

Evaluation of chemomechanical caries removal (Carisolv™) using the Vickers hardness test "An in vitro study"

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Abstract

The Vickers hardness of dentin at the cavity floor after in vitro removal of caries with Carisolv™ gel and the microhardness of sound dentin was evaluated. The carious dentin of 18 extracted human permanent molars was removed using Carisolv™ for one minute. Caries removal was verified according to the colour and hardness of the lesion. The Vickers hardness number (VHN) of the cavity floor was determined and the adjacent sound dentin for each tooth was used as a control reference. The results show that Carisolv™ gel does not cause a significant change in the microhardness of sound dentin. *First published in Int Dent S Afric 2007; 9: 34-45.*

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Introduction

There has been considerable interest in developing alternative methods for cavity preparation and caries removal due to the disadvantages of using traditional rotating instruments, which can result in heat, pressure, dentin desiccation, vibration and pain¹. In addition, for patients with dental anxiety, caries removal by means of conventional instruments is often associated with discomfort². Furthermore, tissue should be preserved wherever possible; invasive treatment should be kept to a minimum and natural tissue should be replaced with artificial substitutes only when it is absolutely unavoidable³.

Our traditional insistence that a cavity floor must be unstained and hard after cavity preparation, this may be unnecessarily destructive of tooth material and lead to carious exposures of the pulp. The question immediately arises, how 'clean' must a cavity be before restoration? And what is the fate of slightly soft dentin if left behind, and whether it is a source of secondary caries⁴. Kidd et al.⁵ took samples of carious dentin during cavity preparation, and cultured the samples so as to count the number of bacteria. The number of bacteria recovered diminished significantly as the caries became dryer and harder and the cavity became deeper. There was no significant difference between the numbers of organisms cultured from medium as opposed to hard dentin. The color of the sample was not associated with the number of bacteria recovered. This suggests

that after the removal of wet soft dentin, further removal of medium hard stained dentin may not contribute to further reduction of infected material.

The technique used in carious dentin removal has been developed since GV Black in 1893, who initially proposed the principle of extension for prevention in the operative treatment of carious lesion. He also proposed that the removal of sound tooth structure and anatomical form at sites that might otherwise encourage plaque stagnation (e.g. occlusal fissure, approximal contact point) would help to minimize caries onset and progression. These principles of cavity preparation were based on the clinical presentation of caries and constrained by the knowledge of the disease process and the restorative materials, which are available at that time. However, in more recent years with the advent of adhesive restorative material and the subsequent development in minimal cavity designs^{6,7}, the widely acceptable principle is now considered too destructive method for caries removal². Latest theories regarding the rationale of carious dentin removal are also beginning to question the amount of tissue that need to be excavated in order to be successfully treated caries lesion, when removing demineralised dentin. It is not always easy to know at what point to stop excavation because there is an apparent lack of objective clinical markers⁸. However, hardness of dentin might be a useful marker in this respect. Hardness of carious dentin is significantly lower than the noncarious dentin⁹⁻¹¹. The removal of infected dentin and sparing the dentin capable of remineralization has been a goal of conservative dentistry. Minimally invasive dentistry is relying on this technique to minimize loss of tooth structure¹². A reliable method of limiting caries removal to infected dentin will advance the minimally invasive dentistry¹³.

The best way to ensure the maximum lifespan of the natural tooth is to respect the sound tissues and protect them from damage. Several alternatives have been introduced for conventional cavity preparation with rotary instruments and hand excavation. These methods include air-abrasion, air-polishing, ultrasonic instrumentation, sonoabrasion, different kinds of laser techniques and chemomechanical preparation of carious dentin. In common with all these techniques is their attempt to gain higher selectivity of removing only carious tissue and to avoid the painful and excessive preparation of sound dentin^{14,15}.

Chemomechanical elimination of carious dentin has so far been the most promising method as an alternative treatment procedure, particularly in paediatric dentistry, and for anxious or medically compromised patients¹⁶. This new method of treatment involves the selective removal of soft carious dentin without the painful removal of sound dentin¹⁷. It can also be applied to patients where the administration of local analgesics is contraindicated, since local analgesia is not necessary for 82-92% of the patients with this technique¹⁸. Miller et al.¹⁹ found that negative experiences regarding smell, taste and noise were limited in the chemomechanical caries removal technique.

Chemomechanical caries removal is a method for minimally-invasive gentle dentin caries removal based on biological principles. The system uses a gel and special instruments that preserve healthy tissue and patient comfort is significantly enhanced. Chemomechanical caries removal system involves the application of a gel, which is applied, to the caries affected area of the dentin, softening the diseased portion of the tooth, while healthy tissue is preserved. The softened carious dentin is

removed with special instruments and the treatment is quiet and effective²⁰. The dentinal surfaces formed after chemomechanical caries removal are very irregular with many overhangs and undercuts with visible patent and occluded dentinal tubules. The remaining dentin is sound, properly mineralized and well suited for restoration and bonding to modern restorative materials¹⁶.

The indications for using chemomechanical caries removal are exposed buccal lesions; cervical or root caries; very deep carious lesions (potential pulp exposure may be reduced) as well as the treatment of the uncooperative paediatric patient or the older, frightened child. Contraindications include sessions that necessitate short treatment time, and pit and fissure caries that are not deep where rotary preparation will suffice to remove caries with little discomfort²¹.

In comparison with drilling, the chemomechanical method is often more time-consuming²². To optimise the efficiency and effectiveness of Carisolv™ gel with respect to chemical caries dissolution and minimal effect on healthy dentin, a new, modified gel has been developed. The original Carisolv™ red gel contains three differently charged amino acids which are mixed with sodium hypochlorite prior to treatment. The new gel has no colour agent. It contains half the concentration of amino acids and a higher concentration of sodium hypochlorite 0.475%, almost twice the 0.250% in the original Carisolv™ gel²³.

The procedure avoids the painful removal of sound dentin but it is ineffective in the removal of hard eburnated part of the lesion, removal of eburnated caries, however, it may not be necessary⁵. The purpose of this in vitro study is to find out if the complete removal of carious dentin is possible with the Carisolv™ system

alone and to compare the effect of the "Carisolv™ gel" and sodium hypochlorite solution 0.25% (which is the same concentration used in Carisolv™ gel after mixing its components) on the microhardness of sound dentin. This study was also made to evaluate the effect of aminoacids present in the Carisolv™ gel in the control of sodium hypochlorite during caries removal using Carisolv™ gel.

Materials and methods

Preparation of the Carious Samples

Eighteen permanent molars with dentin caries on the proximal surface and ten caries free premolars extracted for orthodontic purpose with patient age range between 20 to 45 years old were used in the study. Teeth were stored in 0.1% thymol solution (BDH Chemicals Ltd. England) at room temperature to avoid dehydration and further microbial growth and used within 2 weeks after extraction. Each carious lesion of the eighteen teeth was analyzed according to the color and hardness of the lesion. Carious lesions with a brown to black color and medium consistency (resistant to probing but readily penetrated when tested with a sharp explorer) were selected for this study.

All lesions had no enamel coverage and the dentin was easily accessible through the cavity openings. In addition, each tooth was evaluated by a radiograph so that the carious lesion extends about half distance through the dentin surface. If caries extends more than half distance of dentin during treatment of the sample with Carisolv™ gel, the sample was neglected. The Carisolv™ (MediTeam, GoteborgAB, Sweden) system was applied according to the manufacturer's instructions using Carisolv™ hand instruments. For each tooth a fresh portion of

Carisolv™ at room temperature was prepared. Prior to mechanical treatment, the solution was applied for one minute to the carious tissue. The caries was then gently excavated using specially designed instruments. The procedure continued for as long as carious tissue could be removed. The cavity was then rinsed thoroughly with water and gently dried. The caries removal was verified according to the color and hardness of the lesion by checking the hardness of the dentin with a dental explorer until a leather-hard texture was reached or a sharp scratching sound was heard as suggested by previous studies^{14,24}.

All cavities were cross-sectioned perpendicularly to the tooth axis at the occlusal third of the crown using a diamond wheel cutter with water-cooling to avoid injury to the dentin. The tooth was placed in a jig to avoid movement of the sample during cutting (Figure 1). Cavity sections were flattened and smoothed with sandpaper of 400, 500 and 600 grit in a universal polishing machine. The sections were then embedded in a chemically-cured acrylic resin so that the occlusal surface was exposed to external surface. The blocks were soaked in a container filled with distilled water with few crystal of thymol, immediately at the dough stage of polymerization of the resin. At the doughy stage the temperature rise as a result of the auto curing is very low^{25,26} and it will not affect the tooth tissues. After polymerization of the resin, each block was smoothed with sandpaper of 400, 500 and 600 grit. The blocks were kept in distilled water containing thymol 0.1% at room temperature until hardness measurement is completed within 24 hours.



Figure 1. Tooth fixed on holder to facilitate sectioning.

Measurements of the Hardness of the Cavity Floor

Microhardness was measured with a Vickers hardness tester (Wolpert, Germany). Testing was performed with diamond pyramid indenters, which have a square-based diamond indenter with a 136° angle. Measurement was taken using a microscope of 200x magnification since identification was too small to be seen and measured with the naked eye. The test was determined using a load of 1 Newton (100 gm) applied to the specimens for 15 seconds as recommended in the pilot study (a pilot study was conducted to choose the most appropriate preparation of the samples, The hardness test was first determined by using load of 0.5 Newton (50 gm) applied for 15 second at four points along the cavity. The indentation was too small and its boundaries were not clear and not sharp under the microscope so the load was increased to 1 Newton (100 gm) which gave a clear indentation). This load and time were constant for all samples throughout the study.

The Vickers hardness number (VHN) was measured at four points in each treated cavity where the minimum distance between two consecutive indentations was more than 40µm. The indentation was never close to any edge of the

specimen or another indentation. The criteria for accepting an indentation were sharpness of diagonal edges, uniformity of diagonal shape (geometry) and free of irregularities in the testing area.

To determine the degree of residual softened dentin, the hardness change of the adjacent sound dentin (reference control) on the same specimens was evaluated. Since obtaining a Vickers hardness measurement of the cavity surface was impossible, recordings were obtained next to the cavity floor. The hardness of the subsurface at a point **25 μm next to the cavity floor** was used as that of the cavity floor and regarded as the Carisolv™ treated dentin²⁷, adjacent sound dentin (areas at least **1000 μm next to the cavity floor**) of the same samples was used as a control reference (Figure 2). The mean of the measurements was used as the VHN of the dentin and a statistically significant difference between the VHN of the Carisolv™ cavity floor and adjacent sound dentin was determined by T test; a value of $p \leq 0.05$ was considered significant.

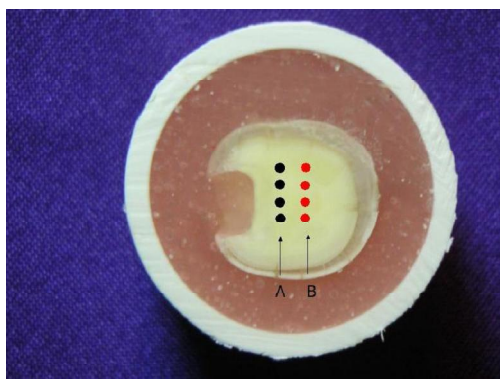


Figure 2. The picture shows points of microhardness measurements on the sample.

- a) Carisolv™ treated dentin, area located $25\mu\text{m}$ next to the cavity floor.
- b) Control points, area located $1000\mu\text{m}$ next to the cavity floor.

Preparation of the caries free samples

Ten sound permanent premolars extracted for orthodontic purposes were used for this study. Samples were sectioned from the occlusal third of the crown using a water-cooled diamond wheel cutter and placed in moulds in the same way as the carious samples and smoothed and polished. The blocks were placed in a container filled with distilled water, containing thymol crystals 0.1% at room temperature until measured.

Microhardness measurement of caries-free teeth

After preparation the sample was fixed in acrylic device and a shallow groove was made (bucco-lingually) at the midline of with a small diamond bur in a high-speed hand piece fixed on surveyor. This was done to obtain a parallel line separating the test and control surfaces into two equal halves and creating a groove that could be seen in the microscope of the Vickers hardness machine. This groove is considered the boundary between the test and control surface of dentin. Adhesive tape was then placed on the cut surface of dentin in a parallel direction next to the groove previously made to separate control area from tested area into two equal halves. The five randomly selected teeth were then treated with Carisolv™ gel, which was applied to the cross-sectioned dentin for three minutes and then washed away with water. The other five teeth were treated with 0.25% sodium hypochlorite solution (NaOCl 0.25%), which was applied to the cut dentin surface for 3 minutes and rinsed off with water. The tape was removed for both Carisolv™ and NaOCl treated samples and thus the same sample was used as a control.

The points where the Vickers test indenter was applied were at the

mid distance of the dentin, moving parallel and near to the boundary groove between the test and the control area (Figure 3). Measurements were taken at 50micrometer intervals and the Vickers hardness test was applied for both the Carisolv™ and NaOCl treated samples in addition to the non-treated areas. The data were tabulated and statistically analyzed.

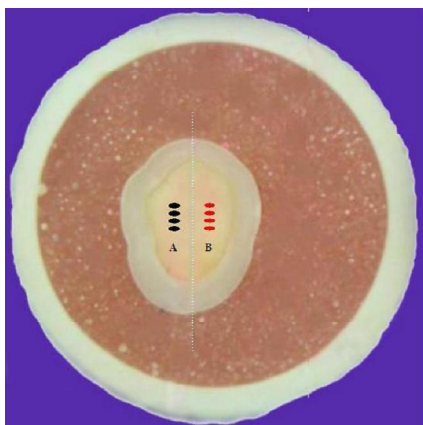


Figure (3): Picture shows carious free sample.
a: Points of measurements of the VHN at non treated control area.
b: Points of measurements of the VHN for Carisolv™ treated area.

Data Analysis

For the carious samples data were analyzed using T-test, a value of $p \leq 0.05$ was considered significant while for the caries free samples, T-test were used for the VHN of both Carisolv™ and NaOCl treated dentin followed by the analysis of variance (ANOVA) to indicate if there is any statistical difference between Carisolv™, NaOCl treated sound dentin and control ($p \leq 0.05$). Duncan multiple range tests were then used to compare among the significantly different groups.

Results

The results of this study can be analyzed by addressing the two types of samples used in the study separately, namely, carious samples and caries-free samples.

Carious Samples

The results revealed that the Vickers hardness number of the cavity floor prepared by Carisolv™ ranged from 60 to 63.5 kg/mm² (mean \pm SD: 61.85 \pm 1.23) which does not differ not statistically significantly from the Vickers hardness number of the adjacent sound dentin that ranged from 61 to 64.6 kg/mm² (mean \pm SD: 62.58 \pm 1.03). The results indicated no change in the microhardness of the dentin in the cavity floor after treatment with Carisolv™ gel compared with the adjacent control ($p = 0.064$).

The microhardness of the dentin in the treated cavity floor with Carisolv™ gel showed no statistical difference in the mean values compared with the adjacent sound untreated dentin.

Caries-Free Samples

The mean values of Vickers hardness number for the Carisolv™ treated dentin was (61.77 \pm 0.599) and for the adjacent untreated dentin (control) was (62.57 \pm 0.576). The microhardness of dentin for the samples in which sound dentin is treated with Carisolv™ gel showed no significant difference compared with the adjacent untreated dentin.

The mean value of the Vickers hardness number for the NaOCl 0.25% treated dentin was (56.72 \pm 1.07) and for the adjacent untreated dentin (control) (62.55 \pm 0.779). The microhardness for the samples in which sound dentin are treated with sodium hypochlorite 0.25% showed a significant difference compared with the adjacent untreated dentin.

A one way analysis of variance (ANOVA) was performed to make a comparison between the Carisolv™ and sodium hypochlorite treated sound dentin with their control, which showed significant

difference ($p \leq 0.05$). The results of (ANOVA) are shown in Table (1). The Duncan multiple range test for the VHN revealed that the Carisolv™ treated sound dentin and control had no significant difference and that both of them are significantly different from NaOCl treated sound dentin (Table 2).

dental tubule density at different locations (increased tubule density near the pulp was shown to correspond with reduced hardness). The third reason is the reduced hardness of the inter-tubular dentin when approaching the pulp.

Table 1. ANOVA Results for the VHN (kg/mm²) of Sound Dentin Treated with Carisolv™, NaOCl and Non Treated Control Groups.

Source	DF	SS	MS	F Value	P value
Factor	2	118.702	59.351	103.17	0.000
Error	17	9.780	0.575		
Total	19	128.482			

DF = Degree of Freedom, SS = Sum of Squares, MS = Mean square, F value = F calculated, P value = Probability value.

Discussion

Chemomechanical caries removal involves the chemical softening of carious dentin followed by the cleaning of the softened material with instruments similar to excavators. The typical chemicals used for such procedures are chloramines, prepared by mixing sodium hypochlorite with amino acids. The adverse effects of sodium hypochlorite on sound dentin and soft tissue are minimized using chloramines, but the effect on carious dentin is retained²⁸.

Variations in dentin hardness within a tooth may be due to several factors, the first of which is the calcification level of dentin (transparent dentin was found to be harder than the adjacent dentin). The second is the difference in

The fourth is the distance from the DEJ (dentin hardness increased with distance from the DEJ) (Kinney et al., 1996). The locations for the indentation in this study were thus carefully selected. The dentin was inspected to avoid any irregular areas, and the equal distances from the DEJ to the pulp were kept constant for all indentations.

Collys et al.³⁰ suggested a load of 50 g and more for studies of hardness in teeth because they found out that lower loads influence the indentation size. They indicated two aspects for this load influence: 1) the sample surface is altered during the polishing process, producing a coating larger than the largest depth reached for the indenter; and 2) with lower loads, the difficulty to read the indentation marks increased. However in this

work the use of a load of 100g gave a clear indentation to be observed under microscope. In this

i.e. the material should be in contact with the adjacent sound dentin for at least three minutes during clinical

Table 2. Duncan Multiple Range Test for the VHN (Kg/mm²) of the Carisolv™, NaOCl Treated and Non Treated Control Sound Dentin.

Source*	Mean**	N***	Duncan Group****
Control	62.56	10	A
Carisolv™	61.77	5	A
NaOCl	56.72	5	B

*: Source of significance.

***: Number of samples.

** : Mean of VHN (Kg/mm²).

****: Means with the same letters are not significant.

study, the hardness change of human dentin following carious dentin removal by Carisolv™ was assessed by in vitro Vickers hardness measurement of the cavity floor. The Carisolv™ gel was used according to the manufacturer's instructions on carious dentin for one minute followed by excavation with special instruments until the cavity was clean. In addition, the hardness of sound dentin when exposed to Carisolv™ gel and sodium hypochlorite 0.25% [the concentration is related to the amount of active chlorine, which is 0.25% after mixing the sodium hypochlorite with the aminoacid liquid²³ was studied to find out if the Carisolv™ gel affects the hardness of sound dentin and if the amino acids present in the Carisolv™ gel have any role in minimizing the effect of sodium hypochlorite on sound dentin. A time of three minutes was chosen for this study from a clinical aspect for the use of Carisolv™ gel,

work before the cavity is completely clean³¹.

Since this material is newly developed there are limited studies concerning the hardness of the treated cavity floor. However, previous studies have indicated the complete removal of carious dentin is difficult with Carisolv™ treatment and that the possibility of remaining caries following the Carisolv™ treatment is a major concern. Caries removal with Carisolv™ leaves up to a mean of 50 µm more carious dentin than round burs¹⁴. Clinical guidelines are therefore necessary to identify residual carious dentin. Splieth et al.¹⁴ and Cederland et al.²⁴ verified caries removal according to the colour and hardness of the lesion with a sharp explorer. The hardness of dentin was checked with a dental explorer until a leather-like hard texture was reached or a sharp scratching sound was heard.

The degree of softened dentin removal was determined by Vickers hardness number measurement of the cavity floor and the adjacent sound dentin as suggested by Aoki et al.³². The results of the Vickers hardness measurements of the Carisolv™ cavity floor confirmed that the possibility of the remaining residual softened dentin was minimal in this study as no statistical significant difference was noted in the microhardness of the Carisolv™ cavity floor dentin and the adjacent sound dentin (reference control). The results further indicate that the efficiency of complete carious dentin removal by the Carisolv™ chemo-mechanical system is no longer difficult when a proper clinical guide is used. The Carisolv™ gel appears to have no effect on sound dentin compared with sodium hypochlorite solution which has a softening effect on sound dentin when used in the same concentration present in the mixed Carisolv™ gel. This means that aminoacids do have a control effect on the sodium hypochlorite by limiting its effect to denatured and demineralized dentin without affecting the sound dentin.

Sodium hypochlorite has two main properties depending on the pH of the solution. The first is a sterilizing effect at around pH 7 and the second is a solvent effect on organic material at a higher pH. Chloramines are generally produced by a combination of sodium hypochlorite and amino nitrogen, which makes the effect of sodium hypochlorite less aggressive and prolonged. While chloramines are commonly used as a disinfectant, the solvent effect is expected in the application of chemo-mechanical caries removal.

The results are also in agreement with Hanning³³ who compared Carisolv™ with sodium hypochlorite and reported that Carisolv™ selectively dissolved an artificially demineralized and

denatured dentin, but did not dissolve a demineralized dentin of no denaturation. Sodium hypochlorite dissolved unselectively both demineralized and denatured dentin. The difference between the action of Carisolv™ containing sodium hypochlorite and the pure sodium hypochlorite solution could be explained by the amino acids added to Carisolv™. The amino acids might react with the sodium hypochlorite, thus reducing the organic tissue solvating properties of the sodium hypochlorite in Carisolv™ gel.

Tonami et al.³¹ reported that Carisolv™ softened only the outer layer of carious dentin and the hardness of the inner layer of carious dentin and the sound dentin was not changed, and that Carisolv™ selectively dissolved the degenerated collagen in carious dentin. The results are in agreement with the results in this study.

Ericson et al.³⁴ explained the behavior of amino acids in Carisolv™ gel from two aspects: one is the reduction of aggressive effect of the sodium hypochlorite on sound tissue and the other is that the chlorinated three amino acids of different electric charge reacted to different moieties of carious dentin.

Hossain et al.³⁵ evaluated the dentinal composition and Knoop Hardness measurements of the cavity floor following the removal of carious dentin by the Carisolv™ chemo-mechanical caries removal system in vitro and found that there were no significant differences between the quantities of calcium content (Ca weight %), phosphorus content (P weight %) and the Ca/P weight ratio of Carisolv™ cavities with that of the adjacent sound dentin ($P < 0.01$). The Knoop Hardness number of the Carisolv™ cavity floor was almost similar to that of the adjacent sound dentin. The scanning electron microscope analysis revealed an extremely rough

or irregular surface and there remained minimal debris like smear layer; most of the dentinal tubules were opened. The results indicate that Carisolv™ does not produce any adverse side effect on dentinal compositions of the treated cavities. The possibility of remaining residual softened dentin was also minimal in this study.

The results in this study were compared with the results of the previous study made by Hossain et al.³⁵ that worked with Knoop microhardness based on the study by Ryge et al.³⁶ who demonstrated that when working with loads between 50 and 100 g, Knoop and Vickers microhardness is equivalent. The results were in agreement with each other.

In this study the Vickers hardness test was used instead of the Knoop hardness test as it was suggested by Maria and Jorge³⁷ that the Vickers indenter has to be used always in the tooth hardness studies and, according to Guetierrez-Salazar and Reyes-Gasga³⁸, the Vickers indenter is more useful in tooth hardness studies than the Knoop's because a square shape has to be always conserved, and that close to the outer surface and the DEJ, a small elongation of the diagonals of the indentations that produce errors in hardness measurements, is easily detected. Therefore it was proposed that the Vickers indenter should always be used in tooth hardness studies.

The results in this study disagree with Splieth et al.¹⁴ because it was found that complete caries removal is not difficult with Carisolv™ alone. The results in this study are in agreement with the results of several researchers who investigated the hardness of carious dentin after chemo-mechanical caries removal with Carisolv™ and concluded that when a proper technique is used, this treatment will

result in complete caries removal without affecting the sound dentin^{31,33,35}.

The results of the microhardness in this study indicated that Carisolv™ solution does not produce any adverse side effects on dentinal microhardness. Furthermore, complete carious dentin removal by Carisolv™ is no longer difficult when proper clinical procedure is followed. Therefore, cavity preparation with Carisolv™ provides a clean dentin surface without affecting the adjacent sound dentin, which may be favourable in clinical dentistry.

Conclusion

Carisolv™ gel does not cause a significant change in the microhardness of sound dentin and the treated carious dentin. In addition, the aminoacids present in Carisolv™ gel play a role in the control of the sodium hypochlorite and minimize its aggressive effect on sound dentin. This is because when NaOCl is used alone in a concentration of 0.25% (which is the same concentration used in the mixed Carisolv™ gel), it will cause a softening effect on the sound dentin. However, when mixed with amino acids such as those found in Carisolv™ gel, this effect is minimized. Furthermore, it was found that the complete removal of carious dentin is possible with the Carisolv™ system alone when a proper clinical procedure is used.

摘要

本文评估了使用Carisolv™胶生物体外去除齿龋后牙洞底壁的牙釉质维氏硬度及健康牙釉质的微硬度。

18颗拔出的人类恒臼齿中的龋化牙釉质通过使用Carisolv™一分钟去除。

齿龋去除根据牙损的颜色和硬度核实。牙洞底壁的维氏硬度数值(VHN)被测定, 每颗牙齿的相邻健康牙釉质用作控制参

照。
结果表明Carisolv™胶不会引起健康牙釉质微硬度的显著变化。首次发表于 *Int Dent S Afric* 2007; 9: 34-45。

Resumen

Se evaluaron la dureza Vickers de la dentina a nivel del piso de la cavidad, luego de quitar la caries in vitro con gel Carisolv™, y la microdureza de dentina sana. Se quitó la dentina cariada de 18 molares permanentes extraídos de seres humanos, utilizando Carisolv™ por espacio de un minuto. La remoción de las caries se verificó de acuerdo al color y dureza de la lesión. Se determinó el número de dureza Vickers (VHN) del piso de la cavidad y se usó la dentina sana contigua a cada diente como elemento referencial de control. Los resultados mostraron que el gel Carisolv™ no causa un cambio significativo en la microdureza de la dentina sana. Publicado primero en *Int Dent S Afric* 2007; 9: 34-45.

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