocks so that the flat surfaces were perpendicular to the long axis of the blocks, while the other 48 teeth were used for SEM evaluation.

The teeth were assigned randomly to six equal groups as shown in Table 1. In group I, teeth received prophylaxis using a rubber cup and an aquous slurry of pumice for 10 seconds then washing for 10 seconds as a pretreatment before acid etching.

In group II, caries detector dye (Sable Seek- Ultradent, Product Inc., USA) was applied according to the instructions of the manufacturer for 10 seconds then washed for 10 seconds.

In group III, a cavity cleansing agent 2% Chlorhexidine Digluconate cavity cleanser, (Bisco, Inc, IL, USA) was applied according to the instructions of the manufacturer for 10 seconds then washed for another 10 seconds.

In group IV, following application of the caries detector dye (Sable Seek) teeth received prophylaxis using a rubber cup and a pumice slurry.

In group V, following the application and washing of the caries detector dye (Sable Seek) the cavity cleanser (Bisco, Inc) was applied.

In group VI, another caries detector dye (Snoop, Pulpdent Corp, MA, USA) was applied according to the instructions of the manufacturer for 10 seconds followed by washing for 10 seconds.

SHEAR BOND STRENGTH EVALUATION

In all the groups, following enamel and dentin pretreatments, the surfaces were dried with an oil free air for 10 seconds then the enamel surfaces were etched for 30 seconds with 37% phosphoric acid (3M Co. St. Paul, MN, USA).

The surfaces were then washed for 20 seconds and dried for 10 seconds. The bonding agent (Scotchbond multipurpose plus, 3M Co. St. Paul, MN, USA) was applied and cured for 20 seconds. For dentin the surfaces were etched with 37% phosporic acid then washed for 20 seconds then dried for 10 seconds leaving the dentin slightly damped, the primer was applied and air thinned, then the bonding agent was applied and cured for 20 seconds.

A hard plastic cylindrical rod 2.5 mm in diameter and 3 mm in length was attached perpendicular to the enamel or dentin surfaces. The rods were filled by Z-100 composite (3M Co. St. Paul MN, USA) in 2 increments of 1.5 mm. Each increment was cured for 40 seconds. The plastic cylinder was cut off, then the composite rod was cured again for 40 sec.

All the specimens were incubated for one week at 37°C and 100% humidity. Each specimen was mounted in an Instron Universal testing machine (Instron 1193, Instron Limited, England) and a shear force was applied perpendicular to the composite cylinder at the base, at a cross head speed of 2mm/min until debonding occurred.

The shear bond strength was calculated by dividing the obtained load by the surface area and expressed in MPa. The shear bond strength values of the six groups were compared using the Kruskall-Wallis one-way analysis of variance.

THE SEM INVESTIGATION

Forty eight teeth (24 enamel and 24 dentin surfaces) were divided into the same 6 groups (Table 1). In each group the topographic details were studied using the SEM (JEOL 5300, scanning microscope, Japan) following the different pretreatments and after acid etching. The specimens were dried, mounted and sputter coated with gold to enable examination, then placed in the vacuum. The surfaces were scanned using different magnifications. The topographic details of each group were noted and the area was photographed and analyzed.

Table 1. Enamel and dentin pretreatments before acid etching.

Group	Enamel and Dentin Pretreatments
I	Prophylaxis (aquous slurry of pumice)
II	Caries detector dye (Sable Seek)
III	Cavity cleanser (2% Chlorhexidine Digluconate)
IV	Caries detector dye (Sable Seek) then prophylaxis
V	Caries detector dye (Sable Seek) then cavity cleanser (2% Chlorhexidine Digluconate)
VI	Caries detector dye (Snoop dye)

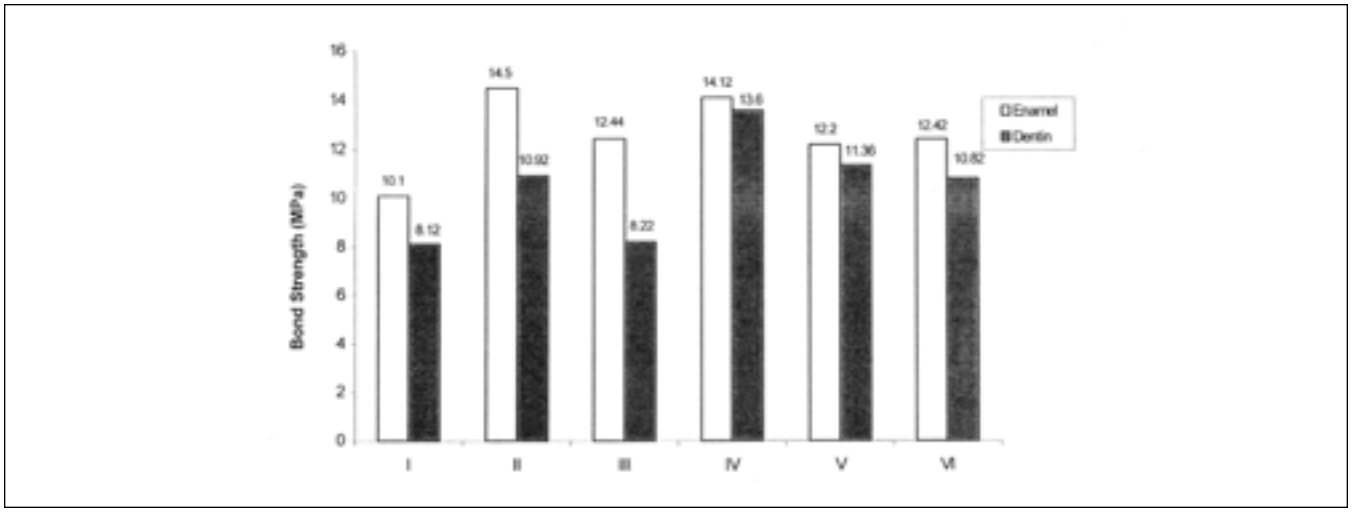

Figure 1. Mean shear bond strength (MPa) of composite resin bonded to enamel and to dentin in the six groups.

RESULTS

Shear Bond Strength

The results of the composite resin shear bond strength measurements to enamel and to dentin surfaces are represented in Table 2 and Figure 1. No statistically significant difference was found among the 6 groups (P> 0.05) for either enamel or dentin.

Scanning Electron Microscope (SEM)

Analysis of the scanning electron microscope photomicrographs revealed that flattening the tooth surfaces with a diamond bur left a smear layer on both enamel and dentin (Figure 2). This smear layer was preferentially removed by the acid etching as shown in group I (Figure 3).

Using the caries detector dye (Sable Seek, group II) or the cavity cleansing agent (group III) did not remove the smear layer and deposits were observed on both enamel and dentin (Figure 4). However following acid etching, it was obvious that the enamel as well as the dentin were preferentially demineralized. Similarly acid etching after using Sable Seek dye and pumice (group IV) and after the application of Sable Seek dye then the cavity cleanser (group V) removed the smear layer and produced preferential etching patterns. On enamel (Figure 5) a preferential removal of prism peripheries was found with areas in which prism cores were dissolved faster than the interprismatic substance. The dentin appeared smooth and openings of the dentinal tubules were widened (Figure 6) as a result of removal of intertubular and intratubular dentin.

No substantial differences in SEM results could be detected between Sable Seek dye (group II) and Snoop dye (group VI), regarding the enamel and dentin topographical changes.

Table 2. Shear bond strength (MPa) of composite resin to enamel and to dentin surface in the six groups.

Group		Minimum	Maximum	Mean ± S.D.
I	Enamel	7.3	14.5	10.10 ± 2.82
	Dentin	5.3	14.2	8.12 ± 3.54
II	Enamel	7.0	20.4	14.50 ± 6.01
	Dentin	6.1	16.7	10.92 ± 4.16
III	Enamel	7.1	20.4	12.44 ± 5.15
	Dentin	6.7	11.8	8.22 ± 2.10
IV	Enamel	9.8	20.4	14.12 ± 3.93
	Dentin	7.9	17.4	13.60 ± 4.71
V	Enamel	8.8	18.2	12.20 ± 3.60
	Dentin	8.2	17.3	11.36 ± 3.50
VI	Enamel	7.0	20.4	12.42 ± 5.88
	Dentin	7.7	13.0	10.82 ± 1.93

DISCUSSION

The use of resin based restorative materials in posterior teeth has increased in recent years due to the demand for tooth-coloured restorations and concerns about the mercury content of silver amalgam.[26,27]

Laboratory studies have been conducted through the years to determine shear or tensile bond strength of resin materials to acid etched surfaces. The shear test such as that used in the present study would seem to have an advantage over the tensile test on that it appears to be more likely to produce failure at the tooth-adhesive interface.[28]

The significant progress in using composite resin in restorative dentistry occurred over the past several years is based on an increased understanding of the caries process and introduction of increasingly effective bonding techniques. In view, of the current trend to keep cavities as small as possible, utilization of caries detector dyes to identify carious dentin has been suggested as an appropriate basis for objective decision making on cavity size.[29] The ability of com-

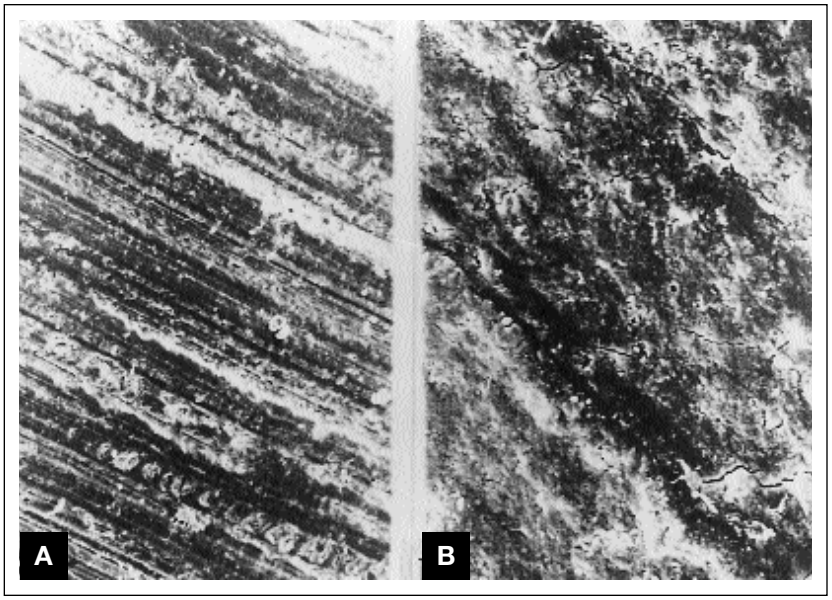

Figure 2. A smear layer is seen on: (A) enamel surface (x500) and (B) dentin surface (x2000) flattened with diamond bur.

posite resin to bond to enamel or dentin substrate could be influenced by any chemical agent used in sufficient concentration that could change the efficacy of phosphoric acid etching. The present investigation showed that the use of caries detector dyes before acid etching, did not interfere with the etching patterns as evidenced by SEM, or composite bonding to either enamel or dentin. This result can be attributed to either lack of substantial effect of the dyes or to acid etching which dissolves the superficial layers of enamel and dentin with the production of preferential etching patterns suitable for resin bonding. This suggestion is supported by Legler *et al.,*[30] who reported that the application of 37% phosphoric acid solution to enamel for 30 seconds resulted in an approximately 16 (m depth of etch. This depth of dissolution might have allowed removal of the smear layer and the debris left on the enamel surface. Similarly, it was reported that acid etching of dentin removes the smear layer and smear plugs from dentinal tubules and also removes the mineral content of intertubular dentin to a depth of approximately 2-7 μm.[31] Thus the overall bond strength of composite resin to dentin is achieved by surface adhesion, resin tags formation and hybrid layer formation.[32]

The bond strength values obtained in the present study were not compared with the values of other studies because it is not possible to compare the results of the bond strength obtained from different laboratories since these values are influenced by the teeth used, the method applied, and the cross head speed of the testing machine. A small modification of the same method can give 2 to 4 fold differences in bond values for the same product.[33] However, the overall changes were compared with the results of similar studies.

Although previous studies reported an increase in the surface free energy caused by chlorhexidine adsorption to enamel[24] and might have a similar effect on dentin the use of chlorhexidine cavity cleanser in the present study had no significant effect on bond strength. This finding is supported by Filler *et al.,*[34] who found no significant difference in the bond strength between composite bonded to enamel treated with 0.12% chlorhexidine mouth rinse and untreated enamel. It is also supported by Perdigao *et al.*,[35] who found that applying chlordexidine cavity cleanser after acid etching had no significant effect on the shear bond strength of composite to dentin.

A typical smear layer was observed by SEM in the present study. This observation is supported by other investigators[31,36,37] who reported that dental instrumentation results in a smear layer of organic and hydroxyapatite particles, which cover both enamel and dentin surfaces and penetrates into the dentinal tubules to form smear plugs. This smear layer was not removed by the application of the caries detector dyes and/or the cavity cleanser, which do not seem to influence the attachment of the smear layer. This finding is in agreement with previous reports which suggested that only demineralizing solutions or acidic agents are apparently able to perform this.[31,36] However, after the application of the phosphoric acid the smear layer and the debris formed on the surface were removed and preferential etching patterns of both enamel and dentin were produced. This finding is in accordance with other investigations[14,36,38] which showed that 37% phosphoric acid completely removed the smear layer from

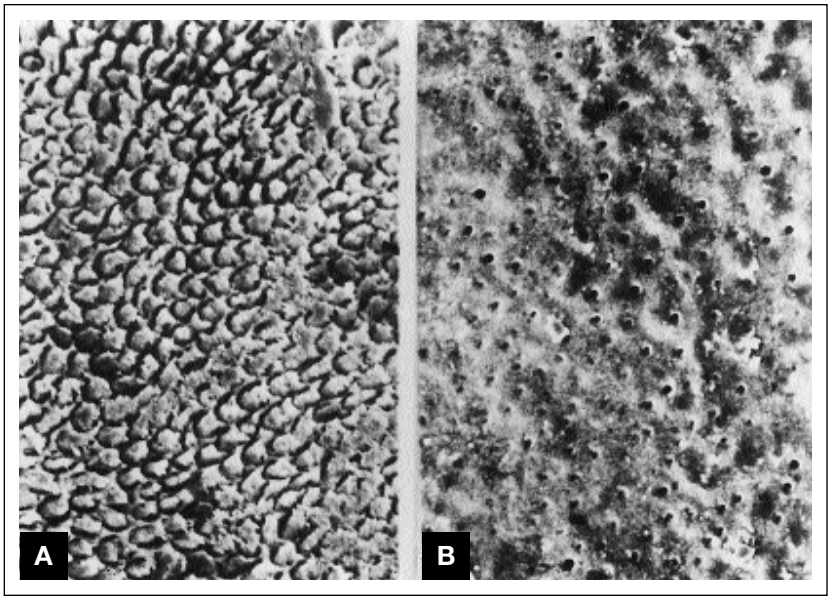

Figure 3. Group I following acid etching. (A) The enamel surface (x1000) shows preferential removal of the prism peripheries. (B) The dentin surface (x1000) shows opening of the dentinal tubules.

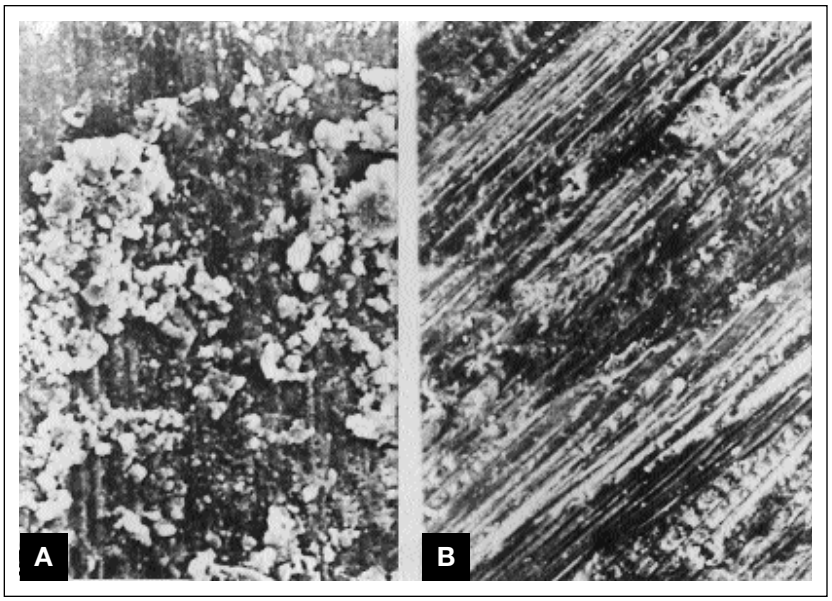

Figure 4. A smear layer and surface deposits are seen before acid etching. (A) The dentin surface in group II (x2000) following the application of Sable Seek dye. (B) The enamel surface in group III (x500) after using the cavity cleanser.

both the enamel and the dentin surfaces. The enamel was preferentially etched, whereas the dentin appeared smooth and the opening of the tubules were widened.

Caries detector dyes can be used as an adjunctive clinical procedure to aid the dentist in treatment of carious teeth, especially for those individuals who do not possess a high degree of clinical expertise for removing decay.[3] However, since these dyes do not completely eliminate the chances of viable bacteria remaining in a cavity preparation.[11] The combined use of caries detector dye and cavity cleanser will aid the clinician in the caries removal process, especially the unexperienced ones, and help to disinfect the cavity. As shown in the present investigation, this combined use would not compromise composite bonding to either enamel or dentin. However, clinical performance of composite resin placed after the use of caries detector dye and/or chlorhexidine cavity cleanser should be evaluated regarding to bonding and tooth sensitivity.

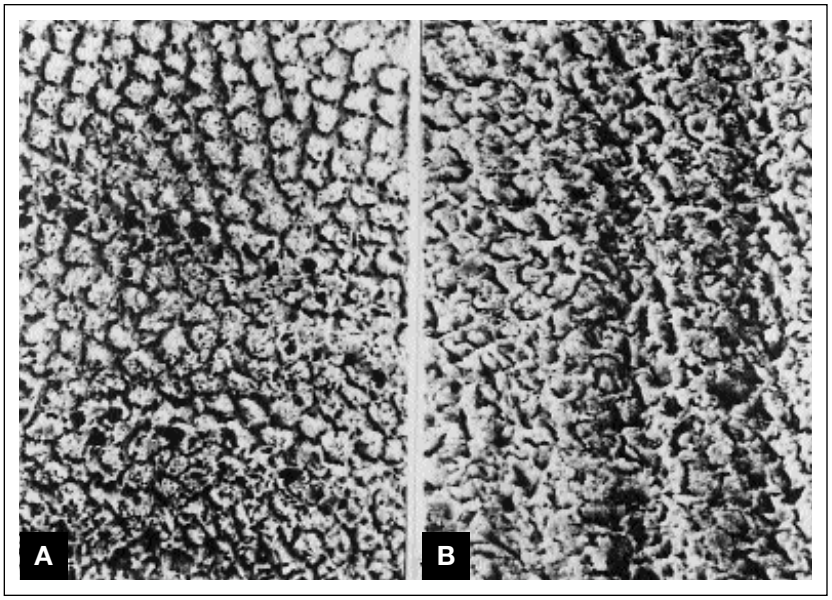

Figure 5. The enamel surface: (A) group IV (x1000), (B) Group V (x1000) following acid etching shows preferential removal of the prism peripheries in some areas and prism cores in other areas.

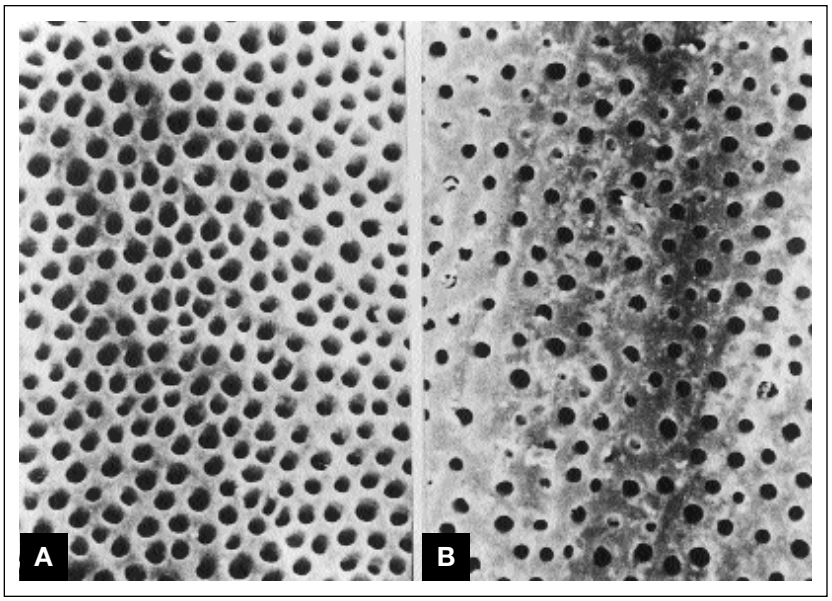

Figure 6. The dentin surface: (A) group IV (x1000), (B) group V (x1000) after acid etching shows widening of the dentinal tubules.

CONCLUSION

The results of the present study suggest that using caries detector dyes and/or chlorhexidine cavity cleanser before acid etching does not significantly affect bonding of composite resin to enamel and dentin.

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