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The Effect of EDTA-containing Surface-active Solutions on the Morphology of Prepared Dentin: An *in vivo* Study

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The capacities of EDTA-containing and surface-active antibacterial solutions and their combinations for removing amorphous smear layers produced by cutting of dentin were studied in vivo *on 132 human dentin surfaces ground at high speed with a diamond point.*

A combination of 0.2% EDTA and surface-active antibacterial solutions removed most of the smear layers without opening too many tubule apertures or removing peritubular dentin. No difference was found between the cleaning capacity on surfaces ground under water cooling compared to air cooling.

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Introduction.

In a previous study,[1] it was found that when dentin had been cut at high speed with a tungsten/carbide bur or worked by hand with a chisel, neither treatment with hydrogen peroxide/ethanol nor water spray produced dentinal surfaces with "normal" morphologic details. However, in some cases such surfaces were seen after treatment with surface-active solutions. When dentin had been cut at high speed with a diamond point, all the tested methods failed to remove the amorphous smear layer attached to the dentin.

If the smear layer produced at high speed with instruments such as diamond points is to be removed or reduced from dentinal surfaces, other more effective methods have to be applied. Recent *in vitro* and *in vivo* studies have indicated that polishing with pumice[2] or acid etching are both methods capable of removing the smear layer attached to prepared dentin.[3,4] However, acid etching may result in the loss of peritubular dentin near the surface. The tubular apertures are often widened about three times, and an organic film may also remain intertubularly after such treatments. It is possible that these changes may negatively influence the retention of restorative materials. Wide, open tubules can also be infected, thus being a potential risk to the pulp.[5]

Since the smear layer attached to cut dentin surfaces probably contains a high amount of calcium phosphate, it was considered worthwhile to study if such layers could be removed or morphologically changed by the addition of a chelating agent to the surface-active cavity cleanser used in the previous investigation.[1]

Materials and methods.

The material consisted of 40 pairs of intact maxillary and mandibular premolars from individuals 12 to 16 years old. The teeth were to be extracted for orthodontic reasons. In all teeth, the buccal and lingual cusps of the maxillary premolars and the buccal cusps of the mandibular ones were ground with a diamond point* at high speed, 200.000–300.000 rev/min as measured with a tachometer. The preparation was performed under water spray until flat areas of 1.5 to 2 mm^2 of the dentin were exposed. Since it has been suggested that dry preparations of dentin surfaces may produce a "deeper and more smeared layer than wet preparations,"[6] two experimental series were carried out where dentinal exposures were produced in exactly the same way as described above, except that air jet cooling was used during the final ten to 15 seconds of preparation of one tooth in each pair.

After the preparation, the patients were allowed to rinse, thus contaminating the cut

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surfaces with saliva. A rubber dam was then applied, and the surfaces were sprayed with ample amounts of water and dried for five seconds with compressed air before the experimental cleaning procedures were started. Five different solutions were used for cleaning (Table 1). In three series the effects of two different cleaning solutions were compared within the pairs of surfaces. In two series the experimental parameter was the cleaning effects on surfaces cut under wet or dry conditions (Table 2).

The tested cleaning solutions were applied by initial scrubbing of the surface for five seconds with a soaked cotton pellet. The solutions were then allowed to remain in contact with the cut surfaces for 60 seconds (in order to permit the action of the antibacterial component) before the beginning of another five seconds of scrubbing. After final drying with an air jet for five seconds, the teeth were extracted with the rubber dam in place.

Fig. 1 – Surface cleaned with Tubulicid. Cleanliness grade I. A thin amorphous smear layer covers the surface. The position of tubule apertures is indicated by slight elevations. X 1.100

Fig. 2 – The contralateral surface to that seen in Fig. 1. This surface was cleaned with the experimental solution containing EDTA 0.2%. Cleanliness grade 3. The tubule apertures are clearly visible. X 1.100

The extracted teeth were immediately placed in a 10% neutral buffered formalin solution. Using conventional techniques, the ground surfaces were prepared and examined in a Cambridge scanning electron microscope, and three to eight pictures were taken of each experimental area in magnifications varying from 60 to 6000. About 600 pictures were taken of a total of 132 dentin exposures. The pictures were coded and examined according to the double-blind technique, by two independent, experienced examiners, who graded the surface according to a previously described scale.[1] In brief, the degree 0 represents a dentin surface completely covered with a smear layer without anatomical details such as dentinal tubule apertures, while degree 3 represents a surface with the tubule apertures open or slightly filled with cutting debris and with the intertubular area without any signs of smear layer.

TABLE 1
COMPOSITION OF TESTED SOLUTIONS*

No.	Name	Composition
A	Tubulicid Blue Label[R]	Chlorhexidine-digluconate 0.1g; Dodecyldiaminoethyl Glycine (9% solution) 1.0g Aqua Dest. ad 100g.
B	Experimental (0.20% EDTA)	Amphoteric – 2:0.3g.; Benzalkon Chloride 0.1g.; Disodium Edetate, Dihydrate 0.2g.; Phosphate Buffer Soln. q.s. ad pH 7.3 Aqua Dest. ad 100g.
C	Experimental (0.15% EDTA)	Same as B except for the concentration of EDTA: Disodium Edetate Dihydrate 0.15g.
D	Experimental (0.10% EDTA)	Same as B and C except for the concentration of EDTA: Disodium Edetate Dihydrate 0.10g.
E	EDTA, 0.20%	Disodium Edetate, Dihydrate 0.2g.; Phosphate Buffer Soln. q.s. ad pH 7.3; Aqua Dest. ad 100g.

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TABLE 2
EXPERIMENTAL METHOD AND RESULTS

Pairs of Surfaces	Parameters	The Removal of Smear Layer (Graded 0-3); Effect of Tested Solutions (Table 1)										Level of Significance**
		A		B		C		D		E		
		m	sd	m	sd	m	sd	m	sd	m	sd	
17	Solution A vs. B wet prep.	0.9	0.4	2.6	0.4							1%
9	Solution B vs. E wet prep.			2.5	0.3					1.8	0.4	1%
9	Solution A wet prep.	1.0	0.5									
	vs. dry	0.8	0.5									no sign.
9	Solution B wet prep.			2.3	0.5							
	vs. dry			2.2	0.4							no sign.
22	Solution C vs. D wet prep.					2.1	0.5	1.8	0.4			5%

**Nonparametric Wilcoxon's test for pair comparisons

Results.

The results are given in Table 2 and in Figs. 1 to 5. It was found that a combination of EDTA and surface-active antibacterial solutions with EDTA concentration of 0.15 and 0.2% had the ability to remove most of the smear layer without opening too many tubule apertures or removing peritubular dentin. The results of the cleaning were better when a combination of the tested solutions was used. No difference was seen between the ability to remove the smear layer from surfaces ground under water cooling and air cooling, respectively.

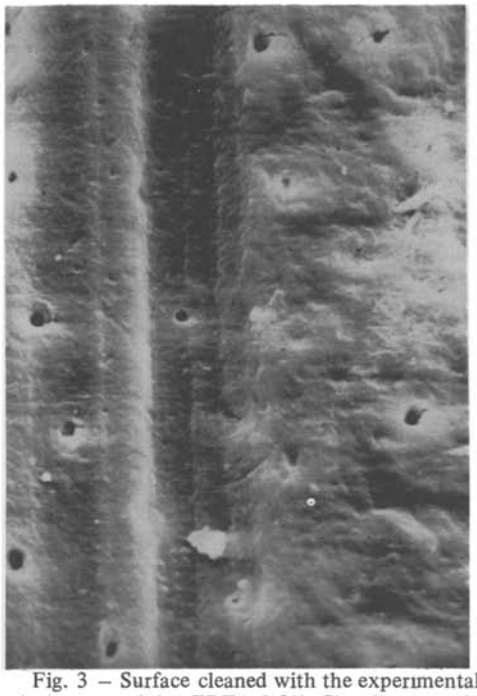

Fig. 3 – Surface cleaned with the experimental solution containing EDTA 0.2%. Cleanliness grade 3. Some tubule apertures are open and the intertubular dentin is slightly rough. X 2.000

Fig. 4 – Surface cleaned only with 0.2% EDTA. Cleanliness grade 1.5. A thin smear layer covers the surface, especially at the tubule apertures. X 1.650

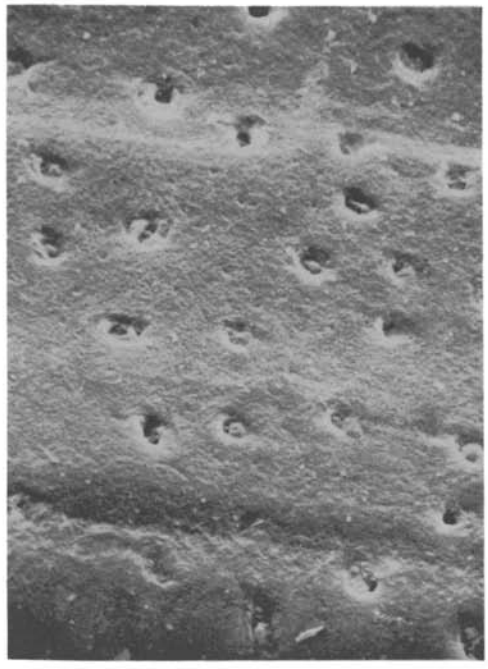

Fig. 5 – The contralateral surface to that seen in Fig. 4. The surface was cleaned with the experimental solution containing EDTA 0.2%. Cleanliness grade 2.5. A slight depression of peritubular dentin is seen at some tubules. Smear layer is present only in tubule apertures. X. 1800

Discussion.

In a previous *in vivo* study,[1] diamond-ground dentin surfaces were scrubbed for one minute with the same experimental solution used here without the addition of EDTA. The mean value for cleanliness was 0.4. With the addition of EDTA in concentrations of 0.15% and 0.2%, the values increased to 2.1 and 2.2-2.6, respectively, even though the surfaces in the latter experiments were scrubbed for a total of only ten seconds. The present results (Table 2) thus indicate that it is possible to obtain relatively clean surfaces of prepared dentin by using a combination of a surface-active solution and EDTA. Theoretically, it is also conceivable that the addition of EDTA may potentiate the action of the antibacterial component of the experimental solution.

In case a deeper and more smeared layer is created by dry cutting,[6] it is clear that the present cleaning procedure is equally

effective on dry- as well as wet-ground surfaces. Concerning the concentration of EDTA in the cleaning solution, 0.15 and 0.2% seem to be sufficient for the cleaning of diamond-ground surfaces.

Conclusions.

A combination of EDTA and surface-active antibacterial solutions (the combination having an EDTA concentration of 0.1 to 0.2%) has the ability to remove most of the smear layers produced during grinding without opening too many tubule apertures or removing peritubular dentin. The results of the cleaning were better when a surface-active solution was combined with EDTA than when each of them was used separately. There was no difference between the cleaning capacity on surfaces ground under water cooling compared to air cooling.

The experimental solutions containing 0.15 and 0.20% EDTA were more effective at removing the smear layer than the solution containing 0.10%, the optimum results being obtained with 0.20% EDTA in the experimental solution.

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