Effect of a chemo-mechanical caries removal system (Carisolv™) on dentin topography of non-carious dentin

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The purpose of the present study was to examine the morphology of healthy dentin surfaces after treatment with Carisolv™ followed by conditioning with phosphoric acid and EDTA, since surface morphology may be of interest for dentin bonding. Another purpose was to evaluate the effect of treatment with Carisolv™ on healthy non-carious dentin surfaces with exposed collagen fibers. Scanning electron microscopy was utilized to carry out a detailed morphological examination of the dentin surfaces with regard to presence or absence of both smear layer and collagen fibers. Twelve premolars extracted for orthodontic reasons from young adults were used. The two etchants appeared to have produced two distinctly different surfaces. Etching with phosphoric acid following Carisolv™ treatment resulted in a porous dentin surface, while EDTA etching without prior Carisolv™ treatment appeared to have uncovered an intact collagen network. In contrast, the surfaces treated with Carisolv™ prior to EDTA etching displayed smooth intertubular surfaces with only occasional fibers. Apparently, the ability of EDTA to expose collagen in the dentin surface is counteracted or inhibited by the Carisolv™ treatment. Furthermore, it cannot be excluded that the Carisolv™ treatment in itself may have dissolved collagen fibers. Since most bonding systems claim bonding to the collagenous component of dentin, the question arises which of the etched surfaces is preferable and to what degree the collagenous component contributes to bonding strength. Further studies are thus needed to evaluate the micromechanical retention of a restoration to the different surfaces described in the present study. □ *Carisolv™; dentin; EDTA; etching; in vitro; phosphoric acid; SEM*

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A new chemo-mechanical caries removal system, Carisolv™ (Medi Team Dentalutveckling i Göteborg AB, Sävedalen, Sweden) has recently been introduced. This system utilizes a mixture of sodium hypochlorite and three amino acids (Lysine, Leucine and Glutamic acid) in a gel preparation.

The chemo-mechanical caries removal system has earlier been shown to minimize the disadvantages of traditional cavity preparation using burrs or sharp edge hand instruments (1–3). Mechanical caries removal often induces pain and therefore requires local anesthesia. In many clinical situations, for example in pediatric dentistry, a chemical, less traumatic caries removal system may be favorable (4).

It has recently been proposed that caries excavation, using only the Carisolv™ system, can increase the risk of residual caries in the dentin-enamel junction (5), so it may be necessary to extend the enamel margins of the cavity with a conventional burr to obtain good visual access and minimize the risk of leaving caries.

The bonding mechanism of many dentin bonding systems is based on the formation of a hybrid layer between hydrophilic resin components and partially demineralized dentin (6, 7). Excavation with Carisolv™ has also been shown to produce a smear-like debris covering the dentin and enamel surfaces of the cavity (5). These findings, which are in accordance with earlier studies using Caridex® (1), have demonstrated the need to condition the cavity walls with phosphoric acid or other surface-active solutions in order to remove smear and debris before a bonded restoration is introduced (8).

The purpose of the present study was to examine the morphology of healthy non-carious dentin surfaces following treatment with Carisolv™. Since surface morphology may be of interest for dentin bonding (9, 10), it was also within the scope of the study to describe dentin topography following Carisolv™ treatment and etching with phosphoric acid or EDTA.

Material and methods

Twelve premolars extracted for orthodontic reasons from young adults were used in the present study. On the buccal surface of each tooth a flat dentin surface was ground using a 600 grit wet abrasive paper. The experimental surface included both coronal and root dentin. A horizontal notch was made in the dentin surface with a diamond disk, dividing the experimental surface into a coronal and an apical part. The teeth were stored in a

Table 1. Dentine surface treatment in test groups I–III

		Dentin surface treatment			
	Tooth surface	Grinding	Carisolv	Phosphoric acid	EDTA
Group I	Control	×			
	Test	×	×		
Group II	Control	×		×	
	Test	×	×	×	
Group III	Control	×			×
	Test	×	×		×

water thermostat at 37°C for 1 h before any further treatment was performed.

Carisolv™ treatment

The apical part of all teeth was treated with Carisolv™ for 5 min without instrumentation and the coronal part served as control. Following Carisolv™ treatment, the teeth were rinsed in deionized water for 2 min.

Etching

After the Carisolv treatment the teeth were randomly divided into 3 groups (I–III), each containing 4 teeth (Table 1).

Group I—The teeth in this group received no further treatment. The coronal part served as untreated control and the apical part as Carisolv™-treated control.

Group II—The teeth in this group, both the apical and the coronal parts, were etched with 37% phosphoric acid for 20 s and subsequently rinsed in deionized water.

Group III—The apical and the coronal parts of the teeth in this group were etched with a 24% EDTA gel-solution for 2 min. After treatment, the teeth were rinsed in deionized water.

Subsequent to treatment (Table 1), the specimens from the 3 groups were fixed in a solution of 4% buffered formaldehyde for 24 h followed by dehydration in a graded series of alcohol using 100% acetone and tetramethylsilane as final steps (11). The teeth were mounted on aluminum stubs using silver paint and sputter coated with platinum to a thickness of 20 pm (12). All teeth were examined in a scanning electron microscope (Jeol JSM-820, Jeol Industries Ltd., Tokyo, Japan) at 15–20 kV and working distances between 9 and 12 mm.

Results

Group I

Both the Carisolv™-treated and the untreated control sides showed a homogenous smear layer with grooves and furrows probably produced by the grinding paper. No dentin tubuli openings were visible (Fig. 1).

Group II

The Carisolv™-treated and etched surfaces and the etched control surfaces were both free from smear. The control surfaces showed a granulated appearance (Fig. 2). In higher magnification (×10,000), occasional collagen fibers were seen in the dentin tubuli openings (Fig. 3). The Carisolv™ and phosphoric acid-treated dentin surfaces were markedly eroded (Fig. 4). In higher magnification (×10,000), it was evident that the dentin surface was quite porous (Fig. 5), although without any visible collagen fibers.

Group III

The EDTA etched control surfaces were free from smear (Fig. 6). In higher magnification (×10,000), a confluent coverage of exposed collagen fibers was evident (Fig. 7). The Carisolv™ and EDTA-treated surfaces were also free from smear (Fig. 8). In higher magnification (×10,000) smooth intertubular dentin surfaces were seen instead of the collagen network that was clearly visible in the control surfaces. In the test surfaces, only the ends of occasional fibers were visible (Fig. 9).

Discussion

The purpose of the present investigation was to examine the morphology of non-carious dentin surfaces after treatment with a relatively new product, Carisolv™ for chemo-mechanical caries removal. This may be of particular interest, since bonding of filling materials to dentin surfaces is standard practice and thus the nature of the treated dentin surface to a large extent determines the outcome of therapy (6, 7). In the majority of dentin bonding systems, etching of the dentin surfaces is recommended or is an integral part of the system. Therefore, it was also within the scope of the study to examine the morphology of dentin surfaces treated with

different etchants following treatment with Carisolv™. Phosphoric acid (group II) works at low pH 1, and demineralizes dentin by eroding the surface (15). EDTA (group III) dissolves dentin at neutral pH 7 by chelating the mineral component, and has been shown not to dissolve the organic component of dentin (15). The main constituent of Carisolv™ is sodium hypochlorite, commonly used in endodontic therapy to dissolve organic rests of the pulp in the root canal.

Scanning electron microscopy was utilized to carry out a detailed morphological examination of the dentin surfaces with regard to presence or absence of both smear layer and collagen fibers (13, 14).

Smear layer

Results from experimental group I showed that treatment with Carisolv™ failed to remove the smear layer, which is in accordance with earlier findings (5). However, smear-free dentin surfaces have been described

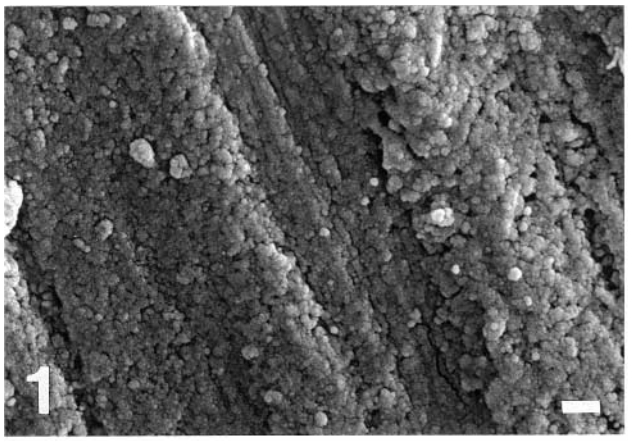


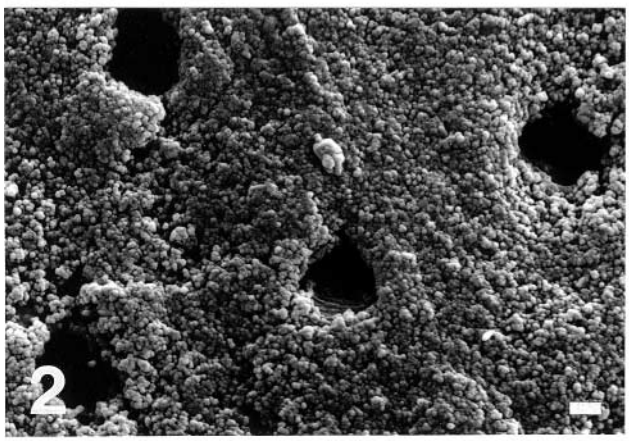
Fig. 1. Smear layer covering a ground dentin surface (original magnification ×5000, bar = 1 μm).

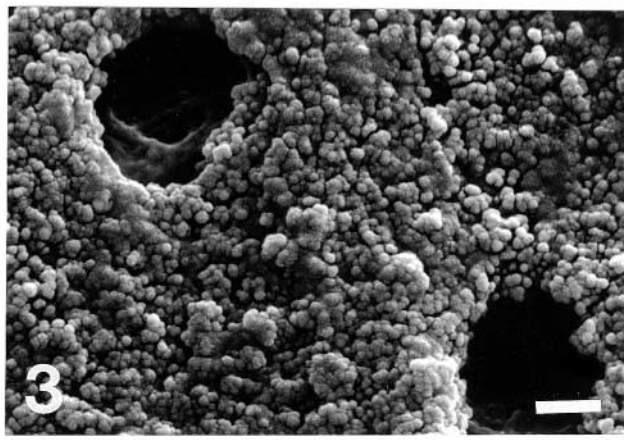
Fig. 2. Dentin surface etched with phosphoric acid for 20 s showing patent dentin tubules and a granulated intertubular dentin surface (original magnification ×5000, bar = 1 μm).

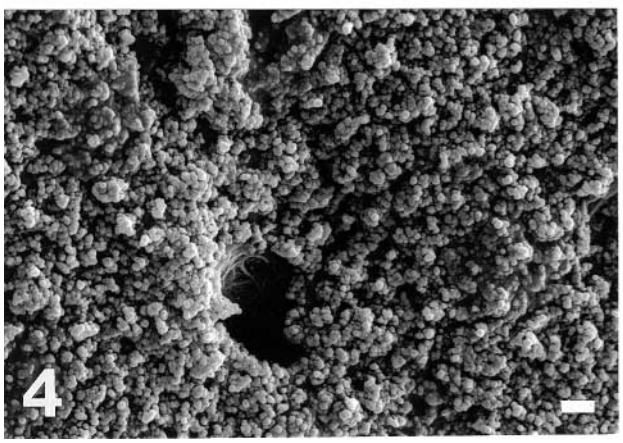
Fig. 3. Higher magnification of Fig. 2 displaying a granulated intertubular dentin surface without apparent collagen fibers in the surface (original magnification ×10,000, bar = 1 μm).

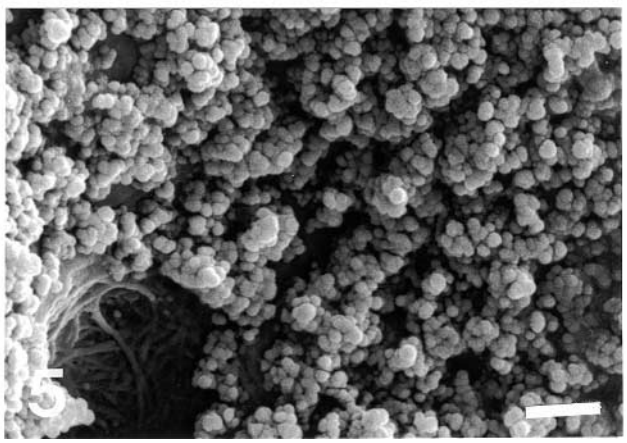
Fig. 4. Dentin surface treated with Carisolv™ for 5 mins and subsequently etched with phosphoric acid for 20 s showing smear-free dentin tubules and an eroded intertubular dentin surface (original magnification ×5000, bar = 1 μm).

Fig. 5. In higher magnification, intertubular dentin revealed a markedly porous surface without apparent collagen fibers (original magnification ×10,000, bar = 1 μm).









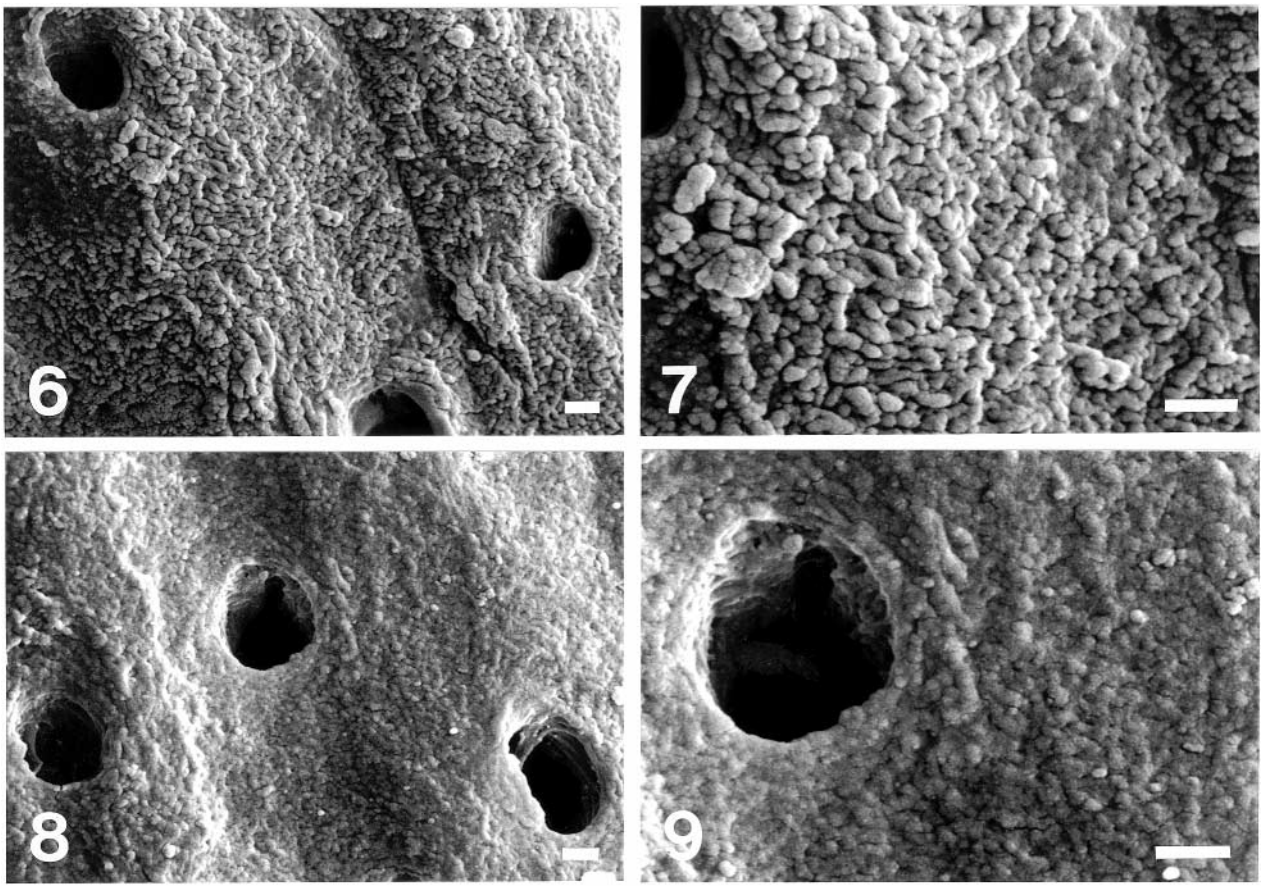


Fig. 6. EDTA etched (2 min) dentin surface with patent dentin tubules and a collagen-like meshwork covering the intertubular dentin (original magnification ×5000, bar = 1 μm).

Fig. 7. Higher magnification of Fig. 6, intertubular dentin covered by numerous collagen fibers (original magnification ×10,000, bar = 1 μm).

Fig. 8. Dentin surface etched with EDTA for 2 min following Carisolv treatment for 5 min. Smear-free tubuli openings and a smooth intertubular dentin surface without evident collagen fibers (original magnification ×5000, bar = 1 μm).

Fig. 9. In higher magnification, the smooth intertubular dentin surface revealed occasional ends of collagen fibers (original magnification ×10,000, bar = 1 μm).

in a study of the first chemo-mechanical caries removal system, Caridex® (16). In the same study it was implied that a Caridex®-treated smear-free surface was more appropriate for direct restoration without etching, than a smear-covered surface prepared with a dental burr. Other studies have shown that a smear layer covering the dentin surfaces provides a weak link between the tooth and a bonded restoration (17, 18).

Etching

The smear layer was removed by etching following Carisolv™ treatment in the other two experimental groups (II and II). However, the two etchants appeared to have produced 2 distinctly different surfaces. Etching with phosphoric acid following Carisolv™ treatment resulted in a porous dentin surface (group II), while EDTA etching without prior Carisolv™ treatment appeared to have uncovered an intact collagen network (group III). This is in accordance with previous studies demonstrating the ability of phosphoric acid to dissolve collagen in a dentin surface (15, 19). In contrast, the surfaces in group III where Carisolv™ treatment had been performed prior to EDTA etching displayed smooth intertubular surfaces with only occasional fibers. Apparently, the ability of EDTA to expose collagen in the dentin surface is counteracted or inhibited by the Carisolv™ treatment. Furthermore, it cannot be excluded that the Carisolv™ treatment in itself may have dissolved collagen fibers.

Since many reports claim bonding to the collagenous component of dentin (6, 7), and others prefer a dentin

surface void of collagen (20), the question arises, which of the etched surfaces described in the present study is preferable and to what degree the collagenous component contributes to bonding strength. Further studies are thus needed to evaluate the micromechanical retention of a restoration and the importance of surface treatment, especially if Carisolv is added to the process.

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