

# EFFECTIVENESS OF NaOCl ALONE OR IN COMBINATION WITH EDTA ON THE DIFFUSION OF HYDROXYL IONS RELEASED BY CALCIUM HYDROXIDE PASTE

*EFETIVIDADE DO HIPOCLORITO DE SÓDIO USADO ISOLADAMENTE OU EM ASSOCIAÇÃO COM O EDTA SOBRE A DIFUSÃO DE ÍONS HIDROXILA LIBERADOS DE PASTA DE HIDRÓXIDO DE CÁLCIO*

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## ABSTRACT

**A**im: To evaluate the effect of different irrigant solutions employed during removal and replacement of calcium hydroxide paste on the diffusion of hydroxyl ions through root canal dentine in vitro. Methodology: Thirty-five maxillary and mandibular human canines with straight and fully developed roots were used. After mechanical preparation up to 1mm short of tooth length, 30 canals were filled with calcium hydroxide paste and 5 canals were left empty; all teeth had their coronal accesses properly sealed. Teeth were placed in plastic containers with distilled water, and pH was read after 30 days when the paste from 20 teeth was renewed. After removal of the paste by endodontic instrumentation and irrigation with distilled water, canals were replenished with newly mixed paste in Group 1 and 2. In these groups, final irrigation was conducted with 5 mL of EDTA followed by 5 mL of NaOCl in specimens in Group 1, and 5 mL of NaOCl only in specimens in Group 2. In 10 teeth the paste was not replenished at 30 days (Group 3). All specimens were returned to the containers with fresh distilled water, and the pH was recorded after another 30 days. The differences between the first (30d) and second (60d) pH readings were calculated and submitted to analysis of variance and individual comparisons using the Scheffé's test. Results: Results of mean analysis on differences of pH readings showed that greater diffusion had occurred on specimens in Group 3. Individual comparisons using Scheffé's test showed statistical significance between Groups 2 and 3, and equivalence between all other groups. Conclusion: It was concluded that the use of EDTA did not enhance diffusion of hydroxyl ions through root canal dentine.

**Uniterms:** Calcium hydroxide, diffusion; EDTA; Hydroxyl ions; Irrigants; Sodium hypochlorite.

## RESUMO

**O**bjetivo: O objetivo desta pesquisa foi comparar o efeito de diferentes irrigantes, usados durante a troca da pasta de hidróxido de cálcio, sobre a difusão de íons hidroxila. Metodologia: Foram empregados 35 caninos humanos, com canais retos e raízes totalmente formadas. Efetuado o preparo mecânico até 1 mm aquém do comprimento do dente, 30 canais foram preenchidos com pasta de hidróxido de cálcio e 5 permaneceram vazios (controle). Após o selamento, os dentes foram colocados em frascos plásticos contendo água destilada. Passados 30 dias, o pH da água foi medido e a pasta de 20 dentes foi renovada. Depois de removê-la com água destilada e instrumentos endodônticos e, antes de repô-la, foi feita uma irrigação com 5 ml de EDTA seguida de 5 ml de NaOCl (Grupo 1) ou somente com 5 ml de NaOCl (Grupo 2). Em 10 dentes, a pasta não foi renovada (Grupo 3). Os dentes foram repostos em seus frascos com nova água destilada e, após 30 dias, o pH foi novamente registrado. As diferenças nas medidas de pH, realizadas aos 30 e 60 dias, foram calculadas e submetidas à análise de variância e a comparações individuais pelo teste de Scheffé. Resultados: A análise das diferenças mostrou que a difusão foi maior nos dentes do Grupo 3. Comparações individuais usando o teste de Scheffé mostraram significância estatística entre os Grupos 2 e 3 e equivalência entre todos os outros grupos. Conclusão: O uso do EDTA não aumentou a difusão de íons hidroxila através da dentina radicular.

**Unitermos:** Hidróxido de cálcio, difusão; EDTA; Íons hidroxila; Soluções irrigadoras; Hipoclorito de sódio.

## INTRODUCTION

Calcium hydroxide (CH) has been used in endodontic therapy since Hermann<sup>8</sup> recommended its application in dentistry as a material for pulp capping. It is commonly used as an intracanal medicament because of its antiseptic action<sup>1,17</sup> and its capacity to stimulate and create favorable conditions for tissue repair<sup>1,15</sup>.

In the presence of water, CH dissociates into hydroxyl (OH<sup>-</sup>) and calcium (Ca<sup>2+</sup>) ions, which are responsible for its therapeutic activity. Diffusion of OH<sup>-</sup> ions raises the pH<sup>11,20</sup> causing destruction of bacteria, inactivation of their enzymes, reduction of osteoclastic activity, and activation of alkaline phosphatase that is involved in tissue mineralization<sup>20</sup>.

Following canal preparation the dentinal walls become covered with a smear layer that acts as a physical barrier for OH<sup>-</sup> ion diffusion<sup>12</sup>. Various investigators have recommended the removal of this layer, to allow greater ion diffusion<sup>7,12,16</sup> and, as a consequence, enhance its activity as intracanal disinfectant.

In some cases CH is used for some weeks to achieve a greater antiseptic action, as the diffusion of hydroxyl ions and consequent alkalinization of dentine do not occur immediately<sup>5,11,15</sup>. If the root canal is shaped, clean and dry, there is no need to change the dressing, because under these conditions and with proper coronal sealing the amount of CH placed in the canal can maintain ion dissociation for a considerable period<sup>1,4,5</sup>. Nevertheless, there are situations when replenishment of the paste is desirable, for instance if coronal sealing is compromised or lost.

It has been shown that CH may reduce dentine permeability because it may be transported or mechanically forced into the dentinal tubules causing its obstruction<sup>13</sup>, or through precipitation of calcium phosphate salts within the dentinal tubules<sup>3,5,12</sup>. Deardorf, et al.<sup>3</sup> showed that additional applications of CH increased the amount of calcium at the root periphery but at a decreased rate, probably because of the precipitation of a calcium-phosphate compound in the dentinal tubules. If it is necessary to replenish the CH paste, it may be beneficial to use a solution that not only removes the dressing, but also recovers the original permeability of dentine, so as to improve the diffusion of OH<sup>-</sup> ions.

Using distilled water, 15% ethylenediamine tetracetic (EDTA), 5.25% sodium hypochlorite (NaOCl), and a combination of 5.25% NaOCl and 15% EDTA to irrigate root canals previously filled with CH-glycol base (Calasept), Tatsuta, et al.<sup>18</sup> concluded that all were effective in removing the paste. In a SEM study, Çalt and Serper<sup>2</sup> verified that root canal irrigation with 17% EDTA + 5% NaOCl completely removed the CH dressing, allowing greater penetration of root canal sealers into the dentinal tubules. On the other hand, Lambrianidis, et al.<sup>10</sup> observed that irrigation with saline, 3% NaOCl or 3% NaOCl + 17% EDTA, in addition to endodontic instrumentation was not able to remove different CH preparations (Calxyl, Pulpdent paste, and pure CH mixed with distilled water), and areas of the dentinal surface

remained covered with paste.

The objective of this study was to evaluate the effect of NaOCl alone or in combination with EDTA employed during removal and replacement of calcium hydroxide paste on the diffusion of hydroxyl ions through root canal dentine *in vitro*.

## MATERIAL AND METHODS

Thirty-five maxillary and mandibular human canines were used. No data regarding age, sex, or reasons for extraction were available. All selected teeth had straight and fully developed roots. Teeth were initially rinsed with tap water for 12 hours continually, and access performed in a conventional manner. The canal was irrigated with 1% NaOCl, and a hand stainless steel instrument was introduced until it reached the apical foramen for establishment of the working length.

Root canals were prepared using a circumferential filing technique<sup>9</sup> with Flexofile (Dentsply, Maillefer, Ballaigues, Switzerland), using filing movements up to 1mm short of the tooth length. Four instruments were employed to prepare the apical stop, larger than the one that bound first at length. The apical third of the canal was serially instrumented using further four instruments, each at 1mm short of the anterior instrument. The middle and cervical thirds were enlarged using Gates-Glidden burs (Dentsply, Maillefer) to a maximum size of 5 or 6. Between the use of each instrument or bur, and also at the end of instrumentation, the canals were irrigated with 2 mL of 1% NaOCl.

After shaping was concluded, the outer root surface was marked with a graphite pencil to guide removal of the cementum layer; which was achieved with diamond burs and periodontal curettes. The canals were then irrigated for 3 min with 5 mL of 17% EDTA, and also for 3 min with 5 mL of 1% NaOCl. The outer root surface was also rinsed with EDTA for 3 min. Subsequently, all canals were thoroughly irrigated with 10 mL of water, and teeth were immersed and kept in fresh 10 mL of distilled water for 24 h.

After the 24 h period, all teeth and their outer surfaces were dried with paper points and sterile gauzes. The apical thirds of all roots were covered with a fast-setting adhesive (Araldite, Ciba Especialidades Químicas LTDA., Taboão da Serra, Brazil). Calcium hydroxide powder (Reagen-Qimibrás Indústrias Químicas S.A, Rio de Janeiro, Brazil) and propylene glycol (Quimidrol-Comércio, Indústria e Importação Ltda, Joinville, Brazil) were mixed until a fluid paste similar to that clinically used was achieved. Using Lentulo spiral filler, 30 canals were filled with the paste, and complete filling was verified using radiographs; when there were voids, more paste was added to obtain complete filling. In five teeth the canals were kept empty (Group 4 - control). Access cavities were sealed with Cimpat (Specialites Septodont, Saint-Maur-des-Fossés, France). After washing with distilled water, all teeth were placed in individual containers with 10 mL of distilled water (pH = 6.5).

After 30 days, the pH of 10 mL of distilled water in contact

with the teeth was recorded using a pH-meter (Model-374, Micronal, São Paulo, Brazil) previously calibrated with pH 7.0 and 9.0 standard solutions. Reading was performed 15 seconds after introducing the electrode into distilled water; between readings, the electrode was rinsed with distilled water and dried with absorbent paper. All 30 specimens with canals filled with the CH paste were then randomly divided into 3 groups (n = 10); the 10 teeth in each Group 1 and 2 had the paste replenished. After removing the temporary filling material, canals were irrigated with distilled water. Master apical files were used respectively for each specimen and irrigation repeated until no more CH paste could be visually observed extruding the canal. Specimens on Group 1 were finally irrigated with 5 mL of 17% EDTA and 5 mL of 1% NaOCl for 3 min. All specimens on Group 2 were finally irrigated with 5 mL of NaOCl only, for 3 min. After canals were dried with absorbent paper points, fresh paste was replenished with a Lentulo spiral. The CH paste was not replenished on specimens on Group 3. After sealing of teeth in Groups 1 and 2 with Cimpat, all teeth, including those in Groups 3 and 4, were washed with distilled water and stored in new individual containers with 10 mL of distilled water (pH = 6.5). A further reading of pH was carried out after 30 days.

Finally, all specimens were inspected under light microscopy to ensure that the entire cementum layer had been successfully removed.

The differences in pH readings, taken at 30 and 60 days, were calculated and submitted to analysis of variance and individual comparisons using the Scheffé's test.

## RESULTS

Measurements of pH of distilled water in contact with teeth of Groups 1, 2, 3 and 4, made at 30 and 60 days, are presented on Table 1. Table 2 shows the differences between measurements, as well as the mean of these differences for

each group. These means, when submitted to analysis of variance (ANOVA – Table 2), indicated a significant difference between groups. Individual comparisons using Scheffé's test showed statistical significance between groups 2 and 3, and equivalence between all other groups (Table 3).

Light microscope analysis showed that the technique used to remove the cementum was successful, since root cementum could not be identified on any specimen.

## DISCUSSION

When used as an intracanal medicament, CH acts therapeutically by the diffusion of hydroxyl ions through the root canal system (5, 20). Despite the controversy in the literature about the need to change the medicament (1, 4, 15, 19) there is no doubt that the paste should be changed when coronal sealing is compromised and the root canal is contaminated. When considering replenishing the CH paste, root canal instrumentation combined with the irrigating solution to be used must attain two objectives: remove remnants of paste, and recover the original dentine permeability to allow optimal diffusion of hydroxyl ions or other intracanal disinfectants.

Since previous reports have shown that the presence of smear layer (7, 12, 16) and root cementum (11, 20) might affect ion diffusion, the dentine in this study was made as permeable as possible by removal of cementum and use of EDTA + NaOCl treatments within the canals and EDTA on the outer root surfaces.

Differences in pH were found among teeth, demonstrating that each specimen had a distinct intracanal diffusion capability (3). The differences found in pH measurements could indicate that removal of cementum was not complete. However, light microscope analysis showed that the technique applied to remove cementum was successful. Thus, if cementum was removed, one must

**TABLE 1-** Measurement of pH of water in contact with teeth in Groups 1, 2, 3 and 4

Tooth	GROUP 1		GROUP 2		GROUP 3		GROUP 4	
	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
1	6.80	6.70	8.35	7.05	11.30	11.72	6.98	7.08
2	12.07	11.26	7.18	6.90	6.83	7.12	6.92	7.00
3	7.11	7.05	6.94	6.73	6.85	7.20	6.85	7.08
4	9.88	11.25	7.07	6.84	6.99	7.34	6.82	6.95
5	12.02	11.80	7.07	6.75	6.87	7.62	6.64	6.88
6	11.65	11.88	11.83	11.89	11.65	11.82	—	—
7	7.31	7.15	7.21	6.99	7.25	7.28	—	—
8	11.94	12.04	6.92	6.90	7.41	7.55	—	—
9	7.45	7.29	7.16	7.16	7.23	7.30	—	—
10	7.03	7.13	7.08	6.92	7.14	7.98	—	—

assume that differences in number, diameter and length of dentinal tubules may be responsible for differences in pH readings (6, 14). Nevertheless, the presence of lateral canals should also be considered, since they could allow greater ion diffusion. Teeth with pH values close to 7.0 probably reflected greater presence of secondary dentine, or dentinal tubules of smaller diameter and/or thicker root walls, resulting in less permeability. However, these factors may not be significant since differences in pH between 30d and 60d have been considered in our statistical analysis.

Samples of water from those teeth in the control group (Group 4) also exhibited some alteration in pH. This may have occurred because residues of NaOCl solution may have diffused through the dentine, even though the canals were thoroughly irrigated and maintained in distilled water in an attempt to neutralize that solution.

When analyzing the differences in pH found between periods (Table 2), it was observed that some specimens in Group 1 presented less alkaline measurements at 60d than those at 30 days. However, the mean of these differences remained positive (0.03). The mean was negative (-0.27) in teeth in Group 2, which received only final irrigation with

NaOCl. Statistical analysis did not indicate significant difference between Groups 1 and 2, suggesting that the exclusive use of NaOCl to irrigate the canal in order to remove CH mixed with propylene glycol should be sufficient.

Analysis of pH of water in contact with teeth in Group 3 suggests a different phenomenon. In the second recording, the pH of water for all samples was higher, and the mean of differences was positive (0.34). Such results confirm the findings of Felipe (5), who observed that measurements of pH of water in contact with CH-filled teeth remained high for long periods. In that study, changing the paste caused disturbance in ion diffusion. Statistical analysis did not show significant difference between results for Groups 1, 3 and 4. However, there was a statistically significant difference in results between Groups 2 and 3.

Within the limitations of this *in vitro* study, CH paste replenishment should be avoided. In addition, if replenishing is inevitable, irrigation with 1% NaOCl alone has shown to be effective in removing the CH paste mixed with propylene glycol.

**TABLE 2-** Differences in pH measurement between periods (30 and 60 days) for each group

TOOTH	GROUP 1	GROUP 2	GROUP 3	GROUP 4
1	-0.10	-1.3	0.42	0.10
2	-0.81	-0.28	0.29	0.08
3	-0.06	-0.21	0.35	0.23
4	1.37	-0.23	0.35	0.13
5	-0.22	-0.32	0.75	0.24
6	0.23	0.06	0.17	---
7	-0.16	-0.22	0.03	---
8	0.10	-0.02	0.14	---
9	-0.16	0.00	0.07	---
10	0.10	-0.16	0.84	---
MEAN	0.03	-0.27	0.34	0.16

ANOVA - F = 4.97 p = 0.0055

Negative sign indicates lower pH at 60 days than at 30 days.

No sign indicates higher pH at 60 days than at 30 days.

**TABLE 3-** Individual comparisons using Scheffé's test (p < 0.01)

GROUP	MEAN
3 (no changes)	0.34
4 (control)	0.16
1 (EDTA + NaOCl)	0.03
2 (NaOCl)	-0.27

OBS. Vertical bars indicate statistical equivalence.

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