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Original

The role of Carisolv™ and different auxiliary chemical substances in the removal of bovine root canal smear layer

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Abstract: To evaluate the effectiveness of Carisolv™ and different auxiliary chemical substances in root canal smear layer (SL) removal. SL was produced in the centre of 40 hemi-disks of bovine root dentine. The samples were divided into four irrigation groups (G): GI (control) - 0.9% NaCl; GII - 1% NaOCl + 0.9% NaCl; GIII - Carisolv™ + 0.9% NaCl; GIV - 1% NaOCl + 10% citric acid solution + 0.9% NaCl. The photomicrographs (SEM analysis) were coded (0 - absence of SL; 1 - moderate SL; 2 - dense SL with visible tubules; 3 - dense SL with no visible tubules). GIV was more effective in SL removal ($P < 0.01$). It should be noted that GI and GIII obtained score 3 in 100% of the samples ($P > 0.01$). Conclusion: NaOHCl, citric acid and NaCl solutions, when used together, presented a better performance in the removal of SL when compared to the other solutions. (J. Oral Sci. 48, 99-103, 2006)

Keywords: Carisolv™; smear layer; sodium hypochlorite; citric acid.

Introduction

The success of endodontic treatment strongly depends on the chemomechanical removal of microorganisms and pulp debris using instruments and irrigating solutions (1-3). During the instrumentation phase, a smear layer consisting of inorganic and organic components is formed (2). The inorganic material is composed of tooth structure and some nonspecific inorganic contaminants while the organic components consist of heat coagulated proteins, necrotic or viable pulp tissue, and odontoblastic processes plus saliva, blood cells, and microorganisms (4). According to Lester and Boyde (5) the smear layer is thick enough to completely obstruct dentinal tubules.

In infected root canals, debris should be eliminated because the bacteria found in this layer inside the tubules may be responsible for pathological complications such as external root resorption or periapical pathosis (6). This occurs as a result of the communication between dentine and the adjacent periodontal tissues (6). Moreover, SL removal facilitates good contact between the sealing material and the wall of cut dentine (7). These factors are also valid for the cases of smear layer produced during cavity preparation (8).

Carisolv™ has been widely used in the treatment of carious lesions (9). It comprises a mixture of sodium hypochlorite 0.5% and three amino acids (Lysine, Leucine and Glutamic acid) in a gel preparation. This product decomposes the collagen fibres disorganized by caries (10).

According to Hosoya et al. (11), Carisolv™ is capable of removing the smear layer and exposing dentinal tubules, mostly in carious dentine of primary teeth. Al-Kilani et al. (12) also verified root smear layer removal using Carisolv™. However, the effectiveness of this agent for safe debridement and disinfection of root canal systems, when used as an auxiliary chemical substance, is not well known yet.

With this goal, various chemomechanical methods have been applied, showing a varying degree of success.

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According to Baker et al. (13) and Rome et al. (14), irrigating solutions must be used as a supporting agent for complete eradication of the necrotic tissue and debris. Therefore, in addition to mechanical preparation of the root canal, the application of acidic substances and chelating agents is the most common approach for smear layer removal of the root canal surface (15). For this reason, one of the recommended combinations is 10% citric acid solution (16) with 1% sodium hypochlorite solution (17,18). According to Primo et al. (16) and Gotze et al. (17), the efficacy of these auxiliary chemical substances is explained by the fact that their use provides better disinfection of root canals and they allow better penetration and adaptation of the filling material to the root canals. While citric acid opens dentine tubules, aiding the penetration of the filling material (17,19), sodium hypochlorite has a bactericidal action, removing organic matter (20,21).

Therefore, the purpose of the present study was to evaluate the influence of Carisolv™ and different auxiliary chemical substances in the removal of root canal smear layer.

Materials and Methods

In this *in vitro* study, 10 bovine incisors stored in 10% formaldehyde solution were used. Periapical radiographs were taken to exclude the teeth with highly calcified root canals. In the present study, 3 teeth were discarded for this reason (n = 7).

The samples were prepared according to the method introduced by Calas et al. (18), which was modified in this study.

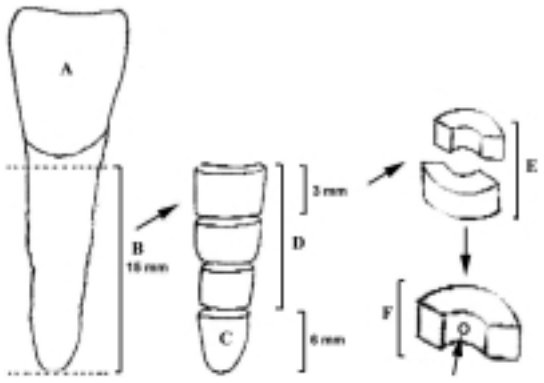

Fig. 1 Fragment preparation.
A: sectioning the crown; B: demarcating a length of 15 mm in the root portion; C: sectioning the apical area; D: sectioning the root portion; E: dividing the dentin disk into 2 fragments; F: the sample after smear layer production.

Fragment preparation

A length of 15 mm was demarcated on the root portion of each tooth using a compass (Fig. 1B). Using a single-face diamond disk (KG Sorensen), 6 mm of the apical area (Fig. 1C) and the remaining coronal portion (Fig. 1A) were removed and excluded from this research.

The remaining 9 mm root was subdivided into 3 disks of 3 mm each (Fig. 1D). These disks were sectioned mesiodistally (Fig. 1E) resulting in 6 fragments from each selected tooth, and a total of 42 samples. Two samples were discarded in order to obtain four groups of 10 fragments each.

Production of Smear Layer

In the most concave area of the inner central portion of each fragment, a smear layer was produced by introducing half of the active tip of a #2 spherical drill (Jet) at low rotation speed and forming a small cavity on the surface (Fig. 1F). After the production of SL, the samples were divided randomly into 4 groups, according to the chemical treatment performed.

Chemical treatment

Group I (GI - control): each fragment was irrigated with 10 ml of 0.9% saline solution for a period of 10 sec.

Group II (GII) received irrigation with 1 ml of 1% sodium hypochlorite solution for 10 sec and then with 10 ml of 0.9% saline solution for 10 sec.

In Group III (GIII), one drop of Carisolv™ gel was properly blended inside its syringe and applied to the dentine surface with the aid of a probe (Duflex) for 30 sec. The fragments were then irrigated with 10 ml of 0.9% saline solution for 10 sec in order to remove the product.

Group IV (GIV) received irrigation with 1 ml of 1%

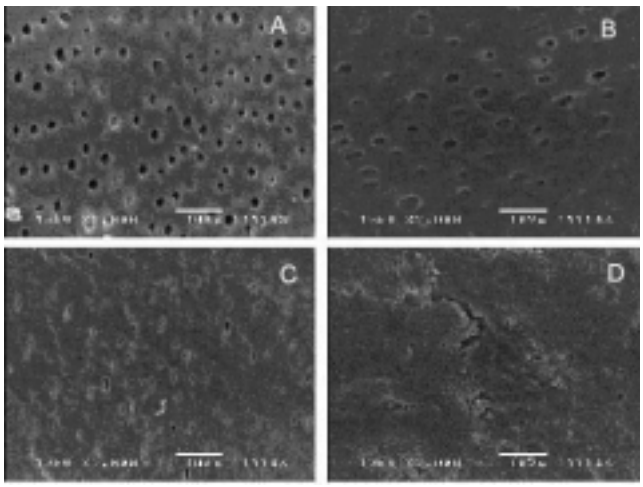

Fig. 2 Photomicrographs showing each sample score.
A: score 0; B: score 1; C: score 2; D: score 3.

sodium hypochlorite solution for 10 sec. The same procedure was repeated with 10 ml of 10% citric acid for 30 sec and finally irrigation with 10ml of 0.9% saline solution for 10 sec.

Analysis of the photomicrographs

After treatment, the fragments were coated with 200 Å of gold-palladium, to be qualitatively analyzed by Scanning Electron Microscopic (SEM) (JSM-5310) at ×2,000 magnification.

Photomicrographs of the most inner portion of the cavity in the central region of each sample were taken. These images were then evaluated using the following rating system: 0 - absence of SL; 1 - moderate SL; 2 - dense SL with visible dentinal tubules; 3 - dense SL with no visible tubules (Fig. 2) according to a modification of the method of Rome et al. (14).

These photomicrographs were scored by three previously trained examiners (mean weight Kappa = 0.864).

Statistical analysis

The scores were placed in a database using the GMC 8.0 software and analyzed using non-parametric statistical tests of Kruskal-Wallis and Mann-Whitney at 1% level of significance.

Results

The mean values of the scores assigned to each group studied are presented in Table 1.

The Kruskal-Wallis and Mann-Whitney analysis revealed no statistically significant difference between GI and GIII, both received a score of 3 in 100% of the samples ($P > 0.01$). The solutions applied in the GIV were able to totally (score 0 = 30%) or partially (score 1 = 20% and score 2 = 50%) remove the SL, this group being statistically superior to groups I, II and III ($P < 0.01$). In GII, partial removal of SL (score 2 = 70%) or complete non-removal (score 3 = 30%) was observed, demonstrating its statistical superiority to GI and GIII ($P < 0.01$) but inferiority to GIV ($P > 0.01$).

Discussion

Bovine teeth were used in this *in vitro* study because the dentine of a bovine incisor has a structure similar to that of a human tooth (22). The substantial size of the root and width of the root canal enables preparation of a large number of samples (17).

The smear layer was produced by introducing a spherical drill in the root dentine. According to Boyde and Knight (23) and McComb and Smith (2), a file-induced smear seems to be similar to one produced when using manual instruments. Consequently, the concept that any cutting activity forms this layer is well accepted.

A variety of chemical substances were used to remove the smear layer. The best results were obtained when 10% citric acid solution was used following 1% sodium hypochlorite solution (GIV). The acid solution allowed disorganization of the debris layer, while the hypochlorite finished the cleaning of dentine walls. However, the application of 1% sodium hypochlorite solution only (GII) did not totally remove the smear layer and open the dentinal tubules. These data are in accordance with other studies (16,18).

Data has been provided to support the fact that 0.9% saline solution used for 10 seconds would be the final step of chemical treatment in GIV to avoid citric acid crystal formation inside the cavity, which the SL was produced (24).

Regarding the results obtained from GIV, the irrigating solution only removed the SL totally in 30% of samples,

Table 1 Mean value (X) and standard deviation (SD) of the scores attributed to photomicrographs of the samples in accordance to the analyzed group

SAMPLE	GROUP I	GROUP II	GROUP III	GROUP IV
1	3	2	3	0
2	3	2	3	0
3	3	2	3	0
4	3	3	3	1
5	3	2	3	1
6	3	3	3	2
7	3	2	3	2
8	3	2	3	2
9	3	3	3	2
10	3	2	3	2
X ± SD	3 ± 0^{A}	2.3 ± 0.5^{B}	3 ± 0^{A}	1.2 ± 0.9^{C}

Note: Mean values followed by distinct letters differ among them at a significant level of 1%.

differing from other previous reports (8,25). Available evidence suggests that it happened because these solutions had not been able to completely penetrate the cavity surface which produced the SL.

McComb and Smith (2), Goldberg and Abramovich (26), Pashley et al. (19), Yamaguchi et al. (27) and Sassone et al. (28) described methods for which the usage time of EDTA varied from 5 min to 24 h with the aim of producing satisfactory results. This long period of application contraindicates the usage of this agent in Pediatric Dentistry. Therefore, in the present study, the authors decided not to use this material.

As for GIII in which Carisolv™ was used for 30 sec followed by 0.9% saline solution, the results demonstrated that these irrigant solutions failed to remove smear in 100% of the samples, in accordance with other published articles which used coronal dentin (29,30). However, there are studies showing that this substance is effective in SL removal (31,32), especially in the coronal dentine of primary teeth (11).

According to Koutsi et al. (33) and Sumikawa et al. (34), compared with permanent teeth, primary teeth have fewer dentine tubules with smaller diameter. For these reasons, perhaps the SL removal is not complete when using Carisolv™ in the permanent teeth.

In this study, Carisolv™ was selected because it has sodium hypochlorite in its formula, which is known for its efficiency in SL removal (20,35,36). Moreover, according to Mentz (37), sodium hypochlorite has three important properties: it is anti-microbial, dissolves pulpal remnants and debris and only slightly irritates the vital tissues.

In this study, Carisolv™ was used for 30 sec as per manufacturer's instructions. However, in other reports this substance was placed on the dentine surface for a longer period of time (11,29), a fact that might have influenced the results of this work. In accordance, Al-Kilani et al. (12) affirmed that Carisolv™ proved itself to be able to significantly enhance canal cleanliness, particularly with an exposure time over 20 min.

In addition, several articles have shown that Carisolv™ can be used effectively in carious dentin (9,30,38), which was not observed in the present work. As this product acts on carious dentin preserving the healthy structure, it may be assumed that the results of this research were not in favor of this substance due to use of healthy dentine, in which only collagen derangement was promoted *in vitro*.

However, it is relevant to report that although Carisolv™ did not demonstrate satisfactory results in this study due to limitations of the experiment, the use of this substance for root smear layer removal should not be discouraged. Further experiments that explore other methodologies may be necessary in order to obtain more conclusive data in relation to the actual effectiveness of this agent.

Conclusions

With the present results, it is possible to say that a combination of the following solutions: 1% sodium hypochlorite, 10% citric acid and 0.9% saline represented the best chemical treatment in smear layer removal consequently exposing the dentinal tubules, when compared to the use of 0.9% saline solution only or combined with Carisolv™ or with 1% sodium hypochlorite solution.

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