Chemo-mechanical dentine caries removal with Carisolv™ using a rotating brush

C. MELLER*,***, A.W. NOURALLAH*,***, C. HEYDUCK*, H. STEFFEN**, C.H. SPLIETH*

ABSTRACT. Aim The aim of this study was to assess the efficacy of removing dentine caries using carbide burs, Carisolv™ with hand instruments and Carisolv™ in combination with a new mechanical excavation method using a rotating brush. Methods 36 extracted permanent teeth, with dentine caries, were assigned into 3 groups according to caries removal technique. Caries removal was monitored by checking the properties of the dentine with a dental explorer. After embedding and sectioning (400 µm), remaining caries was assessed by using a caries detector. In microscope images (7x) of the samples, the mean stain depth of the remaining carious tissue per tooth was calculated by AnalySIS computer software.

Results Four to 8 applications (mean time = 10.9 min) of Carisolv™ were necessary for caries removal with the new method using rotating brushes. The mean thickness of residual dentine caries by this procedure (226 µm, ± 136) was higher than the one using Carisolv™ with hand instruments (57 µm, ± 39) or carbide burs (32 µm, ± 20). Even in areas with good access to the lesion, an unacceptable amount of residual caries was observed.

Conclusion Thus, it seems that Carisolv™ using rotating brushes does not reach the degree of caries removal reached by additional mechanical abrasion of Carisolv™ using hand instruments or conventional rotating carbide burs.

KEYWORDS: Dentine caries removal, Carisolv™, Rotating brush.

Introduction

Caridex™ was the first product available for chemo-mechanical caries removal in the USA in the '80s [Beeley and Yip, 2000], which was followed by Carisolv™ in the '90s [Wennerberg et al., 1999]. Studies on Caridex™, which worked on the basis of dissolving denatured collagen with sodium hypochlorite and amino acids, showed rates of clinically complete caries removal using an explorer from 76% up to 100% [Hannig, 1999; McInnes-Ledoux et al., 1987; McNierney and Petruzillo, 1986; Punwanni et al., 1989]. Similar rates were achieved in a multicenter study [Ericson et al., 1999] and in a German study [Haffner et al., 1999] with Carisolv™ treatment using also the explorer for determining clinically successful caries removal. In a more reproducible approach, Moran et al. [1999] additionally evaluated the caries removal with the Electrical Conductance Measurement (ECM) which resulted in similar values for the Carisolv™ treatment and the conventional caries removal with carbide round burs. In an in vitro study, Banerjee et al. [2000] found similar fluorescence readings for Carisolv™ treatment compared to caries removal with conventional hand instruments. Analysing the residual dentine collagen in vitro, irreversibly destroyed collagen was found in lesions after chemo-mechanical caries removal with Carisolv™ (34%) and after conventional caries removal (12 to 13%), but to a lower extent [Jepsen et al., 1999].

In spite of clinically acceptable results, the dentine surface resulting from caries removal with Carisolv™ is clinically more opaque than after conventional caries removal [Splieth et al., 2001] and it exhibits a modified smear layer with increased roughness compared to conventional caries removal [Cederlund et al., 1999a; Wennerberg et al., 1999; Beeley and Yip, 2000]. This may affect the dentine adhesive qualities [Cederlund et al., 1999b].

The Carisolv™ method uses special hand instruments, which need slightly more working time compared to the conventional caries removal using carbide round burs [Splieth et al., 2001]. Recently, the custom made and denominated “Carisolv™ Power
Drive” – a rotating method using burs which stop when sound dentine is reached – was introduced. As Carisolv™ intended to replace rotating burs, which patients are afraid of [Ericson et al., 1999; Beeley and Yip, 2000], the power drive idea could be seen as a step back to the conventional caries removal with burs. Rotating brushes could be an alternative since brushes are more familiar to the patients. Paediatric dentists are aware of these advantages at the hour of persuading children for treatment. On the other side, reliable, less invasive/destructive caries removal methods, differentiating between infected and non-infected carious dentine are needed in the clinical practice. Considering these facts and looking for new methods, the idea of substituting the conventional hand instruments of the Carisolv™ method with rotating brushes motivated the general aim proposed in this study.

Materials and methods

12 fresh extracted, permanent, filling-free teeth with medium to large dentine caries, stored in 10% ethanol solution, were selected for ex vivo caries removal. The Carisolv™ (MediTeam Dental AB, Gothenburg, Sweden) gels were mixed according to the manufacturer’s instructions and applied to the carious lesion with a soft microbrush. After 20 secs, the softened carious dentine was removed using rotating brushes (Kerr Hawe Prophy Brushes, Bioggio, Switzerland) mounted in a low-speed handpiece (Fig. 1). After cleaning the lesion with air-water spray, the hardness of the dentine was checked with a dental explorer (EXS 8, Hu Friedy, Leimen, Germany). This procedure was repeated until a sharp scratching sound was heard. In addition, the caries removal working time was measured beginning with the application of Carisolv™. For sufficient cavity access, it was necessary to remove enamel with diamond burs in 3 teeth.

In 12 similar carious permanent teeth, each caries was removed using either Carisolv with the custom recommended hand instruments or conventional carbide round burs (size 8-16, Komet, Lemgo, Germany), following the same procedure already described (Fig. 1). All teeth were embedded in polyester resin (Vosschemie, Uetersen, Germany) and mechanically sectioned (Microtom 1600, Leitz, Wetzlar, Germany) into specimens of 400 µm thickness. The remaining caries was then assessed using a caries detector (Caries finder, Danville Materials, San Remo, USA) for 60 secs. Microscope (Olympus, SZH 10, Unterhaching, Germany) images (7x) of the specimens (Fig. 2) were scanned with a video camera into a PC. The outline and length of the stained areas (residual carious dentine) were marked by hand (Fig. 2) and measured automatically by AnalySIS computer software (version 9.0). From these data, the mean depth of each carious lesion was calculated dividing the surface of the marked area by the length of the lesion.

In the statistical analysis (SPSS software version 12.0), the data values for each treatment were calculated and differences were tested for statistical significance with the t-test at a level of 0.05 (Fig. 2).

Results

A greater mean working time (10.9 min, after 4 to 8 applications of Carisolv™ was observed for the
procedure using Carisolv™ with rotating brushes (Table 1) than for Carisolv™ with hand instruments (8.9 min) or carbide burs (4.8 min). Both procedures using Carisolv led to a clinically more opaque remaining dentine after caries removal in comparison to the conventional caries removal with carbide burs. The mean residual stained depth (Table 1) by Carisolv™ with rotating brushes (226 µm ± 136) was significantly higher than for Carisolv™ with hand instruments (57 µm ± 39) and the carbide burs (32 µm ± 20). In a subanalysis for the caries removal using Carisolv™ and rotating brushes, the mean depth of the residual carious dentine in the central third (217 µm ± 153) of the cavity, where the brush could have had a better action, did not differ significantly from the mean value in the periphery (237 µm ± 115) of the cavity (Table 2).

Discussion

Chemo-mechanical caries removal with Carisolv™ conventional method with hand instruments results in good rates of clinically caries-free cavities [Ericson et al., 1999; Haffner et al., 1999], which results of this in vitro study confirmed. A slightly higher but perhaps clinically not relevant amount of residual caries was found for the hand caries removal with Carisolv™ in comparison to that obtained with conventional round burs. After caries removal with Carisolv™ using rotating brushes, the mean value for residual caries was almost 4 times higher than for the method using the conventional Carisolv™ procedure with hand instruments and more than 7 times higher than for the caries removal using rotating round burs. In addition, the high standard deviation suggests unpredictable, non-trustworthy results.

The slightly higher values observed for residual caries present in peripheral areas for the method using brushes, confirm previous observations [Cederlund et al., 1999a; Maragakis et al., 2001] showing that this part of the carious lesion is more susceptible to incomplete caries removal. This could be compensated when a proper cavity access is previously gained.

The mean working time needed to complete the caries removal with Carisolv™ was for both groups (hand instruments and rotating brush) clearly higher, taking in average about twice (5 more min.) as much as the conventional caries removal procedure with round carbide burs. The repeated application of Carisolv™, especially in large lesions, was the main responsible cause for time increase: 4 to 8 applications of Carisolv™ were necessary for the caries removal procedure. Clinically this is often compensated by saving time for local anesthesia, which is mostly not needed with Carisolv™.

The clinical determination of the dentine hardness after caries removal, performed with an explorer, is seen as a good standard prerequisite for future treatment success. Kidd et al. [1993a] found significantly less cariogenic bacteria in hard than in softened dentine. However, clinical hardness does not necessarily correspond to the amount of carious dentine that should strictly be removed. It has to be distinguished between “infected” carious dentine, which should always be removed, from “affected” carious dentine, which may be left [Kidd and Banerjee, 2001]. Intact collagen forming the demineralised, slightly softened inner dentine layer of a carious lesion can be remineralised, i.e., hardened [Kato and Fusayama, 1970], and therefore, does not have to be necessarily eliminated from a therapeutic point of view [Yip et al., 1995]. Unfortunately, several studies [Anderson et al., 1985; Boston and Graver, 1989; Kidd et al., 1993b] showed that caries detector dyes cannot discriminate between affected, non-infected, often sclerotic (translucent) or reparative dentine [Yip et al., 1994]. These important facts have to be considered in studies like the present one using caries detector dyes as the apparently better results for conventional caries removal with burs may lead to overtreatment of cavities. On the other hand, the apparently suboptimal treatment using hand or rotating brushes may lead to a more ‘evidence-based’.

### Table 1 - Dental and periodontal lesions in the examined patients.

<table>
<thead>
<tr>
<th>Method</th>
<th>Residual Caries</th>
<th>Mean Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carisolv+brushes</td>
<td>226 µm ± 136</td>
<td>10.9 min</td>
</tr>
<tr>
<td>Carisolv™+hand instr.</td>
<td>57 µm ± 39</td>
<td>8.9 min</td>
</tr>
<tr>
<td>Carbide burs</td>
<td>32 µm ± 20</td>
<td>4.8 min</td>
</tr>
</tbody>
</table>

### Table 2 - Mean residual caries depth values in central cavity area, peripheral area and overall for caries removal with Carisolv™ and rotating bush.

<table>
<thead>
<tr>
<th>Location</th>
<th>Resid. caries depth</th>
<th>Stand Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>217 µm ± 153 µm</td>
<td></td>
</tr>
<tr>
<td>Peripheral</td>
<td>237 µm ± 115 µm</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>226 µm ± 136 µm</td>
<td></td>
</tr>
</tbody>
</table>
selective, less invasive caries removal method differentiating between infected and non-infected carious dentine. Thus, the exact contribution of each of these factors needs to be clarified in future studies.

In conclusion, under the presented study conditions, residual carious dentine found after caries removal using Carisolv™ conventional technique with hand instruments or with conventional carbide round burs was markedly reduced when compared with Carisolv™ caries removal using rotating brushes. It seems that the Carisolv™ needs a more abrasive type of brush for improving the apparently possible development of this method.

References