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SEM Evaluation of Dentin Surface after Different Types of Caries Removal.

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ABSTRACT

The purpose of this research was to examine the effect of the Carisolv system on elimination of carious dentin compared with the effect of the machine rotary instruments. The research included 20 teeth with open carious lesions without disease of the pulp tissue, extracted because of orthodontic and prosthetic reasons that were divided into two groups. In the first (experimental) group of teeth, in the case of all 10 specimens, the caries was removed with Carisolv system, whereas in the second (control) group of teeth, the conventional method of caries removal was applied with machine rotating instruments. The changes of the dentin surfaces were analyzed with scan electronic microscope. The results of the research showed that Carisolv as chemo-mechanical method is as efficient in the removal of carious matters as the application of mechanical rotating instruments.

Keywords: Carisolv, carious dentin, rotary instruments

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INTRODUCTION

When caries is eliminated by rotary dental instruments, in addition to the carious dental tissue, a part of the sound dental tissue is also removed. Thus, the tooth walls weaken and the possibility of tooth becomes greater. With the wider use of modern materials and adhesive systems, the traditional Black's principles are modified, the need for large retention cavities has been overcome, and in that way, the sound tooth substance is maximally preserved [1].

Taking into consideration the negative consequences that might occur when using machine preparation techniques, and in order to enable maximum duration of the natural teeth, the techniques for preparation and caries elimination should be minimally invasive [2, 3].

In the last years, the favored uses of preparation techniques and methods of caries elimination are those with which it is endeavored for the pain and unpleasant sensations to be reduced to minimum, the efficiency level to be increased, and the treatment to be comfortable for the patients [4, 5]. Numerous scientific works present data on the efficiency of the chemo-mechanical method of caries elimination with the use of Carisolv, referring to it as an alternative to rotating machines. The results disclose complete elimination of caries and clean cavity after applying the gel several times [6].

Carisolv system consists of Carisolv gel and hand instruments with a nickel-titanium working part, and it works by direct action of NaOCl and three natural amino acids on the carious dentin.

Numerous scientific works present data on the efficiency of the chemo-mechanical method of caries elimination with the use of Carisolv, referring to it as an alternative to rotary machines. The results disclose complete elimination of caries and clean cavity after applying the gel several times. These studies also provide answers as to the patients' acceptance of the treatment. Most of the examinees accept the treatment willingly, emphasizing that it is more pleasant and less painful than the classic method of caries elimination [1].

Taking into consideration the above-mentioned, the purpose of this research was to examine the effect of the Carisolv system in the elimination of the carious dentin compared with the effect of the machine rotating instruments.

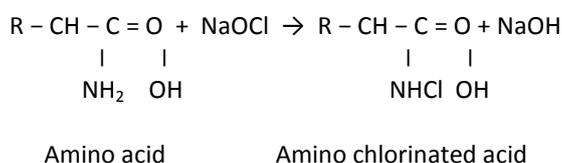
MATERIAL AND METHOD

The research included 20 teeth with open carious lesions without disease of the pulp tissue, extracted due to orthodontic or prosthetic reasons.

After the extraction, the firm and soft layers from the teeth were removed and the teeth were divided into three groups. Then, every individual specimen was placed on an appropriate abutment and they were put on evaporation device.

In the first (experimental) group of teeth, in all 10 specimens, the caries was removed with Carisolv gel. In the Carisolv gel, active components are NaOCl and three (3) amino acids: *glutamine acid*, *lysine* and *leucine*. NaOCl is a strong reactive compound, and its oxidative potential is due to the Cl atom. As a result of this, it can easily get into reaction attracting electrons from other compounds.

In the Carisolv gel the environment is alkaline (pH 11) which disables building reactive compounds and decreases the oxidative potential of NaOCl. In the gel, the highly reactive Cl atom from the hypochlorite gets into reaction with the amino acidic NH₂ group and creates relatively stable compounds – N monochlorine-amino acids in which Cl is less reactive and thereby less aggressive in healthy tissues.



The chlorinated amino acids in the Carisolv gel cannot get into reaction and damage the strong and stable structure among the collagen fibers and crystals of the hydroxyapatite. Huge energy is needed to dissolve it, and the energetic barrier depends on the pH value of the environment. As pH decreases, the crystals of the hydroxyapatite dissolve, and vice-versa. In the Carisolv gel the stable N monochlorine-amino acids are formed in an environment with high pH value so that the mineral component of the healthy dentine is additionally stabilized. In regards with the carious dentine, the collagen fibers are denaturalized which is the reason for exposure of, otherwise, inaccessible relations, in and among the collagen fibers. In this way, the chlorinated amino acids which are of different charges, gets into reaction with hydrophilic and hydrophobic fibers and break the ties that maintain the fibrillary structure of the collagen.

In the second (control) group of teeth, the conventional manner of caries removal with machine rotating instruments was applied. The manner of caries elimination with chemo-mechanical and classic manner of preparation in in-vitro conditions did not differ at all and it was carried out in the same manner as when it was performed in clinical conditions.

Chemo-mechanical manner of caries elimination - The carious lesion was treated with Carisolv gel, which was applied directly on the carious dentin. We left it for 30 seconds until it became softer, and then with the hand instruments we carefully removed the carious tissue. In several cases, we repeated the procedure until we were certain, by inspecting it, that the dentin was firm. The remaining gel was removed with a cotton tampon.

Conventional method of caries removal – in this group of teeth, the caries and carious dentin were removed with the use of machine instruments with a sterile steel borer, as in a clinical procedure.

In the both methods, as a confirmation that the caries was completely removed, a probe and KaVo DIAGNOdent were used.

The changes of dentin surfaces were analyzed with scan-electronic microscope. For that purpose, the teeth on the abutments were placed in the evaporator. The remaining liquid in the enamel and dentin were removed with the evaporator, and the specimens were then metalized with golden dust, so that they could be observed with the scan-electronic microscope under various magnifications.

This part of the research was performed with the scan-electronic microscope JEOL JSM-5300 of the scientific-research center within Faculty of Dentistry in Nish – Republic of Serbia.

RESULTS

Distribution of the 20 samples used in the SEM analysis are given in Table 1.

Table 1: Distribution of specimens used in (SEM) analysis

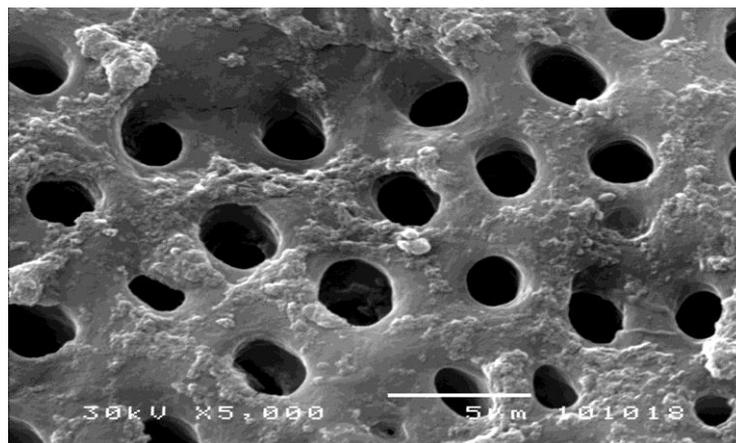
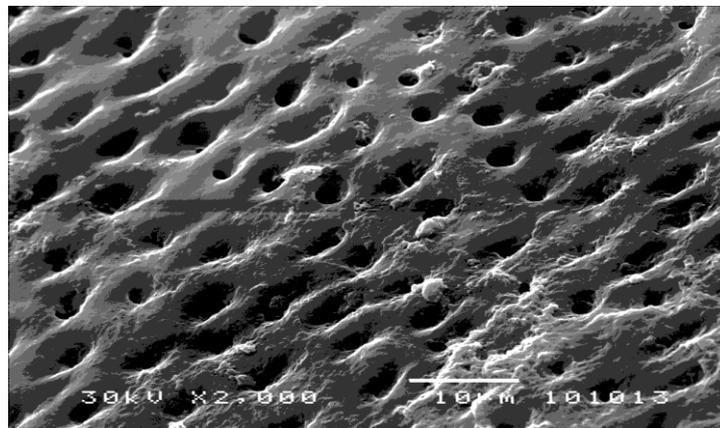
Tooth type	Carisolv group		Control group	
	N	%	N	%
Incisors	2	20,0	1	10,0
Canine teeth	1	10,0	2	20,0
Premolars	4	40,0	2	20,0
Molars	3	30,0	5	50,0
Total	10	100	10	100

The scan electronic microscopy of dentin specimen showed efficiency both of chemo-mechanical and conventional method of caries removal. After one-off application of Carisolv gel demarcation of carious from the sound dentin is noted and the carious dentin was partially dissolved and removed (Fig 1). Dentin specimens had uneven and rough surface after chemo-mechanical caries removal. Numerous open dentin canals are seen on the whole cavity. The smear layer was insignificantly formed in all specimens (Fig 2 a,b).

Figure 1: SE micrography of the dentin after one-off application of Carisolv for carries elimination. Demarcation of the carious from the sound dentin is noted (1000 x)

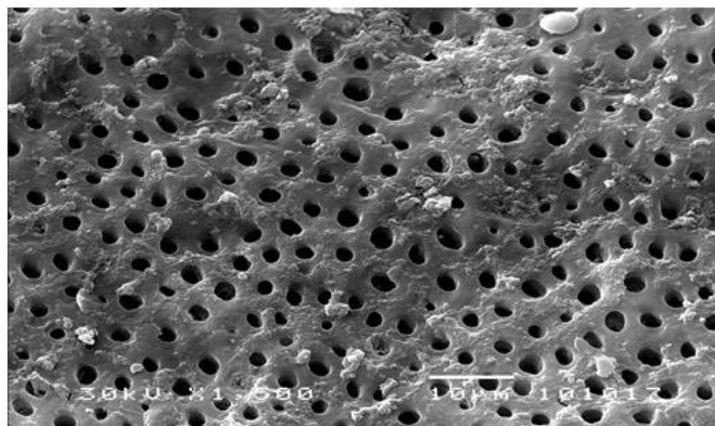
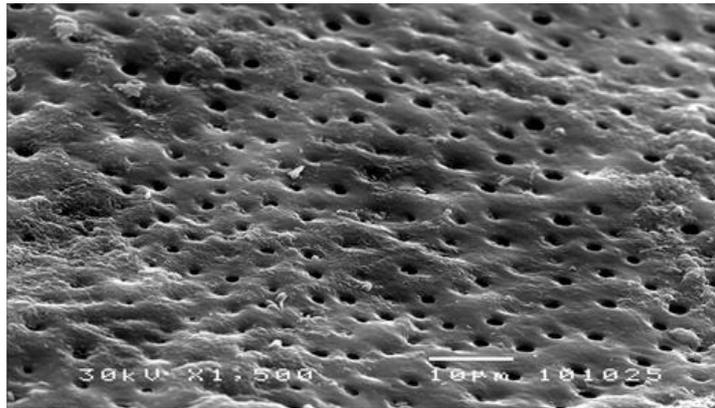


Figure 2 a, b: SE micrography of the dentin after chemical caries elimination. A large number of open dentin channels with insignificant presence of smear layer, a(2000 x), b(5000 x).



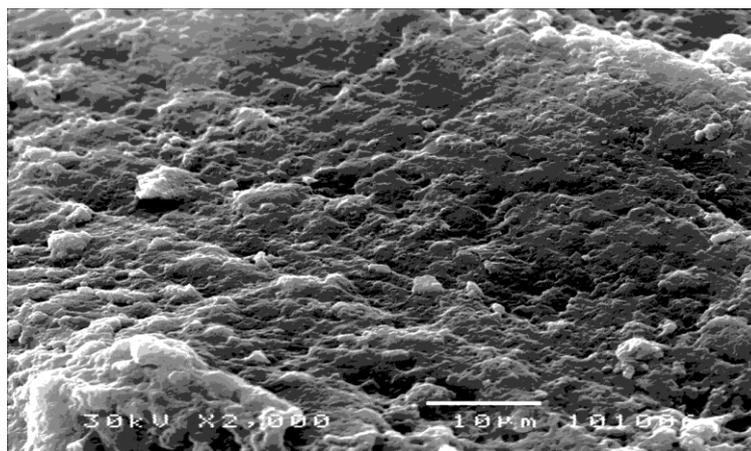
At the scanning electronic micrographs there were no significant differences between the structure and dentine surfaces on which Carisolv gel was applied and those without any previous treatment (Fig 3 a,b).

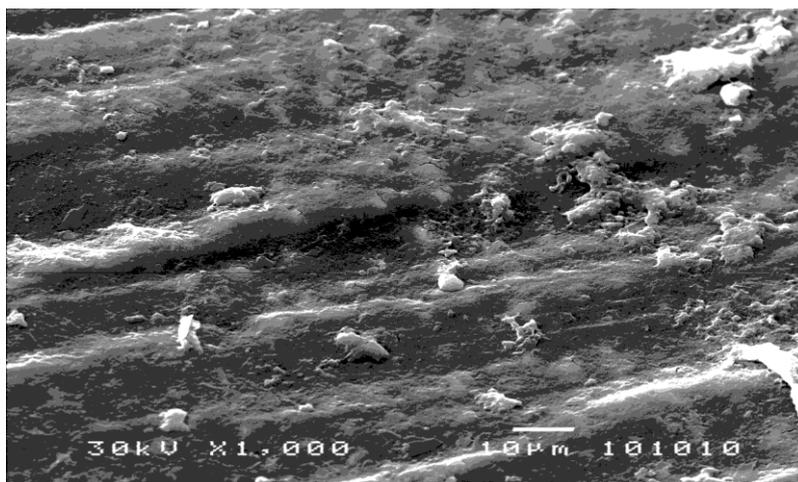
Figure 3 a,b: a-Sound dentin without any treatment (1500 x); b- Sound dentin after 20 – minute exposure to Carisolv(1500 x).



After caries removal with machine instruments, the dentin surface had a flat surface. At the dentin surface, furrows are noted that are a consequence of the machine preparation. The walls of the cavity were covered with well-formed smear layer and the openings of the dentin cannel were occluded (Fig 4 a,b).

Figure 4a, b: SE micrography of the dentin after caries elimination with machine instruments. The surface of the dentin is with noticeable furrows that are a consequence of the mechanical preparation a(2000 x), b(1000 x).





DISCUSSION

Scanning electronic microscopy (SEM) is very frequently used method for research of dentin morphology [1]. Pseudo tridimensional image for the topography and content of the observed surface is created with its use [7].

In our research, SEM analyses when using chemo-mechanical method showed uneven dentin area with open dentin tubules with partially or completely removed smear layer. Likewise, the selective action of Carisolv system only on the carious dentin could be noted. The results of this research are in line with the results shown by several previous research [8-11].

Banerjee et al. in their in vitro research analyzed the dentin surface after the removal of the carious masses with Carisolv, air abrasion, sono-abrasion or the classical method - with machine instruments. The results show that Carisolv is the only method which completely removes the smear layer during excavation, leaving open the dentin channels at the end of the preparation [5].

As opposed to the chemo-mechanical method, a number of research speak of forming a larger quantity of smear layer after caries removal with mechanical rotating instruments [1, 3, 10-12]. In our research of the scan electronic micrographs made after application of machine rotating instruments, we have also noticed a flat bottom, where the bottom and walls of the cavities were covered with a significant quantity of smear layer. The openings of the dentin channels were completely occluded. Some studies that include SEM analyses of the topography of sound and carious dentin, also emphasize the selective action of Carisolv only on the softened – carious dentin, without affecting the sound dentin and enamel [5]. The surface topography of the sound dentin remained after the completed caries removal is rougher, without left smear layer as opposed to the dentin surface after caries elimination with rotating machine instruments.

The smear layer is an amorphous layer composed of organic and non-organic substances that originate from the tooth tissues and exogenous substances such as saliva, microorganisms, blood etc. and is firmly attached to the dentin. Its presence in the cavity affects the strength of the bond between the tooth tissues and adhesive dental materials, therefore it must be eliminated or modified prior to the placement of the filling [13].

In chemo-mechanical manner of caries removal with the help of the Carisolv system, the gel with the lubricant effect helps the mechanical excavation of caries with the hand Carisolv instruments, and at the same time it dissolves chemically the carious dentin [5]. The absence of smear layer after the chemo-mechanical caries elimination is most likely a consequence of the specific technique of preparation without mechanical and thermal effects, the high pH value of the gel, as well as the possibility for dissolution of the smear layer with the active component of Carisolv gel sodium hypochlorite [13,14]. Other research, on the other hand, show that the exposure to the dentin surface solely to the action of a solution of sodium hypochlorite, not only resulted in opening of dental channels, but in contrast, the largest part of them were occluded [16]. The adding of amino acids in Carisolv formula contributes to dissolving of the smear layer, and by that, to opening

of the dentin channels. SEM microscopy of the dentin of sound and permanent teeth that were exposed to action of Carisolv gel showed open dentin tubules after the gel removal, and the surface of the intertubular dentin was rough and the dentin was partially covered with smear layer [17].

On the other hand, Cederlund et al. indicate that the dentin surface after the caries removal with the help of the Carisolv system, as well as after the exposure of the sound dentin to the action of the Carisolv gel was smooth, covered with smear layer, with occluded dentin tubules [18, 19]. These results are contrary to the results obtained with our research, as well as with the results of many other authors. Many studies that include SEM analyses of the topography of a sound and carious dentin [4, 7] were analyzed, which point out to the selective action of Carisolv only on the softened - carious dentin, without affecting the sound dentin and enamel. The surface topography of the sound dentin remained after the complex removal of the caries is rougher, without left smear layer, as opposed to the dentine surface after caries elimination with rotating machine instruments [5, 20].

In the therapy of caries, the morphology and composition of the dentin of the prepared cavity affect the adhesion of the restored dental materials [21]. The fact that after the chemo-mechanical caries elimination, the surface of the dentin is uneven and rough, without abundant smear layer, indicates to an opinion that the application of this method could provide better adhesion of the tooth tissue filling [20, 22, 23].

The conditioning of the dentin 35% phosphorous acid showed a significantly higher level of dentin demineralization after the chemo-mechanical caries removal (7 to 8 μ m) compared with the demineralization of the dentin after the processing of the caries with machine instruments (3,5-4,5 μ m) or demineralization of the sound dentin (1,5-2 μ m) [10]. This occurrence is explained by the deeper penetration of the conditioner in the absence or presence of a thin smear layer, as well as with partial demineralization of the internal layer of the carious dentin which is not removed with application of Carisolv system [10, 24].

Because of the larger extent of demineralization of the dentin after the chemo-mechanical caries removal, the most notable hybrid layer is formed precisely in this manner of caries elimination [25]. The hybrid layer is created when the demineralized dentin area (occurred as a result of the conditioning) is followed by penetration of composite resin. Complete adhesion is achieved by penetration and polymerization of the composite resin in the surface zone of the conditioned dentin, by forming extensions that look like thorns that are interwoven with collagen fibers [26].

The Carisolv system by itself is not invasive and it does not harm the sound collagen fibers, but it should be always taken into consideration that the excessive demineralization of the dentin may cause a collapse of the collagen meshwork and affect adversely the adhesion of the modern composite materials that is based precisely on the penetration of the composite resin around demineralized collagen fibers [27- 29].

A number of authors indicate that the manner of caries elimination does not affect the resistance to expansion or contraction of various composite systems [25, 30].

CONCLUSIONS

On the basis of the results obtained from our research, as well as on the basis of the data from the literature, we can conclude that with the application of chemo-mechanical caries removal, uneven, rough dentin surface is provided without smear layer and with many open dentin channels and therefore, it is considered a suitable method for adhesion of the modern restorative materials.

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