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Efficiency of 4 Caries Excavation Methods Compared

ÁM Lennon • W Buchalla • B Rassner
K Becker • T Attin

Clinical Relevance

Fluorescence Aided Caries Excavation achieves a better combination of excavation time and successful removal of infected dentin compared to conventional excavation, caries detector dye and chemomechanical caries removal.

SUMMARY

This *in vitro* study compared the efficiency (time taken to excavate and successfully remove bacterially infected dentin) of Fluorescence Aided Caries Excavation (FACE), caries detector dye (CD), chemomechanical excavation (CS) and conventional excavation (CE). Teeth with dentin caries were assigned to 4 groups (n= 25). Caries excavation was carried out by one operator. In the FACE group, the operating field was illuminated with violet light. The operator observed the teeth through a high-pass filter and removed orange-red fluorescing areas with a slow speed bur. In the CS group, Carisolv was applied to the cavity using CS hand instruments and allowed to act for 30 seconds before caries was removed. In the CD group, caries was removed using the Caries Detector and, in the CE group, conventional excavation was carried out using visual-tactile criteria. The excavation time was recorded. Undecalcified thin slices (8 µm) were prepared, stained with giemsa and examined using light microscopy. The excavation time (median) was significantly shorter for FACE (3 minutes, 3 seconds) compared to CS (5 minutes, 8 seconds, *p*=0.015), CD (5 minutes, 26 seconds, *p*=0.003) and CE (4 minutes, 2 seconds, *p*=0.025). Histology showed remaining bacteria in significantly fewer (5/25) FACE samples compared to CS (15/25 *p*=0.004) CD (12/25 *p*=0.037) but not significantly fewer than CE (11/25 *p*=0.069). In conclusion: the excavation result with FACE is equal to CE and superior to CD and CS but requires a significantly shorter excavation time.

*Áine M Lennon, BDentSc, Dr med dent, assistant professor, Clinic for Preventive Dentistry, Periodontology and Cariology, University of Zürich, Switzerland and adjunct assistant professor, Oral Health Research Institute, Department of Preventive and Community Dentistry, Indiana University School of Dentistry, Indianapolis, IN, USA

Wolfgang Buchalla, Dr med dent, associate professor, Clinic for Preventive Dentistry, Periodontology and Cariology, University of Zürich, Switzerland and adjunct associate professor, Oral Health Research Institute, Department of Preventive and Community Dentistry, Indiana University School of Dentistry, Indianapolis, IN, USA

Binja Rassner, dentist in practice, Kassel, Germany

Klaus Becker, research assistant, Department of Operative Dentistry, Preventive Dentistry and Periodontology, Georg-August-University Göttingen, Göttingen, Germany

Thomas Attin, dr med dent, head of department, professor, Clinic for Preventive Dentistry, Periodontology and Cariology, University of Zürich, Zürich, Switzerland

*Reprint request: Plattenstrasse 11, 8032 Zürich, Switzerland, e-mail: aine.lennon@zzmk.unizh.ch

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INTRODUCTION

There are numerous caries excavation methods and aids to caries excavation available to dentists today. These include chemomechanical agents, caries disclosing dyes, air abrasion, lasers and, of course, the conventional mechanical caries removal using hand or rotary instruments.[1-4] While the most significant aspect of caries removal is the selective removal of only carious dentin, so that healthy tissue is preserved, the time needed to perform the procedure is highly important for both the dentist and patient. An excessively long working time may be the reason why so few new caries removal techniques actually become established in the dental practice.

One novel system, FACE or "Fluorescence Aided Caries Excavation," has been shown to be more effective than conventional excavation in the removal of infected dentin *in vitro*.[5-6] Using this method, the cavity is excited with violet light. Carious areas fluoresce red and can be seen immediately by the dentist during excavation without the need for time-consuming dye application or instrument changes. The efficiency of this system has not yet been investigated.

Of the established caries removal methods, much has been written about the efficiency of chemomechanical methods and conventional excavation. While newer chemomechanical products have improved compared to their predecessors, they are still slower than conventional excavation.[7,1] Surprisingly, the time needed for successful excavation of caries-disclosing agents has not been documented.

Therefore, this *in vitro* study compared the time taken to excavate and successfully remove bacterially infected dentin of FACE, caries detector dye, chemomechanical caries removal and conventional excavation.

METHODS AND MATERIALS

Sample Selection

One hundred permanent molars with occlusal dentin caries were collected and stored in 0.01% thymol solution at 4°C in the dark. The sample teeth were sectioned using a water-cooled hard tissue saw (Exakt Norderstedt, Germany) through the center of the lesion. Lesion depth and width were measured using stereomicroscopy. This allowed for a stratified randomization of the samples into 4 groups of 25, according to lesion size (depth x width). The tooth halves were reassembled and embedded in acrylic resin (Technovit, Heraeus Kulzer, Hanau, Germany).

Caries Excavation

Caries excavation was carried out by one operator (BR) for all groups. Access cavities were prepared using a #557 diamond bur in a high speed handpiece (KaVo, Biberach, Germany) under continuous water-cooling in all groups. While the method for identification of carious dentin was different for all groups, the method for removing carious dentin was the same for the FACE, caries detector dye and conventional excavation groups. In these groups, carious dentin was removed using a stainless steel round bur in a slow speed handpiece (Star Dental, Lancaster, PA, USA).

Fluorescence Aided Caries Excavation Group (FACE): Violet light (370-420 nm) was generated using a 100-watt Xenon-discharge lamp (Linos, Göttingen, Germany) and a blue band pass filter with peak transmission at 370 nm (Schott, Mainz, Germany). This light was fed into the fiber optics of a slow speed handpiece (Star Dental) so that it illuminated the operating field. The operator inspected the cavity through a 530-nm yellow glass filter (OG530, Schott) and selectively removed the orange-red fluorescing areas. The room lighting was reduced during excavation. Overhead fluorescent lighting was extinguished. The dental operating light was on but directed away from the sample.

Caries Detector Dye Group (CD): Gross caries was removed. The teeth were dried briefly using compressed air. Caries Detector (Kuraray, Osaka, Japan) was applied to the cavity for 10 seconds, and the cavity was then rinsed with water for 10 seconds and dried using compressed air. Dentin, which retained stain, was selectively removed. This process was repeated until no Caries Detector stain remained in the cavity.

Chemomechanical Excavation Group (CS): Carisolv gel singlemix (Mediteam, Sävedalen, Sweden) was mixed according to the manufacturer's instructions and applied to the cavity for 30 seconds. Softened dentin was removed using special Carisolv hand instruments. Carisolv gel was reapplied, and the procedure was repeated, using the hand instrument, until the surface felt hard.

C*onventional Excavation Group (CE):* Stained and softened dentin detected using a sharp explorer (EX85, Hu-Friedy Inc, Chicago, IL, USA) were removed from the EDJ. In the remainder of the cavity, soft dentin was removed, while stained hard dentin was not.

Excavation Time

The time taken for caries excavation for each sample was recorded in seconds.

Histology

All chemicals used in the embedding, deplasticization and staining process were obtained from Merck, Darmstadt, Germany.

The samples were dehydrated in graded ethanol, then infiltrated with a specially designed methylmethacrylate resin embedding material (methylmethacrylate 100 ml, nonylphenolpolyglycolether 20 ml, dibutylphtalate 2 ml, benzoylperoxide 5 ml) at 4°C. Polymerization was completed at 32°C over 48 hours.

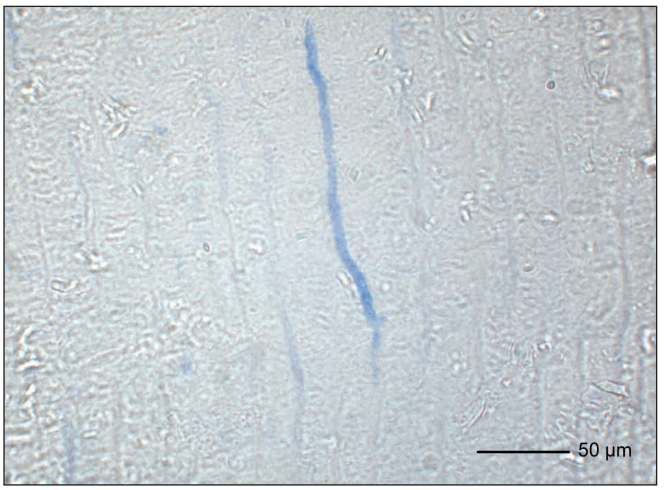

Figure 1: *Photomicrograph of a negative sample showing a single infected dentin tubule. Magnification 1000x.*

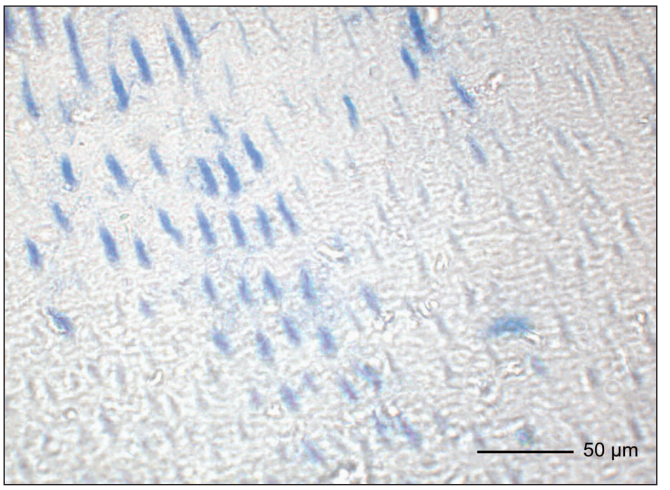

Figure 2: *Photomicrograph of a positive sample showing multiple infected dentin tubules. Magnification 1000x.*

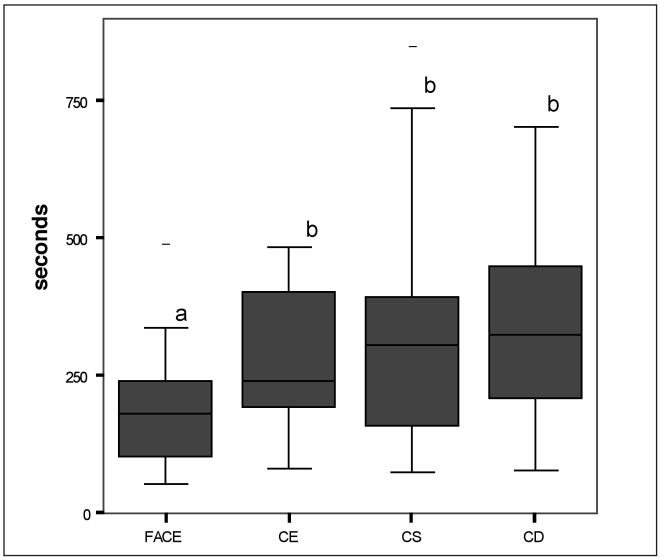

Figure 3: *Box plot showing median, maximum and minimum (whiskers) and 1st and 3rd quartiles (box) for excavation time in seconds. Outliers are marked °. Groups marked with the same letter did not significantly differ from each other. Fluorescence Aided Caries Excavation (FACE), conventional excavation (CE), chemomechanical excavation (CS), caries detector dye (CD).*

Three thin slices per sample (8 µm) were prepared from the center of the caries lesion using a rotary microtome (Leica Microsystems, Bensheim, Germany). For deplasticization, the sections were placed in 3 changes of 2-methoxyethylacetate for 20 minutes each, 2 changes of acetone for 5 minutes each and 2 changes of deionized water for 5 minutes each. The sections were stained with 2% giemsa for 45 minutes, then rinsed extensively with water.

The sections were evaluated for the presence of bacteria in the dentin tubules using light microscopy at a magnification of 1000x. Cases of only single infected tubules or less were scored negative (Figure 1). Cases with more than 1 infected tubule were scored positive (Figure 2).

Statistics

The Pearson Chi squared test was used to test the significance of differences between the groups for the incidence of bacterial infection remaining after excavation. Comparisons between the methods for differences in excavation time were made using the Mann-Whitney U-Test after the Kolmogorov Smirnov test showed that the data were not normally distributed. In all cases, the level of significance was set at $p \leq 0.05$ (2-sided significance). The statistical analyses were carried out using SPSS software version 12 (SPSS, Chicago, IL, USA).

RESULTS

The number of positive samples in the FACE group (n=5) was significantly lower (p=0.004) than in the chemomechanical excavation group (n=15) and the caries detector group (n=12, p=0.037), but they were not significantly lower than in the conventional excavation group (n=11, p=0.069). Chemomechanical excavation, caries detector excavation and conventional excavation did not differ significantly from each other.

The median excavation time was shortest for the FACE group, followed by the conventional excavation group (Figure 3). The excavation time (median) was significantly shorter for the FACE group (3 minutes, 3 seconds) compared to the chemomechanical excavation group (5 minutes, 8 seconds, p=0.015), the caries detector group (5 minutes, 26 seconds, p=0.003) and the conventional excavation group (4 minutes, 2 seconds, p=0.025).

DISCUSSION

Pressure due to time constraints is frequently cited as a major source of stress for dentists in practice.[8-10]

Therefore, in addition to accuracy, the authors felt it was necessary to look at the efficiency of excavation using different methods. For purposes of this paper, excavation efficiency will be defined as a combination of the time taken to excavate and success in the removal of bacterially infected dentin.

In this study, all groups were excavated by one operator (BR) in order to afford standard conditions for all methods.

Very bright room lighting is a limiting factor when excavating teeth outside the mouth using FACE. The samples in this study were excavated outside of the oral cavity and, therefore, the room lighting was reduced. White light interference can be counteracted by increasing the excitation light intensity and is not a major factor when operating inside the oral cavity.

The gold standards used to determine completeness of the excavation include microhardness measurement and polarized light microscopy,[11-12] which are based on demineralization and confocal microscopy, light microscopy and culturing techniques, based on infection remaining after excavation.[13-14,16] The authors chose light microscopy to detect infection in dentin tubules rather than a demineralization based technique, because demineralized but non-infected dentin does not need to be removed during excavation.[16] Undecalcified sections were used for histology rather than paraffin-embedded decalcified material, in order to preserve the hard tissue anatomy.[7] Clinically, it is not considered necessary to remove every single bacteria when removing caries before placing a restoration.[16] Therefore, the authors decided to score sections with only single isolated bacteria negative for reasons of clinical relevance.

Histology showed that the number of positive samples was significantly lower in the FACE group compared to caries detector and chemomechanical excavation but was not significantly lower than conventional excavation. This appears to disagree with the results of an earlier study that found a significantly lower incidence of residual caries for FACE compared to conventional excavation.[6] However, the percentage of carious samples found in the conventional and FACE groups in both studies was almost identical, with only 1 sample in this study having more residual caries in the FACE group. Histology showed no significant differences among the other 3 methods.

The excavation time achieved in the FACE group was significantly shorter than in the other 3 groups. There was no statistically significant difference in excavation time between caries detector, conventional excavation and chemomechanical excavation. Previous excavation time comparisons have shown that chemo-mechanical methods are significantly more time consuming than conventional excavation.[1,17-18] The time taken to excavate with the aid of caries detector dyes has not been reported in the past.

The longer excavation time needed in the caries detector and chemomechanical groups reflects the need for instrument changes and for the application of solution, rinsing and repeating the procedure if excavation was incomplete. In the conventional group, only an instrument change was necessary, but this was also significantly more time consuming than in the FACE group, where no instrument change is required to check the cavity.

CONCLUSIONS

In this study, the best combination of excavation time and successful removal of infected dentin was achieved using FACE. The improved removal of infected dentin achieved using this new technique may be appealing to the clinical dentist, because it reduces working time.

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