



Calcium hydroxide influence and intrachannel medication in apical leakage

Influencia del hidróxido de calcio como medicación intraconducto en la microfiltración apical

Jeanette Sanchez Ortega,* Jorge Guerrero,§ Harolodo Elorza,|| Raul Luis Garcia Aranda†

ABSTRACT

The purpose of this study was to determine the amount of remaining $\text{Ca}(\text{OH})_2$ after three removal techniques as well as determining its influence on apical seal. Eighty extracted mandibular premolars were prepared with ProTaper system®, dressed with $\text{Ca}(\text{OH})_2$ paste and stored 10% humidity at 37 °C for 7 days. Experimental groups according to the removal technique were: NaClO 2.5% + EDTA (G1), NaClO 2.5% + EDTA 18% and ultrasonic activation (G2); NaClO and ultrasonic activation (G3). Forty teeth were longitudinally split in order to measure remaining $\text{Ca}(\text{OH})_2$. The other 40 specimens were obturated with ultrasonic condensation of gutta-percha technique. These teeth were cleared and apical leakage was measured. Statistical analysis showed difference among groups with respect to $\text{Ca}(\text{OH})_2$ removal ($P < 0.03$), Group G2 showed least amount of remaining $\text{Ca}(\text{OH})_2$. Likewise, leakage results showed statistical difference among groups ($P < 0.01$). Group 2 showed best results with respect to leakage. There was no statistical difference between groups 1 and 3. Conclusion: Irrigation with NaClO 2.5% EDTA 18% and ultrasonic activation proved to be most effective in removing $\text{Ca}(\text{OH})_2$ from canal walls. Calcium hydroxide medication residuals inside canals might increase apical leakage.

RESUMEN

El objetivo de este estudio fue determinar la cantidad de $\text{Ca}(\text{OH})_2$ remanente en el conducto radicular después de aplicar 3 técnicas para su eliminación, así como determinar su relación con la microfiltración apical. Se aplicó $\text{Ca}(\text{OH})_2$ en 80 conductos preparados y se almacenaron a 37 °C y 100% de humedad por 7 días. Fueron divididos en 3 grupos según la técnica de remoción: NaClO 2.5% + EDTA 18% (G1); NaClO 2.5% + EDTA 18% y energización ultrasónica (G2); NaClO y energización ultrasónica (G3). Cuarenta especímenes fueron divididos longitudinalmente para la medición de $\text{Ca}(\text{OH})_2$ remanente. Los 40 especímenes restantes fueron obturados con compactación lateral modificada por ultrasonido y se realizó la prueba de microfiltración y posterior diafanización para su evaluación. El análisis estadístico mostró diferencia significativa ($P < 0.03$) entre los grupos en cuanto a remoción de $\text{Ca}(\text{OH})_2$, el grupo 2 fue el que mostró menos $\text{Ca}(\text{OH})_2$ remanente. En cuanto a microfiltración apical hubo diferencia estadísticamente significativa entre los grupos ($P < 0.01$), el grupo 2 fue el que presentó menor microfiltración apical. No hubo diferencia significativa entre los grupos 1 y 3. **Conclusión:** La irrigación con NaClO 2.5%, EDTA 18% y energización ultrasónica fue la más efectiva en remover $\text{Ca}(\text{OH})_2$ del conducto. La microfiltración apical es mayor en los conductos que presentan mayor porcentaje de $\text{Ca}(\text{OH})_2$.

Key words: Apical leakage, calcium hydroxide, intracanal medication, ultrasonic activation, sodium hypochloride, EDTA.

Palabras clave: Microfiltración apical, hidróxido de calcio, medicación intraconducto, irrigación ultrasónica, hipoclorito de sodio, EDTA.

INTRODUCTION

In present endodontic therapy, calcium hydroxide ($\text{Ca}(\text{OH})_2$) is the most common internal canal medication. Its use as antibacterial and hard tissue stimulator justifies its being internally placed in the canals.¹

It has been reported that, after use of some medications inside the canals, it is possible to observe their remains in 45% of canal walls, even after attempts are made to remove them.^{2,3}

Before filling the root canal, the medication inside the canal must be removed with the aim of preparing dentine surface and propitiate optimal chemical and physi-

* Graduate, Endodontics specialty, National School of Dentistry, National University of Mexico.

** Graduate School Professor, Dental Materials Laboratory, National School of Dentistry, National University of Mexico.

*** Graduate School Professor. Statistics. National School of Dentistry, National University of Mexico.

**** Graduate School Professor, Endodontics, National School of Dentistry, National University of Mexico.

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cal circumstances to achieve tridimensional seal, capable of avoiding filtration of bacteria and their toxins.³

Ca(OH)_2 removal from the canal walls can imply a greater challenge today, since more efficient methods for placing it have been developed. These methods aim at having the paste making contact all along the dentin wall. Among them, we find application of Ca(OH)_2 paste application with a lentulo, McSpadden compacters, placement with files and paper points, and placement with a syringe.⁴ In scientific literature there are many studies (Sigurdsson et al 1992, Cruz and Holland 2001) which grant the lentulo a better distribution of the Ca(OH)_2 paste inside the canal.^{5,6}

The most described method for the removal of Ca(OH)_2 used in preparation of root canals is use of instruments with the last file in combination with abundant irrigation with sodium hypochloride (NaClO) and EDTA.³ Nevertheless, it has been reported that irrigation and use of instruments by themselves do not completely cleanse the canals.⁷ Some irrigation protocols have incorporated passive ultrasonic irrigation component (PUI) with the purpose of removing dentin detritus. Ultrasonic irrigation is based on energy transmission from an oscillating instrument to the irrigating solution.⁸ Keene et al, 2006, have implemented an assessment of its effect with the purpose of increasing removal of Ca(OH)_2 . They report better results when compared to techniques where no ultrasound was applied.⁹

Ca(OH)_2 remnants inside root canals can result in a thick, non homogeneous coating of sealing cement¹⁰ and could propitiate a chemical reaction with the canal sealer based on Zinc oxide and eugenol. This can result in a reduction of work time due to the formation of calcium eugenolate.¹¹

Margelos & Eliades, 1997, Cai & Serper 1999, and Kim & Kim, 2002, demonstrated that the presence of calcium hydroxide on the canal walls can affect penetration of sealants in the dentine tubules.¹⁰⁻¹²

The objectives of this study were to determine the amount of Ca(OH)_2 after applying several irrigation techniques for their removal, as well as to determine the possible correlation of remaining Ca(OH)_2 with apical leakage.

MATERIALS AND METHODS

Eighty single rooted lower human premolars were gathered and de-crowned with a diamond disk.

Two 1 mm deep grooves were performed with a fissure bur mesially and distally all along the root, to at a later point divide 40 specimens (those used for the Ca(OH)_2 removal tests).

The 80 specimens were prepared with universal ProTaper system (Dentsply, Tulsa Dental Specialties, Oklahoma USA[®]) according to manufacturer's specifications,¹³ up to file F4. Working length was determined to 1 mm from the canal apical foramen.

Irrigation protocol was carried out with 2.5% NaClO and 80% EDTA (Ultradent[®]) during 3 minutes. Canals were dried with paper points.

CALCIUM HYDROXIDE PLACEMENT

The Ca(OH)_2 mix was made with powder and bi-distilled water to obtain a creamy consistency, this medication was placed with a number 35 lentulo (Dentsply Maillefer, Ballaigues, Switzerland[®]). Access cavity was filled with Provisit[®] calcium phosphate based temporary obturation. All teeth were stored at 37 °C and 100% humidity during 7 days in an temperator oven (Felisa[®] Felisa oven, Guadalajara Mexico).

The sample was randomly divided in the following fashion: 3 experimental groups composed of 24 teeth and two control groups of four teeth each (positive and negative control). Each group received a different irrigation technique for removal of calcium hydroxide.

Group 1: 5 mL 2.5% NaClO, EDTA 10% during 5 minutes, 5 mL NaClO 2.5%.

Group 2: 5 mL NaClO 2.5% and passive ultrasonic irrigation (PUI) at 1 mm of working length during 60 seconds (E5 point (NSK[®]), EDTA 18% during 5 minutes and 5 ml of 2.5% NaClO with PUI for 60 seconds.

Group 3: 5 mL of 2.5% NaClO and PUI for 60 seconds.

Positive control: No removal technique was applied.

Negative control: No calcium hydroxide was placed.

The following tests were then applied:

TEST 1. CALCIUM HYDROXIDE REMOVAL

This test was carried out on half the experimental specimens ($n = 36$) and two control groups ($n = 4$). With the aid of a manual tube cutter, roots were divided according to the orientation of the clefts, two fragments were thus obtained (lingual and vestibular) with Lomo[®] stereoscopic microscope, digital pictures were taken at 20x, and with AutoCard 2009 (Autodesk[®]) program the area occupied by the Ca(OH)_2 remnant in each third was measured.

TEST 2: APICAL LEAKAGE

This test was carried out with the other half of the experimental specimens ($n = 36$) and two control groups ($n = 4$). So as to differentiate them from the

Table I. Ca(OH)₂ percentage in each third of the root canal walls.

Third Group	Cervical third		Middle third		Apical third	
	Mean	SD	Mean	SD	Mean	SD
Group 1	31.04%	24.0359	22.14%	20.64	14.58%	16.2
Group 2	5.87%	7.7438	0.16%	0.21	2.03%	3.62
Group 3	29.84%	23.2538	10.19%	10.13	19.74%	21.43
Fisher s test*	$F = 7.65, P = 0.002$		$F = 7.08, P = 0.003,$		$F = 3.34, P = 0.001$	
Kruskal Wallis*	$H = 15.34, P = 0.001$		$H = 20.77, P = 0.003,$		$H = 15.87, P = 0.001$	
Post-hoc Turkey*	$G1, G3 \neq G2 P < 0.005^*$		$G1 \neq G2 P < 0.002^*$		$G2 \neq G3 P < 0.005^*$	

* There are statistically significant differences among groups ($P \leq 0.03$). Group 2 showed lesser percentage of dentinal wall with Ca(OH)₂ in all thirds. Groups 1 and 3 did not show statistically significant difference between them ($P \leq 0.99$).

Table II. Linear apical leakage.

Group	Leakage in mm	
	Mean	SD
Group A	4.78 mm	5.0238
Group B	0.39 mm	0.4030
Group C	4.87 mm	4.2553
Fishers test*	$F = 11.77, P = 0.001$	
Kruskall Wallis*	$H = 20.958, P = 0.001$	
Post-hoc Turkey*	$GB \neq GA, GC P < 0.005^*$	

* There is statistically significant difference between group B and groups A and C ($P < 0.005$) Nevertheless, no statistically significant difference was found between groups A and C ($P \geq 0.7$).

previous experiment, groups were named as follows: Group A, Group B and Group C. Each one corresponds to the aforementioned irrigation technique for groups 1, 2, and 3 respectively. After Ca(OH)₂ removal from the canals, they were dried with paper points and obturated with gutta-percha non standardized Hygienic® cones and Roth 801 cement (Roth Root®, Roth Drug Company, Chicago, III. USA) with lateral compaction technique modified by ultrasound (ultrasonic obturation point E5 NSK®)

Coronary access was sealed with glass ionomer (Ketac Molar 3M ESPE®). The leakage test was carried out in the following fashion: Groups A, B, and C, as well as positive control groups had their root surface covered with paraffin wax, excepting the last three millimeters around the apex.

Negative control group specimens were totally covered with paraffin wax.

All samples were placed in black India ink (Pelikan® Pelikan Ink, Puebla, Mexico) on a grid, inside a 10 pound pressure per square inch (psi) vacuum bell. They were stored in that place for 72 hours at 37 °C.

Later the roots were cleared with the Robertson & Leeb technique and examined with Lomo® stereoscopic microscope at 20x. Digital images were captured to be later measured with Transformer software (FO, UNAM, MX).

The surface showing higher microfiltration values in millimeters was recorded.

STATISTICAL ANALYSIS

Fisher parametric variance analysis was applied as well as the non parametric Kruskal-Wallis and Turkeys Post-hoc test in both experiments.

RESULTS

Ca(OH)₂ mean removal results are shown in *Table I*. Apical leakage results are shown in *Table II*.

There is a statistically significant difference among the three groups with respect to the presence of Ca(OH)₂ remnants in each third ($P < 0.03$) Group 2 shows a significant lesser amount of Ca(OH)₂ remnants in all thirds ($P \leq 0.05$). In the cervical third of this group a 5.87% mean of wall with remnants was observed, 0.16% in the middle third and 2.03 in the apical third (*Figures 1 and 2*). There was no statistically significant difference among thirds between groups 1 and 3 ($P \geq 0.7$).

Statistical analysis of apical leakage test (*Table II*, *Figures 3 and 4*) shows there is a statistically significant difference among groups. Group B shows lower mean microfiltration (0.39 mm) when compared to Group A (4.78 mm) and Group C (4.78 mm). In turn, groups A and C did not show significant difference between them ($P \leq 0.5$).

Figures 3 and 5 show that specimens of each group behave in a similar way in both experiments (Ca(OH)₂,

removal and apical leakage). The greater the amount of the $\text{Ca}(\text{OH})_2$ remnants on the canal walls, greater is lineal apical leakage.

DISCUSSION

The complete removal of $\text{Ca}(\text{OH})_2$ paste from the root canal system represents a challenge. It is necessary to determine whether the $\text{Ca}(\text{OH})_2$ remains have a positive or negative effect on the final obturation. Experimental studies carried out last decade, informed that apical leakage was lesser in groups where $\text{Ca}(\text{OH})_2$ had been applied in aqueous solution when compared to groups where no medication was applied.^{15,16} Holland et al (1995) explained that this leakage decrease was due to the fact that remnant $\text{Ca}(\text{OH})_2$ was incorporated to the sealing cement during obturation, which caused a decrease in cement permeability, or that $\text{Ca}(\text{OH})_2$ was mechanically forced into dentine tubules, blocking them, and thus causing this permeability decrease.¹⁶ It was also suggested that this better sealing was due to the formation of a $\text{Ca}(\text{OH})_2$ plug, which would operate as a matrix against which obturation material could be better condensed.

Nevertheless, in the present study, opposite results have been observed. Teeth with greater $\text{Ca}(\text{OH})_2$ remains showed higher leakage. This can be due to the

fact that $\text{Ca}(\text{OH})_2$ presence could interfere in the adaptation of the dentinal walls.

In the previously mentioned studies, the staining used for leakage tests was methylene blue. It has been reported that $\text{Ca}(\text{OH})_2$ has a bleaching effect on methylene blue staining.¹⁷ Wu et al also studied this effect on six obturation materials, using 1% methylene blue; and found that bleaching effect reached a mean of 74%.⁷ This can be related to the high alkalinity presented by $\text{Ca}(\text{OH})_2$, and having this effect, modifies microfiltration results.

In the present study, India ink was used for leakage tests. The particles of this tincture are of a much larger size than methylene blue particles, but even so, are sufficiently small as to be able to penetrate into the obturation internal phase and dentinal walls in way comparable to that of bacteria found inside the channels.¹⁸

Recent research papers show results commensurate to those obtained in the present study. Goldberg et al (2002)¹⁹ assessed the influence that $\text{Ca}(\text{OH})_2$ medication between appointments could have in the obturation of accessory and lateral canals. The 20 teeth were worked with instruments and then simulated lateral canals were created. One group received $\text{Ca}(\text{OH})_2$ for seven days, while the other did not receive any medication inside the

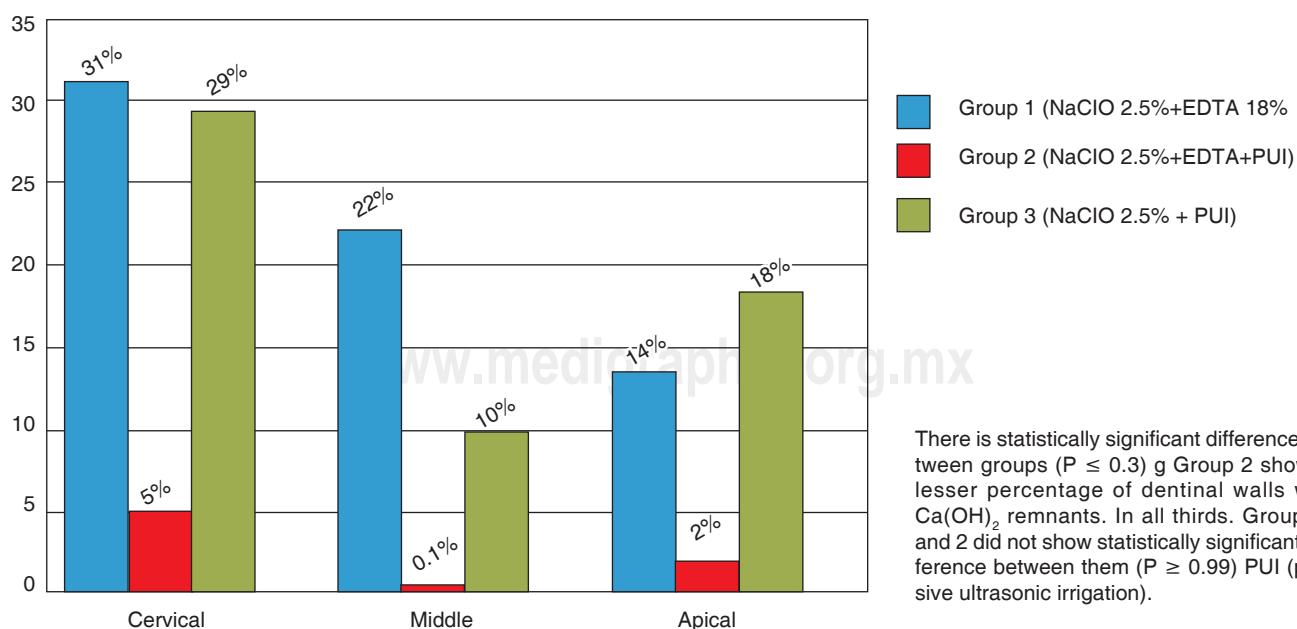


Figure 1. Percentage of $\text{Ca}(\text{OH})_2$ remnants on the root canal walls after applying three removal techniques (by thirds).

There is statistically significant difference between groups ($P \leq 0.3$) g Group 2 showed lesser percentage of dentinal walls with $\text{Ca}(\text{OH})_2$ remnants. In all thirds. Groups 1 and 2 did not show statistically significant difference between them ($P \geq 0.99$) PUI (passive ultrasonic irrigation).

channel. Both groups were obturated with Ultrafil®. The group where no calcium hydroxide was applied significantly showed greater number of obturated lateral canals.¹⁹

Kim (2002)¹⁰ obtained similar results. With the use of stereomicroscopy, he observed that teeth which had not been medicated with Ca(OH)_2 showed better sealing after performing leakage tests with India ink. The method to remove medication was to use a file larger than the one just used in the preparation, and irrigation with 2.5% sodium hypochlorite and 17% EDTA. Filling of canals was carried out with conventional lateral condensation technique with gutta-percha and zinc oxide and eugenol sealer.¹⁰

Association of NaClO and 17% EDTA for 3 minutes has proven to be effective to eliminate dentinal debris. Nevertheless, in this study EDTA importance does not only reside in its capacity to chelate calcium ions from the dentinal walls, it exerts the same effect on the Ca(OH)_2 molecule facilitating the detachment and eviction of the material which is carried out with the activity of the ultrasonic energization. EDTA has also the capacity to neutralize Ca(OH)_2 residues, which could prevent chemical reaction with the sealer cement.²⁰

In this study it was observed that when EDTA was used in conjunction with 2.5% NaClO and ultrasonic irrigation, there was an increase in the level of Ca(OH)_2 removal in all three thirds. The walls of the canals were found to be almost free of Ca(OH)_2 remnants (2% in the apical third). These results are comparable to those of a recent study wherein ultrasonic irrigation combined with 17% EDTA allowed the removal of Ca(OH)_2 in almost a 98%.²¹ On the other hand, in the

present study, when these three elements were not used in conjunction, the level of removed decreased, leaving in some specimens up to 80% dentinal walls covered with Ca(OH)_2 .

It has been demonstrated that traditional methods (hand instruments and irrigation with NaClO and EDTA) are not efficient to remove all the material adhered to canal walls, leaving up to 45% of the surface covered with remnants.²² Salgado et al (2009)²² obtained similar results in a study carried out with scanning electronic microscopy. In this study, the worst result was obtained when Ca(OH)_2 was removed with NaClO irrigation only. The best cleansing was attained in groups where recapitulation with master file and irrigation with 0.5% NaClO, 17% EDTA and Endo PTC® were used.

The use of ultrasound in combination with final irrigation protocol has been implemented from a few years back with the objective of removing dentin detritus resulting from the mechanical preparation of the canals. Kenee⁹ & AL, 2006, assessed the amount of Ca(OH)_2 present in canals after removal following several techniques. Among these were included combinations of NaClO and EDTA, rotary instruments, or ultrasound. It was found that none of the aforementioned techniques completely removed the material. Nevertheless, removal with rotary instruments and ultrasound irrigation significantly removed greater amounts of calcium hydroxide when compared to other techniques.⁹

A study by Van der Sluis & Versluis (2007)⁸ showed that the most effective Ca(OH)_2 removal method was the use of ultrasonic irrigation and NaClO. In that study a 63% average removal was achieved. This situ-

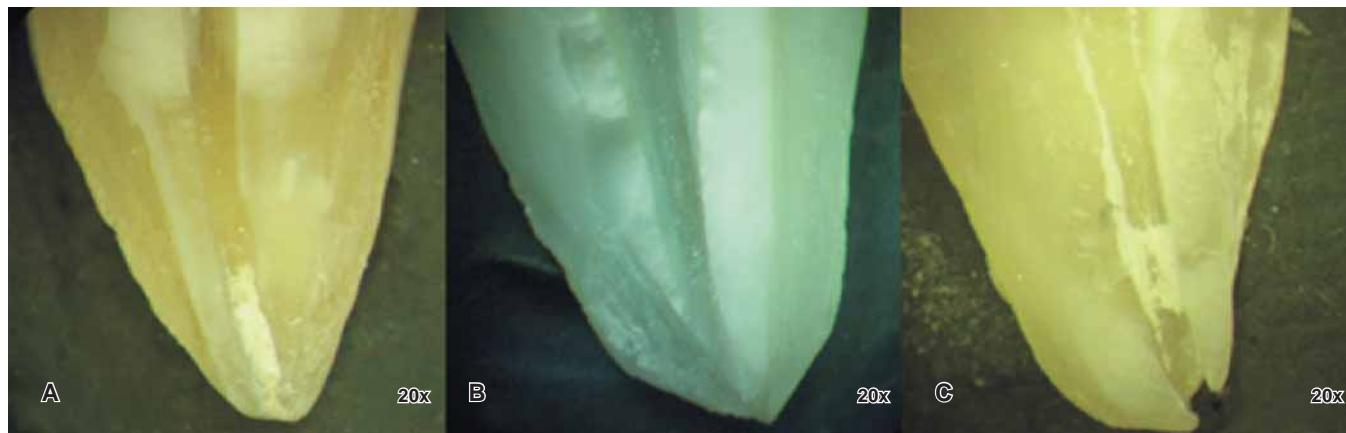


Figure 2. Apical third images after removal of calcium hydroxide. (stereomicroscopy). **A)** Group 1 specimen, **B)** Group 2 specimen, **C)** Group 3 specimen. Note material remnants (residues) of A and B specimens.

ation is similar to that presented in experimental group 3 in our study, where the same irrigation was used and apical level removal results were 80%. Nevertheless, this percentage can be raised if EDTA use is incorporated to the irrigation protocol, as can be observed in results of group 2 in our study (*Figure 1*).

During this study's experimental leakage process, it was decided to submit all specimens to a 10 psi pressure, to simulate intra osseous conditions, this would promote an active entry of the India ink towards the internal phase found between filling material and dentinal walls.

Results obtained in this study show that, the greater the amount of remnant $\text{Ca}(\text{OH})_2$ in the canal, greater will be apical leakage (*Figures 3 and 5*). This suggests that, even though this medication possesses beneficial antibacterial effects, if not removed, its presence can influence the sealing. This can be due to the ability $\text{Ca}(\text{OH})_2$ to dissociate in the presence of water in Hydroxyl ions and calcium ions.²³

The intense leakage observed in groups with larger amounts of $\text{Ca}(\text{OH})_2$ remnants can be due to the fact that these remnants (calcium carbonate particles) can avoid the penetration of the sealing cement in the dentinal tubules, consequently impairing their sealing capacity and resulting thus in a potential decrease of the filling material itself.¹²

Some studies have observed fissures in the zinc oxide and eugenol cement coating when this compound is placed in the presence of retained $\text{Ca}(\text{OH})_2$. It has been associated with the formation of calcium eugenolate which increases the hardening speed of the sealing cement.¹⁰ In spite of all this, in the present study a eugenol and zinc oxide cement was used

(Roth 801) since it is the most commonly used in endodontics practice.

Future studies could be geared towards the determination of whether apical sealing is affected when using sealing cement of different nature (resinous or $\text{Ca}(\text{OH})_2$) in the presence of remnants of intrachannel medication.

CONCLUSION

Apical leakage is larger in canals which present greater remnants of calcium hydroxide.

The most efficient method to remove $\text{Ca}(\text{OH})_2$ paste from the canal walls is the use of a protocol of final irrigation combining sodium hypochlorite as irrigating solution, EDTA as chelating agent, and ultrasonic energization. This favorably influences apical seal since it propitiates favorable conditions to achieve adaptation of filling materials to the root canal system.

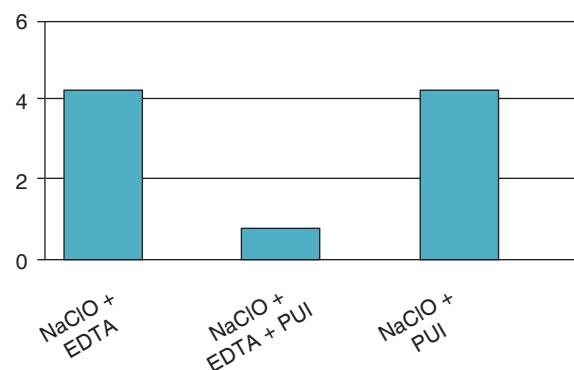


Figure 3. Apical Linear microfiltration.

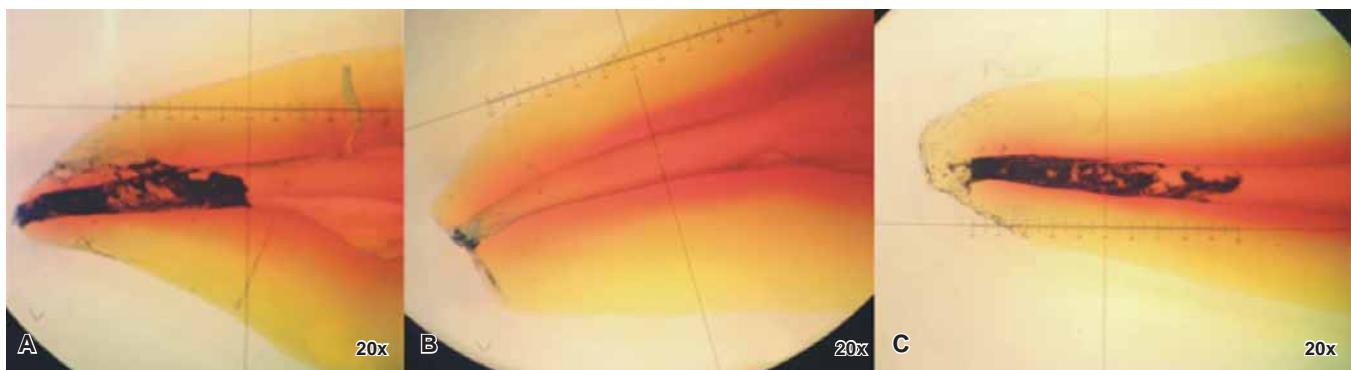
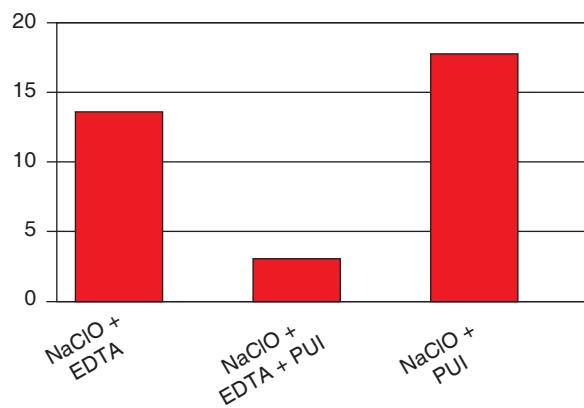


Figure 4. Images of apical microfiltration (stereomicroscopy). A) Group A specimen where 2.5% NaClO and EDTA were applied as final irrigation. A non filled canal is observed as well as apical filtration. B) Group 2 specimen where EDTA, NaClO and PUI were applied. A filled lateral canal is observed with very little microfiltration. C) Group 3 specimen. 2.5% NaClO and PUI were applied. Similar characteristics to those of Group A specimens are observed.



In figures 3 and 5 it can be observed that specimens belonging to any of the three groups behave similarly in both experiments (calcium hydroxide removal and apical microfiltration). The greater the calcium hydroxide remnant is more linear apical microfiltration can be found.
PUI (passive ultrasonic irrigation).

Figure 5. Ca(OH)₂ remnant at apical level.

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Mailing Address:
Jeanette Sanchez Ortega
 Filosofía y Letras 80,
 Copilco Universidad.
 Del. Coyoacán,
 México D.F.
 Phone number: 5538473834
 E-mail: janettsanchez@hotmail.com
 rlgia@servidor.unam.mx