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# *In vitro* study of erosion caused by EDTA on root canal dentin

## *Estudio* in vitro *del grado de erosión que provoca el EDTA sobre la dentina del conducto radicular*

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**ABSTRACT**

In endodontic treatment, disinfection of the root canal system guarantees success. Use of chelating agents like etilendiaminotetraacetic acid (EDTA) is indispensable to achieve such a goal. Nevertheless, dentin experiences topographic structural changes which can lead to endodontic failure. This study was almost experimental. Forty large, straight canals were used for it. Use of instruments in the canals followed the balanced forces technique. Hand instruments were used in the crown and apex, using Flex-R files in the first and second series, each instrument was irrigated with NaOCl. Final irrigation consisted of 3 mL 17% EDTA, followed by 5 mL 5.25% NaOCl. Roots were longitudinally cut with diamond disc. Samples were prepared with a coating of gold in plasma, so as to be able to be examined with a Scanning Electron Microscope. The erosion extent of middle and apex third of the root canal were measured. When using 17% EDTA results were: in the middle third, 50% severe erosion and 25% moderate erosion, and in the apical third 30% severe erosion and 25.7% moderate erosion. The dentin alteration caused by EDTA must be considered when filling (obturating).

**RESUMEN**

La desinfección del sistema de conductos radiculares nos garantiza el éxito en el tratamiento endodóntico. La utilización de quelantes como el ácido etilendiaminotetraacético (EDTA) son indispensables para lograrlo, pero la dentina sufre cambios estructurales en su topografía que puede provocar fracaso endodóntico. Se realizó estudio de tipo cuasiexperimental. Se utilizaron cuarenta conductos amplios y rectos. Los conductos se instrumentaron mediante la técnica de fuerzas balanceadas corono-apical con instrumentos manuales limas Flex-R primera y segunda series y se irrigó entre cada instrumento con NaOCl. La irrigación final consistió en 3 mL de EDTA al 17% seguido de 5 mL de NaOCl al 5.25%. Se cortó la raíz longitudinalmente con un disco de diamante y se prepararon las muestras con un baño de oro en plasma para poder ser observados en el microscopio electrónico de barrido. Fue analizado el grado de erosión de los tercios medio y apical del conducto radicular. Los resultados encontrados al utilizar el EDTA al 17% mostraron en el tercio medio 50% erosión severa y 25% erosión moderada y en el tercio apical 30% erosión severa y 27.5% erosión moderada. La alteración de la dentina que el EDTA provoca debe ser considerada durante el proceso de obturación.

**Key words:** EDTA, dentinal tubule, erosion.
**Palabras clave:** EDTA, túbulo dentinario, erosión.

Methodology and sample preparation for this study were conducted at the Autonomous University of Queretaro, simple readings were performed at the Electronic Microscopy Department of the Center for Applied Physics and Advanced Technology (CFATA), National University of Mexico-Autonomous University of Queretaro, Juriquilla campus.

## INTRODUCTION

Careful and complete removal of remnant tissue, microbes, and dentinal debris from the root canal system are essential to achieve endodontic success. Although use of instruments in the root canal constitutes the primary method to debride canals, irriga-

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tion represents a decisive adjutant.[1] Instruments may not be able to reach the multiple irregularities of the root internal anatomy, therefore, irrigation has to accomplish the task of cleansing and disinfecting canal walls and all lateral and accessory canals, which are especially frequent in the apical zone,[2,3] therefore, the sanitizing process of the canal system takes place through the interaction physical-chemical and antimicrobial factors of the adjutant irrigation solution with the mechanical factors involved in the use of instruments.[4,5] Canalda and Rodriguez Ponce mention that irrigation during canal treatment pursues the following basic objectives:

- Drag the canal contents.
- Dissolve necrotic or vital pulp remnants.
- Cleanse canal walls to remove residues that cover them and block entrance of dentinal tubules and accessory canals.
- Destroy bacteria and neutralize antigenic products and components.
- Lubricate instruments to ease passage and cutting capacity.
- Prevent the darkening of the crown.[6,7]

To achieve all the aforementioned goals, the used irrigator agent must have the following characeristics:

a) be a solvent of tissue or organic residues
b) have low toxicity
c) have low superficial tension
d) be lubricant
e) be able to at least perform disinfection
f) be able to remove dentinal debris.

Other factors related to the utility of the irrigator agent include:

a) availability
b) moderate cost
c) convenience
d) adequate shelf life
e) simple storage

An additional requisite is that the chemical agent must not be easily neutralized in the canal so as to preserve its effectiveness.[8] Nevertheless, there is no ideal irrigating solution, therefore, two or more must be combined to obtain the properties and goals we have mentioned.[9]

Etilendiaminotretraacetic acid (EDTA) was the first chelating agent described by Östby in 1957 for use in Endodontics. This acid is a specific chelating agent for the calcium ion, and therefore for the dentin. Dentin is a molecular complex which counts with calcium ions in its composition. The chelating agent is applied over dentin, this will facilitate dentin disintegration for the EDTA.[10,11] Based on histological and clinical research Östby concluded that EDTA facilitated the broadening of the canal. He used a microscope to demonstrate changes caused by the acid in the root dentin.[12] One fact to consider is that EDTA is an aggregate in the biomechanical preparation of the root canal, and provides the following benefits:

1) Helps to clean and disinfect the wall of the root dentin, since it eliminates dentinal debris which is a result of the forming of the canal during the process of instrument usage.
2) Facilitates the action of the medication used inside the canal since it increases dentinal tubules diameter as well as dentin permeability.
3) Conditions the root canal dentin wall to provide an increased degree of adhesion of the obturation material.[13,14]

Therefore, it has been suggested that chelating agents improve mechanical debridement in the root canal treatment through removal of dentinal debris as well as demineralizing and softening the dentin. Effectiveness of these agents depends on the length of the canal, the depth of penetration of the material, application time, hardness of dentin, pH and concentration of the material to obtain maximum effect.[15]

Dogan and Yamada state that it is necessary to use chelating agents during and after the use of instruments, to this must follow the use of some tissue solvent. Therefore, in our days, it is widely accepted that the most effective method to remove organic and inorganic components from the dentinal debris is to irrigate the canal with EDTA followed by NaClO. The aim of this procedure is to obtain free and permeable dentinal tubules and accessory canals which will allow for a better adhesion and adaptation of filling materials into the dentinal walls, and this in turn will propitiate emetic seal, to finally achieve success in canal treatment.[16,17]



Goldber & al. informed that EDTA optimum working time is 15 minutes. They state that use of the chelating agent for longer periods of time does not increase its effect, and therefore recommend EDTA renewal every 15 minutes. They concluded that the strongest effect was observed at 15 minutes, and found no observable variation after 30 minutes.[18] Östby showed that a 15% EDTA solution with a pH of 7.3 demineralized a limited (circumscribed) zone of root dentin, no deleterious effects were observed on the pulp stump or on the periapical tissue.[19]

Optimum pH for dentin demineralization is between 5 and 6. Nevertheless EDTA commercial preparations usually have a pH of 7.3.[20] Serper conducted a research on EDTA demineralizing effect at different concentrations and pH. His study showed that the chelating action (activity) is most effective at a neutral 7.5 pH than at a 9 pH.[21] When EDTA is used in excess, 73% of the human dentin powder inorganic component can be chelated after a one hour exposition. This suggests it must not be used inside the canal for a prolonged period of time.[22] EDTA used for one minute inside the root canal is effective to remove dentinal debris.[23]Nevertheless, a 10 minute application will erode dentin around and inside the canals. This erosion is due to an excessive opening of the tubules, and a broadening of the tubule diameter. For the aforementioned reasons, use of EDTA for periods longer that 1 minute is not recommended.[24]

EDTA will effectively remove dentinal debris in 1 minute, as long as the liquid properly reaches the surface of dentinal walls. After one minute of exposition on the dentin, it begins to affect dentinal structure.[25] Final irrigation with 17% EDTA followed by 5,25% NaClO results in a synergistic mix (compound) that decreases superficial tension, allowing easier NaClO diffusion to obtain effective chelating action on the dentine tubule hydroxyapatite.[26] Moreover, increases in temperature markedly augment demineralization speed.[27]

When dealing with dentin softening, Fraser showed that EDTA based chelating agents soften root dentin of the canal middle and coronary third, but not in the apical third, that is, softening takes place in wider sections of the canal, not in the narrow ones. Based on these facts, he arrived at the conclusion, that, against common belief, EDTA based chelating agents do not soften dentin in the apical third of the canal. So, if used as adjutant for the use of instruments in the root canal, chelating agents do not directly contribute to the enlargement of the apical portion of the root canal; the softening of the middle and coronal third gives the operator more space to efficiently use instruments in the non chelated portion.[28] Saquy et al conducted a study where EDTA chelating action was assessed when associated to Dakin solution. They concluded that EDTA by itself or combined with Dakin solution decalcifies dentin and decreases its microscopic hardness.[29]

EDTA activity is not only selective for dentinal debris, the demineralizing effect also acts upon the walls of the root canal, and leave a soft and permeable under-mineralized surface. Moreover, collagen fibers result denaturalized, and therefore consequences of this effect in the filling material adaptation can be questioned. On the contrary, it can affect the sealing quality of the filling material.[30]

The aim of this study was to determine the degree of erosion exerted by EDTA on the root canal dentin.

## MATERIALS AND METHODS

The present is a quasi-experimental designed study. Eighty recently extracted teeth were gathered and stored at room temperature in 4% saline solution. With a diamond disk, the clinical crown was removed and canal permeability was assessed by passing through the apex a number K·10 file. With the use of a Flex-R 15 file, work length was radiographically determined to 1mm short of the radiographic apex. Use of instruments was performed following the coronary apical balanced forces with first and second series Flex-R hand instruments. Irrigation with 5.25% sodium hypochlorite was conducted between usage of one instrument and the next. The process was continued until a real working length was obtained with instrument 45. Final irrigation consisted in 3 mL of 17% EDTA for one minute, followed by 5 mL of 5.25% NaClO and 5 mL of distilled water. The canal was then dried with number 45 paper points. The root was longitudinally cut with a diamond disk, and teeth were prepared to be examined in the Scanning Eletron Microscope at the Center of Applied Physics and Advanced Technology (Centro de Física Aplicada y Tecnología Avanzada CFATA) at the Juriquilla Campus. Preparation process consisted on the placement of a silver based conductive coating (varnish) on the root cement area, and fixation in a copper slide with the help of a conductive adhesive to keep the sample in place. All samples were placed in a Metal Sputter Coater Evaporator EMS 550, during two 5 minute cycles, and then they were coated with gold in plasma. Samples were examined in the Scanning Electron Microscope JSM-6060LV. The degree of erosion in the root`s apical and middle third was assessed according to the following parameters:



1 = No erosion. Tubules size and appearance look normal.
2 = Moderate erosion. Dentin around the tubule was eroded.
3 = Severe erosion. Dentin inside the tubule was destroyed, and tubules are connected among themselves.

Data were analyzed with statistics program SPSS v15 to assess proportions.

## RESULTS

When using 17% EDTA on root dentin of the middle third, results showed that, of the total 40 samples, 10 (25%) did not show erosion, 10 samples (25%) showed moderate erosion, and 20 samples (50) showed severe erosion. *(Table I).* A 1:3 relationship is observed in the degree of erosion on the root dentin of the middle third. This is to say, that, for each sample that does not show any type or erosion, there are three samples showing erosion. Microphotographs in *figure 1* show normal looking dentine tubules, and, the dentin surface with severe erosion both on the middle third.

When using 17% EDTA on the root dentin of the apical third, it was observed that, out of the 40 samples treated with 17% EDTA, 17 (42.5%) did not show any kind of erosion; 11 (27.5%) showed moderate erosion and 12 (30%) presented severe erosion (*Table II*) A 1:1.3 relation is shown in the degree of erosion on the root dentin of the apical third. The microphotograph shows dentin with moderate erosion and severe erosion in the apical third (*Figure 2*).

Out of the 40 samples treated with 17%, 75% presented some sort of erosion in the middle third and 57.5% showed erosion in the apical third (*Table III*).

## DISCUSSION

As previously mentioned, Östby showed that, when placed in the root canal, a 15% EDTA solution with 7.3 pH demineralized a distinctive limited area of root dentin.[31] This EDTA demineralizing effect depends on concentration and exposure time.[32] Calt & al in their study on EDTA effected at different exposure times, concluded that EDTA used for 1 minute inside the root canal is effective to remove dentinal debris. Nevertheless, EDTA exposure for 10 minutes causes excessive erosion of dentin around and inside the tubule. This excessive erosion results in a great widening of the tubule diameter, therefore, it is suggested not to use if for periods longer than one minute.[33] Serper reports that after 1 a minute exposition on dentin, EDTA begins to affect dentinal structure.[34] EDTA at 15 to 75% during one minute is sufficient to effectively remove dentin debris without causing erosion in dentin

**Table I.** Presence of erosion degree caused by EDTA on the root canal dentin of the middle third.

| Erosion degree | n | % |
|---|---|---|
| No erosion | 10 | 25 |
| Moderate | 10 | 25 |
| Severe | 20 | 50 |
| Total | 40 | 100 |

Source: Data collection sheet.

**Table II.** Presence of erosion degree caused by EDTA on root canal dentin of the apical third.

| Erosion degree | n | % |
|---|---|---|
| No erosion | 17 | 42.5 |
| Moderate | 11 | 27.5 |
| Severe | 12 | 30.0 |
| Total | 40 | 100.0 |

Source: Data collection sheet.

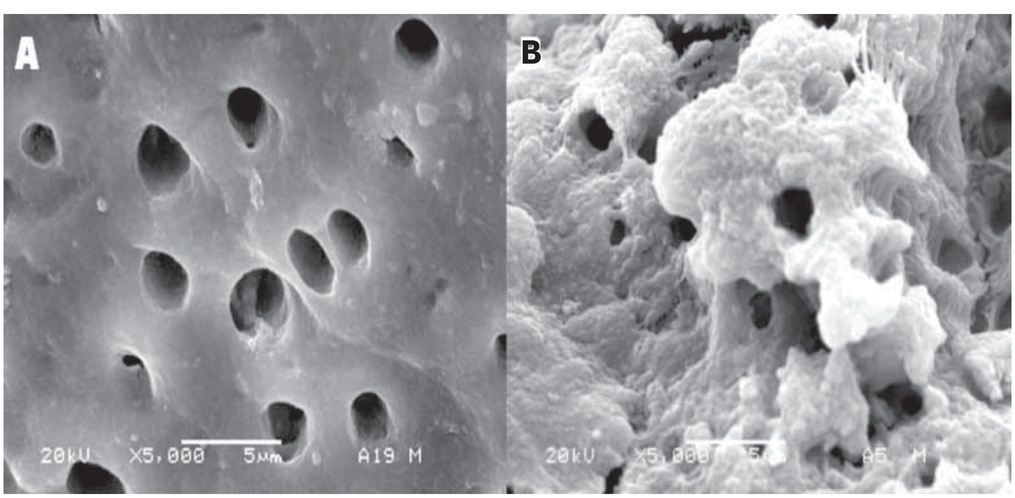


**Figure 1.** Microscopic photographs of middle third show: **(A)** Normal looking dentin in tubules, surface apparently free of erosion. **(B)** The canal wall has sustained alterations; severe erosion and severe dentin destruction are observed (5,000X).

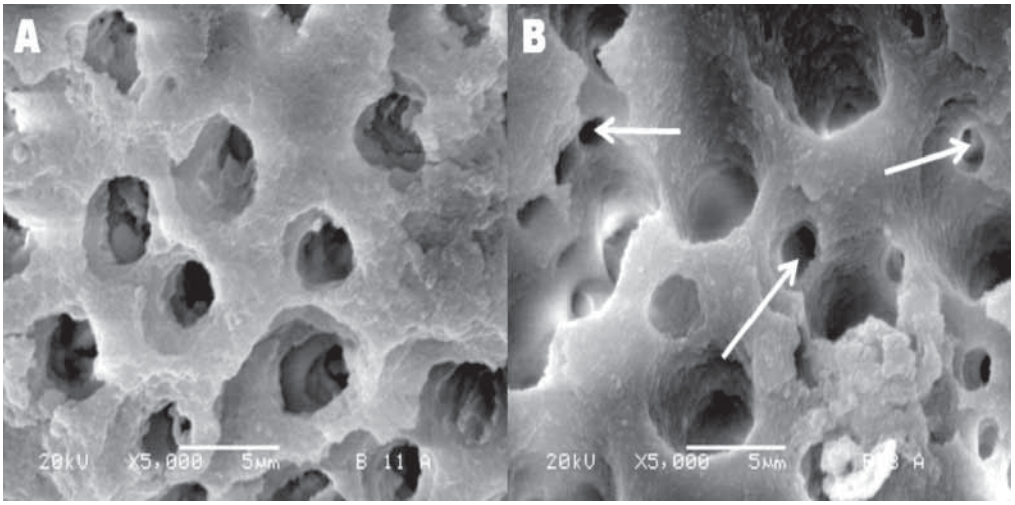


**Figure 2.** Microscopic Photographs of apical third: **(A)** Moderately eroded dentin, there is damage on the dentin surrounding the tubule, as well as enlargement and irregularities at the tubule entrance. **(B)** Severely eroded dentin. There is destruction surrounding and inside the tubules. Communication among dentinal tubules allows to observe dentinal canaliculi (arrows) (5,000X).

**Table III.** Presence of severe erosion degree caused by EDTA on the root canal dentin of both thirds.

| | n | % |
|---|---|---|
| **Middle third** | | |
| No erosion | 30 | 75 |
| Erosion | 10 | 25 |
| **Apical third** | | |
| No erosion | 22.8 | 57 |
| Erosion | 17.2 | 43 |

Source: Data collection sheet.

surface.[35] We do not agree with these authors since, when using 17% EDTA for one minute, we observed a 75% erosion of the middle third dentin.

Fraser mentions that EDTA based chelating agents soften root dentin but only at the middle and coronary thirds of the canal, not at the apical third.[36] We do not agree with Fraser, since, in our 40 samples, a 57.5% apical third erosion could be observed. This demonstrates the presence of erosion in this particular third.

Goldberg explains that EDTA action is not selective for dentin debris. This demineralizing effect also acts upon the root canal walls, leaving them almost devoid of mineralized surface which is soft and permeable. On the contrary it can affect the sealing ability of the filling material.[37] EDTA, as final irrigation, creates a 4 to 6μ demineralized surface, in the middle and apical third area of the root walls.[38] We do agree with Tay, since we observed in microphotographs a severe degree of erosion in the middle and apical third of the root canal.

## CONCLUSIONS

EDTA is an excellent contribution to endodontic practice. Since it removes effectively dentinal debris, it eases and benefits treatment of canals with the improvement of sealing of the filling material.

EDTA not only removes dentin debris, it also begins the erosion of dentin surfaces through the process of demineralization and excessive opening of the tubules. In this manner, fitting of the filling material to canal walls becomes difficult and decreases sealing, favors bacterial filtration and histic fluid filtration, which ultimately leads to the failure of the root canal treatment.

We conclude that use of 17% EDTA elicits the alteration of the root canal walls morphology. Even when exposure time was restricted to one minute, the degree of erosion present in the middle third was 75% of all sample, and 57.5 % in the apical third of samples.

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