Chemical and topographical analyses of dentine surfaces after Carisolv™ treatment

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Abstract

\textbf{Objectives.} The aim of this study was to characterise the surface chemistry of cavities after chemomechanical caries excavation, and also to measure the surface topography after caries removal with Carisolv™ or burs, followed by acid etching.

\textbf{Methods.} Fourier transform (FT)-Raman spectroscopy was used to study the relative amounts of organic material and minerals of sound enamel, dentine, and cavities, after caries excavation. Fourier transform infrared spectroscopy (FTIR) and laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) were used for detection of Carisolv™ substances (i.e. mainly sodium hypochlorite, amino acids, and the gelling agent carboxymethyl cellulose). In total, 19 carious and 11 sound extracted teeth were used for the chemical analyses. Topographic examination of 30 carious extracted teeth was performed with a contact profilometer.

\textbf{Results.} The relative amounts of organic material and minerals did not significantly differ between sound dentine and the cavities after caries removal with burs or Carisolv™. The FTIR analyses indicated extremely small amounts of Carisolv™ substances at the cavity surface, but the LA-ICP-MS analyses did not confirm those findings. Furthermore, the topographical parameters did not significantly differ between etched cavities after caries removal using burs or Carisolv™.

\textbf{Conclusions.} The chemical and topographical analyses in the present study imply that any differences between the cavities after caries excavation with burs or with Carisolv™ are insignificant. © 2002 Elsevier Science Ltd. All rights reserved.

\textbf{Keywords:} Dental caries; Chemomechanical caries removal; surface properties; Spectroscopy; Topography

1. Introduction

Traditionally, caries excavation was performed with use of burs, but today there are complementary methods such as chemomechanical and laser techniques for caries removal. The main indicators for a chemomechanical approach are deep caries lesions, root surface caries and dental treatment of children. Caridex was one of the first chemomechanical methods for caries removal. Since it was considered expensive and circumstantial, it was never well accepted. From Caridex, a new product was developed during the 1980s to include four active components — hypochlorite and the three amino acids leucine, lysine and glutamic acid. In 1989, the product was patented [1] and today it is commercially available as Carisolv™ (MediTeam Dental AB, Sweden). When caries is excavated with Carisolv™, the active components are mixed and applied to the lesion. The carious tissue is then softened and can be scraped off with some specially designed hand instruments. This procedure is repeated until all caries has been removed. However, more research on the mechanisms of action of Carisolv™ is needed for a full understanding of this treatment method. For example, the outcome of the bonding between the tooth and filling materials partly depends on the surface properties of the cavity. How those surface properties might change after Carisolv™ treatment is not entirely known. In this study, the surface chemistry was studied with Fourier transform (FT)-Raman spectroscopy, Fourier transform infrared spectroscopy (FTIR) and laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS). Contact profilometry was used for a topographical examination.

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Dentine surfaces after caries excavation with Carisolv™ were examined earlier for bacterial deposits [2] and natural autofluorescence of carious tissue [3]. None of the two studies mentioned, showed any carious tissue remaining at the dentine surfaces after caries removal with Carisolv™. However, the chemical composition of dentine surfaces after caries excavation with Carisolv™ has not been reported.

Surface topography after Carisolv™ excavation has previously been demonstrated to be rougher than after conventional caries excavation [4]. However, in the clinical situation, acid etching frequently follows caries excavation. Consequently, the difference in topography after etching is of great clinical interest since it is this surface that usually comes in contact with different filling materials.

The purpose of the present study was to characterise the surface chemistry of cavities after chemomechanical caries removal, and also to investigate whether component substances of Carisolv™ are left on the cavity surface after such caries removal. An additional aim was to measure the surface topography after acid etching after caries removal with Carisolv™ or with burs.

2. Material and methods

In the present study, extracted human permanent teeth were used for all the experiments. The time between extraction and analysis was not more than 3 months. During this time, the teeth were stored at +4°C in 0.05 M phosphate buffered saline solution with pH 7.2.

2.1. Chemical analysis

The chemical analyses were primarily performed by FT-Raman spectroscopy. FTIR and LA-ICP-MS were used as complementary methods.

2.1.1. FT-Raman spectroscopy

Six different kinds of tooth surface were studied: enamel, sound dentine, cavities after caries removal with burs, cavities after caries removal with Carisolv™, etched cavities after caries removal with burs, and etched cavities after caries removal with Carisolv™. In total, 10 normal teeth and 16 teeth with dentine cavities were examined.

The normal teeth were used for examination of sound enamel and dentine. To gain access to sound dentine surfaces, five normal teeth were sectioned longitudinally under water irrigation using an Exakt™ sawing and grinding machine. The carious teeth were used for examination of cavity surfaces and the caries lesions were removed with either burs or Carisolv™ just before analysing. Drilling was performed at 15 000 revolutions/minute and Carisolv™ was used according to the manufacturer’s instructions. In both cases, complete caries removal was confirmed with a sharp dental probe. Half of the cavities were etched with gelled 35% phosphoric acid (Ultra-Etch®, Ultradent Products, USA) immediately before chemical analysis. The etching agent was abundantly applied and after 30 s, the cavities were rinsed under profuse running tap water. All the tooth samples were damp during analysis.

The Raman spectra were characterised in air with a Bruker IFS66 FT-IR spectrometer equipped with a FRA 106 FT-Raman module. Excitation was provided by a liquid nitrogen cooled Nd:YAG laser at a wavelength of 1064.1 nm with the beam focused to 100 μm in diameter. Laser power output was controlled to 80 mW after checking for no photodecomposition. A liquid nitrogen cooled germanium detector recorded the Raman spectra at a resolution of 4 cm⁻¹, at ambient temperature. Ten replicates of each kind of tooth surface were characterised. Raman spectra were also recorded from a damp caries lesion surface and from powders consisting of pure hydroxyapatite and calcium carbonate (Aldrich, Milwaukee, USA) and type I collagen from calf skin (Fluka, Milwaukee, USA). The powders were packed into sampling cups before the analysis. Two replicates were recorded of hydroxyapatite, calcium carbonate, collagen type I, and the caries lesion surface.

Integrated intensities were determined by the instrument software. Intensity ratios were calculated as a measure of relative amounts.

2.1.2. FTIR

First, the caries of an extracted tooth was excavated with Carisolv™. Complete caries removal was confirmed with the use of a sharp dental probe. An approximately 6 μm thick surface layer of the cavity was gently scraped off with a fresh scalpel blade. The thickness removed was calculated from the weight of dentine (0.2 mg), the estimated surface area of the cavity (1.5 × 10⁻⁷ m²), and an average of the density of wet and dry dentine (2.3 × 10³ kg/m³). The dentine material removed was mixed with potassium bromide (KBr) for KBr-pellet preparation and subsequent FTIR examination. The total weight of the KBr-pellet was 100 mg.

A KBr-pellet was also made of 0.5 mg sound dentine using a scalpel in the same way as described above, after accessing sound dentine by sectioning a normal tooth under profuse water irrigation using an Exakt™ sawing and grinding machine. After FTIR examination, about 10% of the KBr-pellet was carefully mixed with pure KBr and a new 100 mg pellet was made and examined. This procedure was repeated until no IR band from dentine was present in the FTIR spectra. This procedure was also repeated for a dried Carisolv™ mixture. This was to estimate the minimum detectable amount of dentine and Carisolv™ by FTIR spectroscopy.

The IR analyses were performed using a Mattson Cygnus 100 FTIR spectrophotometer with 4 cm⁻¹ resolution. Each spectrum was acquired from about 100 scans. To remove effects of atmospheric carbon dioxide and water vapour, the instrument was purged with analytical instrument quality air, dried and purified with a Balstron type 75–60
conditioner. All FTIR spectra were acquired within a few hours of KBr-pellet preparation, immediately after production of the KBr-pellet. The spectra were baseline corrected using the FTIR software. For all spectra the same wavenumber positions were chosen.

2.1.3. LA-ICP-MS

The aim of the LA-ICP-MS measures was to investigate possible changes in the chlorine (Cl) and sodium (Na) concentrations of cavities after caries excavation with Carisolv™, since both these elements are present in the Carisolv™ mixture. One caries lesion of an extracted tooth was excavated with Carisolv™. Complete caries removal was confirmed with the use of a sharp dental probe. Thereafter, the tooth was cut through the cavity with the Exakt™ saw to access the depth profile of the cavity. The sample was dried spontaneously in ambient air. Chlorine, sodium and calcium (Ca) measurements were made with a laser ablation system (Merchantech EO) equipped with a Nd:YAG laser (operating at 266 nm, each pulse had an energy of ~0.2 mJ and width of 2–3 ns), connected to a platform ICP-MS (Micromass). The ICP-MS was optimised, with respect to hexapole gases and instrument settings, for maximum signal/background ratio for Cl. Mass/charge ratios 23, 35 and 43 were used to measure Na, Cl and Ca respectively. Ca was used as an internal standard to correct for differences in the ablation efficiency [5]. The measurements were performed in five parallel discrete gradients, where the signals of chlorine and sodium relative to calcium were recorded. The gradients were recorded from the cut surface of the cavity edge for 300 µm towards the tooth pulp. Each gradient consisted of four spots of 10 µm diameter, spaced 100 µm apart.

2.2. Topographical analysis

The surface topography of cavities after caries excavation with Carisolv™ or burs, and etching was measured with a contact profilometer (Surfscan 3J®, Somicronic, France).

2.2.1. Contact profilometer

Thirty teeth with clearly visible carious lesions were sectioned along the longitudinal axis of the tooth, as described above. To enable to use each tooth as its own control, one half was excavated with burs, the other half with Carisolv™ including the use of the specially designed hand instrument. The statistical comparison was made only between the two halves of the same tooth. As for the previously described chemical analysis, a sharp probe was used to determine when the teeth were free from caries. The excavated cavities were then rinsed with water to remove loose particles and were allowed to dry. Gelled phosphoric acid at a concentration of 35% (Ultra-Etch®) was applied for 30 s. After rinsing the cavities with water, they were dried in air and immediately measured with a contact stylus instrument. The maximal vertical range was 1 mm, and the vertical resolution was 8 nm. In all cases, an area 1 × 1 mm of 512 × 512 pixels was evaluated. The stylus used had a radius of 2 µm and an angle of 90°. A Gaussian digital filter was used to separate roughness from deviations caused by form and waviness. The size of the filter was set to 250 × 250 µm. To numerically describe the surface roughness, 10
different parameters were calculated. Four parameters described height deviation (amplitude parameters), three parameters the spatial properties of the surface (spatial parameters) and three parameters included information from height and space, so-called hybrid parameters. All ten have been described earlier [4].

2.3. Statistical analysis

All statistical analyses in this study were performed with SPSS (SPSS, Chicago, IL, USA). Mean and standard deviation were calculated of the Raman intensity ratios and the parameters achieved from the topography measurements. The normality assumption was checked with normal probability and scatter plots. The normal probability and scatter plots were also used to detect possible outliers. Chemical differences between the different tooth surfaces were studied with F-tests. Topographical differences were studied with paired Student’s t-tests. Furthermore, since 10 different topographical parameters were difficult to interpret, a statistical factor analysis was performed to investigate whether any parameters correlate with each other, and if so the surfaces could topographically be described with fewer parameters.

3. Results

3.1. Chemical analysis

3.1.1. FT-Raman spectroscopy

Fig. 1 shows the Raman spectra of sound enamel and dentine, cavities after caries excavation with burs and Carisol® respectively, and etched cavities after caries excavation with burs or Carisol®. The spectra were normalised with reference to the intense band at 960 cm⁻¹. As can be seen, the bands at 2942, 1666, 1451 and 1270 cm⁻¹ were all weaker for sound enamel than sound dentine and the four different kinds of dentine cavities. The spectra of sound dentine, cavities after caries excavation with burs or Carisol®, and etched cavities after caries excavation were very similar. Reference Raman spectra of type I collagen, hydroxyapatite, calcium carbonate, and a caries lesion surface are shown in Fig. 2. As can be seen, the spectrum of dentine is a combination of the spectra of type I collagen and hydroxyapatite. The most intense signal of calcium carbonate at 1086 cm⁻¹ is difficult to distinguish in the spectrum of dentine since collagen and hydroxyapatite have vibration bands in the same region. The peaks of the major bands of the spectra in Figs. 1 and 2 are summarised in Table 1. There, it can be seen that variations of the peak positions for the bands of the different tooth surfaces were within the spectral resolution. The relative intensities of two vibration bands can be studied in Table 2, which shows the calculated intensity ratios. Normal probability plots confirmed that the intensity ratios of the tooth surfaces were normally distributed. No outliers were observed.

At 0.05 significance level, the F-test showed no differences between the 1666/960 intensity ratios of the sound dentine surfaces, the cavities after caries excavation with burs and Carisol®, respectively, and the etched cavities after caries excavation with burs or Carisol®.
3.1.2. FTIR

With reference to the KBr-pellet preparation procedure, both dentine and Carisolv™ could be detected well below 0.001 mg in a 100 mg KBr-pellet, i.e. well below 0.5 wt% of the KBr-pellet containing 0.2 mg dentine. It should thus be of no problem, concerning sensitivity of the FTIR technique, to detect Carisolv™ in dentine below a concentration of at least 1 wt%.

In Fig. 3, spectra of dentine from a Carisolv™ treated cavity, sound dentine, and pure Carisolv™ are shown. No major differences can be observed between the spectra of sound dentine and dentine from a Carisolv™ treated cavity. The dominating bands of Carisolv™ were detected at 1590, 1411, and 1058 cm⁻¹, which unfortunately partially overlap bands of sound dentine. To enable the detection of differences between the sound dentine spectrum and the spectrum of the cavity, a difference spectrum was generated by subtracting the dentine spectrum from the spectrum of the cavity. After magnifying the intensity 200 times, bands appeared at 1628, 1456, 1395, 1120 and 1060 cm⁻¹, which might be related to the Carisolv™ bands (Fig. 3).

3.1.3. LA-ICP-MS

The discrete gradients of Cl/Ca and Na/Ca are shown in Table 3. As can be seen, no change was seen in the concentrations of chlorine or sodium near the cavity surface after caries excavation with Carisolv™.

3.2. Topographical analysis

3.2.1. Contact profilometer

Normal distribution of the 10 different parameters was confirmed by probability plots, although two outliers were observed among the Carisolv™ related data material.

Amplitude parameters have limited value, as described earlier [4]. For reliable surface characterisation, parameters describing surface variation in the spatial direction are also needed. Factor analysis showed that some of the parameters correlate positively with each other and therefore constitute one factor together. The surfaces excavated with burs could be topographically described with five parameters; $S_{as}$, $S_{ac}$, $S_{a}$, $S_{d}$ and one of $S_{s}$, $S_{as}$, $S_{aq}$, $S_{aq}$, or $S_{d2}$. The surfaces excavated with Carisolv™ could be described with four parameters; $S_{d}$, $S_{as}$, $S_{d}$ and one of $S_{a}$, $S_{aq}$, $S_{d}$, $S_{d2}$ or $S_{ac}$. Based on that result, the following parameters were selected to describe the surface topography:

3.2.2. Amplitude parameters

$S_{as} = \text{Average height deviation, measured in } \mu\text{m. A statistical average property.}$

3.2.3. Spatial parameters

$S_{d} = \text{Density of summits, measured in } /\mu\text{m}^2$

$S_{a} = \text{Fastest decay autocorrelation length, measured in } \mu\text{m. A large } S_{a} \text{ indicates a surface dominated by low frequency components.}$
Table 2
The 1666/960 Raman intensity ratios of the different tooth surfaces. The intensity ratios are based on the integrals of the two bands: 1666: 1710–1600 cm$^{-1}$, 960: 990–900 cm$^{-1}$. The figures represent the mean values calculated from 10 measurements, standard deviations within parenthesis

<table>
<thead>
<tr>
<th>1666/960 Raman intensity ratio</th>
</tr>
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<tbody>
<tr>
<td>Enamel</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>0.14 (0.04)</td>
</tr>
</tbody>
</table>

$S_n$ = Texture aspect ratio used to separate isotropy and anisotropy of surfaces. Smaller values than 0.3 represent surfaces with a long crestness, while $S_n$ values greater than 0.5 indicate a uniform structure.

3.2.4. Hybrid parameters
$S_{sc}$ = Arithmetic mean summit curvature, measured in rad/μm. Describes the curvature of high spots.

Mathematical formulas of these parameters can be found in the work by Stout [14].

Table 4 shows the mean and standard deviation values of the different parameters for the investigated surfaces. Paired Student’s $t$-tests at 0.05 significance level showed no difference between the dentine surfaces after caries excavation with burs or with Carisolv™, followed by etching the dentine with 35% phosphoric acid. When the two outliers in the Carisolv™ data were excluded, $t$-tests still failed to achieve significant difference between the two different kinds of tooth surfaces.

Digitised images from contact profilometer measurements of dentine surfaces after caries excavation with Carisolv™ and burs are shown in Fig. 4. Images with and without errors of form are presented to show the surface topographic resemblance between the two surfaces that may appear different when the cavity forms are included. Waviness and roughness are included in all images.

4. Discussion
Chemical and topographical analyses showed no major differences between cavities excavated with burs or with Carisolv™. FT-Raman spectroscopy showed no difference in relative amounts of organic material and mineral. Extremely small amounts of Carisolv™ substances were detected by FTIR analyses at the excavated cavity surface. However, the LA-ICP-MS analyses did not confirm the FTIR result. Topography measurements with Surfscan 3J™ did not show any significant differences between etched cavities after caries excavation with burs or Carisolv™.

The Raman spectra of enamel differed from the dentine Raman spectra with less intense bands from organic compound functional groups, which agrees with the theoretical chemical composition. The distinct band at 960 cm$^{-1}$ was used as representative for the mineral since it is caused

Fig. 3. FTIR spectra from (A) dentine from a Carisolv™ treated cavity, (B) sound dentine, and (C) difference spectrum (C = 200 × (A − B)), where the spectrum of sound dentine is subtracted from the spectrum of the Carisolv™ treated cavity. In addition, a Carisolv™ spectrum is shown as D. The dentine spectra are normalised with respect to the band at 563 cm$^{-1}$. Some bands in the difference spectrum are marked in the figure. FTIR peaks of dentine have earlier been interpreted by Eliades et al. [13].
by a phosphate vibration [11,12]. To represent the organic material, the band at 1666 cm\(^{-1}\) was chosen. This band is caused by a C=O stretching of amides [6]. No significant differences (\(p > 0.05\)) could be detected between the relative amounts of organic material and minerals in sound dentine surfaces, in cavities after burs or Carisolv\textsuperscript{TM}, or in etched cavities after burs or Carisolv\textsuperscript{TM}. This is despite the fact that 30 s etching with 35% phosphoric acid demineralises the dentine to a depth of 15 \(\mu m\) [15]. The FT-Raman spectroscopy result may be explained by the fact that it is difficult to define the depth of focus when analysing a porous surface. This difficulty is related to the sample absorption characteristics, which are in turn, partly related to the porosity of the analysed material. Furthermore, the molecules closest to the sample surface contribute most to the Raman signal and the analysis depth does not form any sharp boundary.

However, the equal relative amounts of organic materials and minerals for dentine surfaces and Carisolv\textsuperscript{TM} excavated cavities are in accordance with the earlier studies by Cedernlund [2] and Banerjee [3]. These indicate that caries excavation with Carisolv\textsuperscript{TM} removes adequate quantities of tissue.

Raman spectroscopy mirrors only one part of the chemical composition, since only bands that change their polarisability during vibration are detected. The functional groups that are Raman inactive usually are infrared active; therefore, some FTIR analyses were performed. The bands in the difference spectrum were very weak and the intensity had to be magnified 200 times until the bands were interpretable. Though the absorption of some functional groups may be changed, if the ionic environment is changed, the bands might be identified in the Carisolv\textsuperscript{TM} spectrum. However, some of these bands occurred at wavenumbers at which dentine exhibits intense absorption, possibly masking the contribution. Keeping in mind that the difference spectrum was expanded 200 times compared to the Carisolv\textsuperscript{TM} spectrum and that possible signal contributions from Carisolv\textsuperscript{TM} to the difference spectrum bands were small, the possible signal contribution of Carisolv\textsuperscript{TM} in dentine from the cavity was at most, extremely small.

To further investigate Carisolv\textsuperscript{TM} substances at the cavity surface, LA-ICP-MS analyses for Cl and Na were undertaken. No traces of Carisolv\textsuperscript{TM} were detected at the cavity surface. Thus, the LA-ICP-MS results did not confirm the FTIR results. However, LA-ICP-MS is less sensitive to halogens than to metals. Furthermore, this technique is also sensitive to varying hardness within a sample. Lower hardness leads to the removal of more material by the laser, which results in an increased signal that may be misinterpreted as an increased concentration. To avoid such misinterpretations, intrinsic Ca was used as a standard [5] in the present study, meaning that the amounts of Cl and Na were related to the amount of Ca.

It should be emphasised that the chemical results in this study mean that there were no or extremely small traces of Carisolv\textsuperscript{TM} components in or on the dentine surface after caries excavation. However, when using extracted teeth for studies of clinical interest, the differences between extracted and in vivo teeth must be considered. For example, an outward flow of fluid has been reported in dentine in vivo [16,17], which may limit the absorption of chemical substances into the dentinal tubules. Furthermore, it is not known how or if small amounts of Carisolv\textsuperscript{TM} could affect the following cavity preparation and filling. Since the FTIR analyses indicated Carisolv\textsuperscript{TM} traces at the cavity surface after Carisolv\textsuperscript{TM} treatment, further studies of the effects of treatments such as etching and resin bonding would be interesting.

The choice of topographical method is based on requirements of a large measuring area combined with a high vertical resolution, which are satisfied by the contact stylus profilometer. Besides the contact stylus instruments, there are two more major groups of topographical measuring equipment; scanning probe microscopes (SPM), and optical instruments. Earlier studies have shown that measuring area of SPM is too small for this kind of investigation [4]. Optical instruments require sample reflectivity and scattered light may disturb the measurements on etched surfaces. Furthermore, for optical instruments, the typical measuring range in height is 100 \(\mu m\) if a high resolution should be possible. As

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### Table 3
Discrete LA-ICP-MS concentration gradients after chemomechanical caries excavation using Carisolv\textsuperscript{TM}. The concentration gradients were recorded from the cutting surface and extended from the cavity edge 300 \(\mu m\) towards the pulp of the tooth. The figures represent the mean values calculated from 5 measurements, standard deviations within parenthesis.

<table>
<thead>
<tr>
<th>Distance from the cavity, ((\mu m))</th>
<th>Cl/Ca ratio</th>
<th>Na/Ca ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0095 (0.00045)</td>
<td>0.191 (0.0194)</td>
</tr>
<tr>
<td>100</td>
<td>0.0098 (0.00047)</td>
<td>0.215 (0.0146)</td>
</tr>
<tr>
<td>200</td>
<td>0.0092 (0.00113)</td>
<td>0.219 (0.0205)</td>
</tr>
<tr>
<td>300</td>
<td>0.0104 (0.00095)</td>
<td>0.235 (0.0146)</td>
</tr>
</tbody>
</table>

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### Table 4
Surface topography after the two methods of caries excavation. The figures represent the mean values calculated from 30 or 28 measurements, standard deviations within parenthesis.

<table>
<thead>
<tr>
<th></th>
<th>Nr of replicates</th>
<th>(S_v (\mu m))</th>
<th>(S_{av} (\mu m^2))</th>
<th>(S_d (\mu m))</th>
<th>(S_y)</th>
<th>(S_w) (rad/(\mu m))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carisolv\textsuperscript{TM} + etch with outliers</td>
<td>30</td>
<td>2.53 (1.39)</td>
<td>876 (213)</td>
<td>0.053 (0.01)</td>
<td>0.454 (0.18)</td>
<td>0.041 (0.01)</td>
</tr>
<tr>
<td>Carisolv\textsuperscript{TM} + etch without outliers</td>
<td>28</td>
<td>2.22 (0.71)</td>
<td>901 (197)</td>
<td>0.052 (0.01)</td>
<td>0.446 (0.18)</td>
<td>0.038 (0.01)</td>
</tr>
<tr>
<td>Burs + etch</td>
<td>30</td>
<td>2.36 (1.28)</td>
<td>886 (205)</td>
<td>0.055 (0.01)</td>
<td>0.412 (0.20)</td>
<td>0.034 (0.01)</td>
</tr>
</tbody>
</table>
tooth surfaces often exceed this range, this group of instruments was rejected. The pressure due to the contact stylus on the surface has been shown not to influence the outcome of the measurement [18]. Furthermore, in the earlier study by Wennerberg [4], the contact stylus was found to be appropriate for topographical description of dentine cavities, and a significant difference was found between cavities after burs and Carisolv™.

The topographical measurements in the present study did not show statistically significant differences between etched dentine surfaces after caries excavation using burs or with Carisolv™. These results may imply that, at least from a topographical point of view, the Carisolv™ excavated surface is comparable with that achieved with burs, when acid etching follows caries excavation. However, even if the dentine surface after chemomechanical caries excavation was not greatly altered topographically or chemically, it may differ with respect to mechanical and physical properties such as hardness and surface energy. Investigation of such characteristics would be valuable not only for clinical purposes but also for facilitation of the interpretation of results from chemical analyses.

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