



ORIGINAL ARTICLE

René Carrasco¹.
Ricardo Román¹.
Makarena Ojeda².
Carolina Vergara³.

1. Escuela de Odontología, Facultad de Medicina, Universidad Austral de Chile.

2. CESFAM Los Volcanes, Llanquihue. Chile.

3. Instituto de Salud Pública de la Facultad de Medicina, Universidad Austral de Chile, Valdivia. Chile.

Corresponding author: Ricardo Román. Rudloff # 1640, Valdivia. Chile. Phone:(63)2293751. E-mail: ricardoromanpro@hotmail.com

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Sonic *versus* ultrasonic activation for the cleaning of the root canal after post space preparation: an *in vitro* study.

Abstract: Objective: To compare the efficacy of 3 intracanal cleaning protocols used before cementation of prosthetic posts. Material and Methods: 40 anterior teeth received endodontic treatment in hand, using lateral condensation technique. After two weeks, gutta-percha was appropriately removed from the teeth to get the necessary space to install a post. Then, teeth were randomly divided into groups; root surface was treated with chlorhexidine (CHX) activated by ultrasound (US) (group I), with chlorhexidine activated by sonic instrumentation (S) (group II), chlorhexidine without activation (group III) and without treatment (group IV). All teeth were fractured longitudinally getting 2 sections. The middle third of the root canal was microphotographed with a scanning electron microscope (SEM) and the contaminated surface was measured using detritus with ImageJ 1.47. It was analyzed with Kruskal-Wallis-test using GraphPad Prism 5.01. Results: The median percentage of contaminated area of Group I was 20.06%, Group II, 19.3%; Group III, 36.05%; and Group IV, 56.45%. Conclusion: There are significant differences among different intracanal cleaning protocols in the removal efficiency of detritus from the root canal, being the activated protocols the most effective ones.

Keywords: Detritus, Activated irrigation, Sonic, Ultrasonic, Chlorhexidine.

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INTRODUCTION.

Endodontically treated teeth usually require a post inside the root canal to retain a coronal restoration¹. Fiber posts offer advantages over metal posts, such as favorable fracture patterns that could be restored because they are less rigid, and because they provide an easy removal of the post from the root canal in case of repeated endodontic treatment². Various resin cements are used for bonding fiber posts. The method of application involves multiple steps, and is rather complex and dependent on the technique used by the dentist, and therefore it may affect the quality of the adhesion³.

Manufacturers suggest removing detritus or debris from tooth surfaces by using ultrasound or pumice. They also

suggest keeping tooth surface clean with ethanol, citric acid, ethylenediaminetetraacetic acid (EDTA) or phosphoric acid to improve adhesion and eliminate any residue⁴. However, surface treatments with different root dentin agents can cause changes in its chemical and structural composition, which in turn, may alter its permeability and solubility characteristics⁵.

It is important to have in mind that the penetration of irrigation in the canal depends on the anatomy of the root canal, on the irrigant application techniques, the volume of the solution, instrumentation of the root canal and physicochemical characteristics of the irrigant⁶. These features have the potential to significantly the surfaces

of the treated dentin.

Cecchin *et al.*⁷ compared bond strength and fracture patterns between experimental groups irrigated with chlorhexidine (CHX), under different application times (30, 60, and 120 seconds) and a control group irrigated with saline. Significant differences for both fracture patterns and bond strength were observed. They concluded that the use of CHX pretreatment could preserve the bond strength of the fiber post for 12 months using resin cement, regardless of the time of application and the adhesive system used.

As mentioned above, given the existence of various irrigants and their different forms of application, it is possible to obtain different degrees of effectiveness of root canal cleaning. This is important because effective canal cleaning improves adhesion and cementing of the post.

The null hypothesis is that there are no significant differences between the different cleaning methods, therefore, the objective of this study is to compare three intracanal cleaning protocols used before cementing prosthetic posts, and to evaluate the effectiveness of each protocol in removing detritus using a scanning electron microscope (SEM).

MATERIALS AND METHODS.

An *in vitro* experimental study was conducted on human anterior teeth that did not have root canal treatment. The study was approved by the Committee of the School of Medicine at Universidad Austral de Chile.

The teeth were obtained from donor patients aged between 18 and 30 years, treated at the Dental Clinics of Universidad Austral de Chile in Valdivia, Chile, during August and October 2014. Each patient who had one or more teeth removed, and met the inclusion criteria and accepted to participate in the study were asked to sign the informed consent form.

The teeth were stored in a solution of 0.2% sodium azide at room temperature for a maximum period of 1 month, until the completion of the research⁸.

Inclusion criteria were: previous teeth with complete root formation, unique and tapered canal. Exclusion criteria were: presence of root caries, previous edodontic

treatment, curved canal and internal root resorption.

Once teeth were gathered and selected, they were checked by X-ray at the Dental Radiology Service of the School of Dentistry at Universidad Austral de Chile.

A sample size of 10 teeth per group was estimated using EpiDat 4.0 software (Servizo of Epidemioloxía de la Dirección Xeral de Innovación e Xestión da Saúde Pública de la Consellería de Sanidade (Xunta de Galicia)), with a confidence level of 99 %, statistical power of 99%, and level of effect of 10% in area with debris, previously selected with the agreement of researchers.

Sample preparation

Endodontic treatment was performed on all selected teeth at the School of Dentistry, Universidad Austral de Chile. A palatal access cavity was performed using a N° 10 high speed round diamond bur (SS White, Gloucester, England) mounted on a turbine (NSK Panamax, Tokyo, Japan). The working length was set to 2mm of the radiographic apex of the tooth.

Canal preparation was made with Gates-Glidden drills 1-2-3 (Dentsply Maillefer, Ballaigues, Switzerland), used decreasingly, and K-file endodontic files (Dentsply Maillefer, Ballaigues, Switzerland) number 15-20 -25-30-35-40-45-50-55-60-70-80 using Crown-down and telescopic techniques. Master file was number 50.

The canals were irrigated with 10 ml of 5.25% sodium hypochlorite (NaClO) (Química, Hertz, Santiago, Chile), using an endodontic syringe with a Monoject needle (Kendall, Mansfield MA, USA); which was used between one file and the next. The canals were dried with paper points (GAPADENT, Incheon, Korea) before filling the root with gutta-percha (GAPADENT, Incheon, Korea). The main cone was number 50, but accessory cones 35 and 25 were also used.

Filling was performed by lateral condensation, with spacers number 40 and 30 (Dentsply Maillefer, Ballaigues, Switzerland) and Grossman's cement sealer (Química Hertz, Santiago, Chile); a Matchou condenser (Dentsply Maillefer, Ballaigues, Switzerland) heated in an alcohol burner was used to cut the Gutta-percha cones

and then a vertical compaction was performed.

After two weeks, the canal was unblocked using low-speed Largo® Peeso® drills number 3-2 (Dentsply Maillefer, Ballaigues, Switzerland), mounted on a contra-angle handpiece (NSK, Tokyo, Japan), removing some of the gutta-percha to accommodate the post (first 10mm of the canal).

Teeth were marked at their roots with numbers 1 to 40 using a tapered diamond bur. The same number was recorded on the X-rays used to monitor endodontic filling.

A simple randomization was performed using EpiDat 4.0 to create 4 groups according to the type of cleaning protocol:

-Group I, root surface treated with 2% chlorhexidine (CHX) (DifemPharma, Difem Laboratorio SA, Santiago, Chile) activated by ultrasound (US) E-11 tip, mounted on ultrasonic instruments (NSK Varios 350, Tokyo, Japan) at 16,000 Hz per minute for 60 seconds.

-Group II, 2% CHX activated by sonic instruments (S) with blue insert 30/.06 mounted on sonic equipment (Dentsply EndoActivator York, Pennsylvania, USA) at 10,000 Hz per minute for 60 seconds.

-Group III, 2% CHX without activation for 60 seconds.

- Group IV, without a cleaning protocol.

All solutions were applied using endodontic syringes with a Monoject needle. Finally, canals were irrigated using a triple syringe with distilled water as a spray and dried with paper points.

To split the 40 teeth longitudinally, fracture lines were carved with a high-speed cylindrical diamond bur N° 10 (SS White, Gloucester, England) at the teeth's ends to subsequently produce the desired shear fracture. They were wrapped in plastic wrap film (ALUPLAST, Valparaíso, Chile) and held in a closed styrofoam box for up to a week.

Microscopic evaluation

Half of the samples collected were randomly selected for evaluation with a scanning electron microscope (SEM) (Leo Electron Microscopy 420, Carl Zeiss, To-

kyo, Japan) at the Department of Electron Microscopy (Research and Development Unit, Universidad Austral de Chile, Campus Isla Teja, Valdivia-Chile).

Each of the samples was set on an aluminum sample holder, using an electrically conductive adhesive (Colloidal graphite, Agar Scientific Ltd., London, United Kingdom). The samples were coated with 200 Å gold-palladium. Images obtained by SEM were assigned a new name before being submitted to evaluation by examiners to avoid bias regarding the cleaning protocol.

Calibration of examiners was performed a month before the first analysis of samples. Calibration consisted of two theoretical sessions led by the principal investigator, plus two practice sessions, where microphotographs showing varying degrees of debris and remains of sealing cement/gutta-percha were discussed. The degree of cleanliness obtained was observed in the middle third, calculating the area covered by debris, gutta-percha or sealing cement.

In each section an area of 30,000 μm^2 was observed. The two calibrated examiners (without knowing the irrigation method) performed a blind evaluation of the surface of the root canal prepared to install the posts, taking a microphotograph at a magnification of 4000x.

The area contaminated with debris, remains of sealing cement and gutta-percha from the sections (without showing the name or the type of the cleaning protocol), was evaluated using ImageJ 1.47 (National Institute of Health (NIH), Maryland, USA). Later, data were tabulated in a spreadsheet (Google Inc., Amphitheatre Parkway Mountain View, USA), which were entered as a percentage of contaminated area.

Statistical analysis was performed using the Kruskal-Wallis test, with a confidence level of 99% ($p < 0.01$) using GraphPad-Prism 5.01 (GraphPad Software, Inc., California, USA).

RESULTS.

Detritus was observed in all experimental groups, in the control group and in all the other groups that

Figure 1. Percentage of contaminated area by cleaning method used.

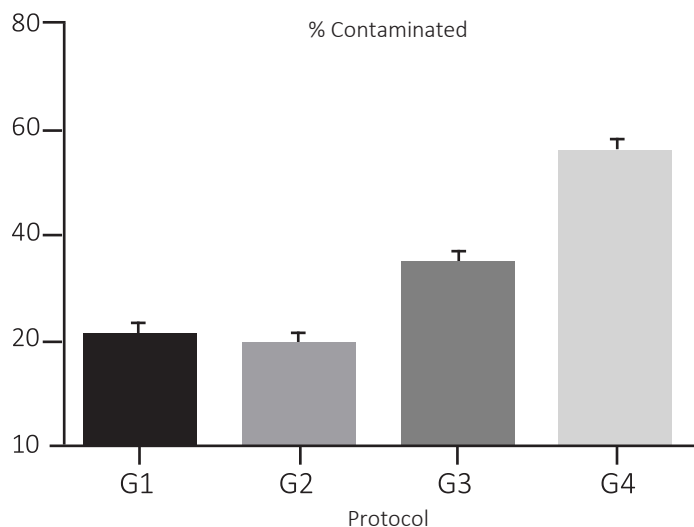


Figure 2. Chlorhexidine irrigation activated by ultrasound.

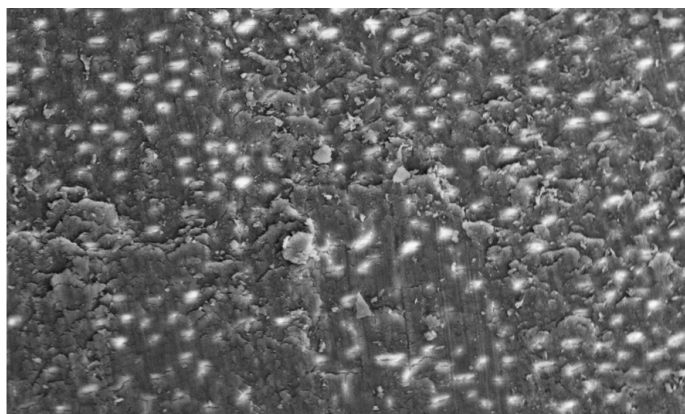


Figure 3. Chlorhexidine irrigation activated by sonic instruments.

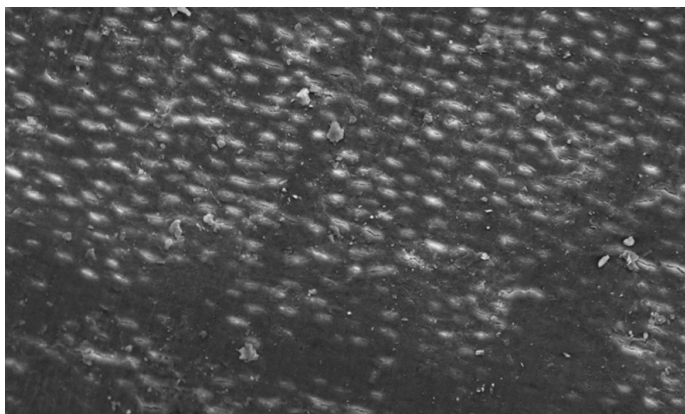


Figure 4. Chlorhexidine irrigation without activation.

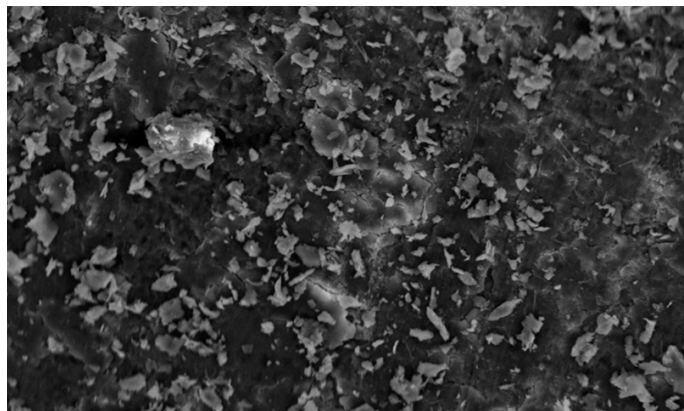


Figure 5. Without irrigation or cleaning protocol.



received different cleaning protocols.

Sonic (S) and ultrasonic (US) activation methods achieved better cleaning results when compared to the use of chlorhexidine (CHX) without activation and to the control group.

Figure 1 shows the percentage of remaining contaminated area by group. The median percentage of contaminated area of Group I was 20.6% (Figure 2), Group II 19.3% (Figure 3), Group III 36.05% (Figure 4) and Group IV 56.45% (Figure 5).

Kruskal-Wallis analysis showed that there are statistically significant differences ($p < 0.01$). Dunn's test established that differences are statistically significant between group II and III, as well as between group I and groups III and IV.

DISCUSSION.

Various agents are used for cleaning root canals: CHX, NaClO, EDTA and the alternate use of them. The alternate use of 5.25% NaClO and 17% EDTA is widely accepted as an effective method to remove organic and inorganic root canal debris⁹.

To achieve an optimal rehabilitation is necessary to make a good cleaning of the area in which the post will be installed and, secondly, to make sure that the irrigants are compatible with the subsequent cementation method of the post to be used.

Serafino *et al.*⁹ state that the action of drills used to remove the filling material from the root produces a new layer of detritus of sealing material and gutta-percha, that become laminated by the frictional heat produced by low-speed drills. Evaluation by scanning electron microscope (SEM) showed discontinuous areas of dentin demineralization alternating with areas characterized by open tubules and other areas covered by detritus and remains of sealant and gutta-percha. Dentinal tubules, which were partially occluded by "caps" of gutta-percha and/or traces of sealant were also observed.

Different studies refer to the presence of detritus at various levels of the preparations studied. Higher volumes of detritus were found in all groups at the apical level, compared to lower volumes at coronal level^{9,10}. This type of comparison was not carried out in this study. Its aim was to analyze different methods of intracanal cleaning after unblocking on endodontically treated teeth and prior to cementation of prosthetic posts; bearing in mind that the coronal third is more accessible for proper cleaning, the apical third is not entirely unblocked for this type of rehabilitation and that the middle third will be in full contact with the post, the cuts observed with the SEM are at an average level between the coronal and apical levels; as it is in this third where there is an influence of cleaning on teeth restored with posts.

With respect to the time assigned for irrigation, Ferreira *et al.*¹¹ state that the final irrigation of CHX done during 3-5 minutes produces a greater removal of debris,

and that the shorter the irrigation time the less effective the removal. While some authors suggest a longer irrigation time, irrigation during 60 seconds (1 minute) with inactivated CHX results in a decrease of debris in the area, and when it is activated and applied during the same amount of time, its cleaning effect is even better. Although the aim of this study is not to compare the length of the different cleaning protocols, we used as a reference the minimum irrigation time with CHX that can produce a decrease of debris in the area.

Regarding the use of S instruments, Niu *et al.*¹² studied the activation of irrigants using the EndoActivator system for a period of 30 to 60 seconds. Observing the samples by SEM, they said that activation of the irrigant maximized the removal of detritus and reduced the time required for cleaning compared with conventional irrigation.

The use of S and US equipment is justified because when they are used in small canals, there is a certain amount of cushioning. This passive action reduces debris and produces turbulence in the liquid leading to an increase in hydrostatic pressure, and increases in temperature and pressure, which results in shock waves on the canal walls producing the removal of detritus¹³. Other authors report an increased antibacterial activity of CHX, since increasing its penetration into the dentin tubules increases the effect of the irrigant¹⁴.

According to Sabins *et al.*¹⁰, the passive use of US instruments with NaClO irrigation produced cleaner canals in comparison to the passive use of S equipment using the same irrigant. The fact that US equipment removes more debris than S equipment could be explained because the former have more power. Furthermore, Mancini *et al.*¹⁵ say that the use of S activation, by EndoActivator system, was significantly more effective than US activation at 3.5 and 8mm from the apex. This last statement is confirmed with the one obtained in this study. While the difference between S and US instrumental activation is not significant, the CHX activated with S instruments produced a smaller surface

area with detritus than CHX activated by US instruments, both activated for the same length of time.

The results obtained in this study confirm that activation with US instruments had a positive effect in removing debris. This result coincides with the reports of Lui *et al.*¹⁶ and Curtis *et al.*¹⁷, who compared the final irrigation activated by US with conventional irrigation needle. Their results revealed that there was significantly less detritus in the group activated by US compared to the group treated with conventional needle. Conversely, Gu *et al.*¹⁸ noted that US activation does not improve the effect of irrigation and consequently does not improve the removal of debris nor the opening of the dentinal tubules. It is important to note that the study carried out by Gu *et al.*¹⁸ included other irrigants, such as EDTA, NaClO and sodium chloride (NaCl), which makes us infer that there are differences in the activation of different irrigants.

Despite the controversies found in some studies, there is a general consensus that US activation of the irrigant is more effective than the use of a conventional syringe^{14,19,20}.

The results of this study agree with the statement above and show that both S and US activation are more effective compared to the use of CHX without activation and to the control group. Moreover, some authors report that there are significant differences in terms of the degree of cleaning provided by this system in apical and middle thirds, independently of the final irrigant used¹⁴.

It is noteworthy to mention that root dentin acid conditioning should be considered as an essential step in achieving clean root walls. Scotti *et al.*²¹ state that the use of liquid phosphoric acid effectively removes debris remaining after irrigation, leaving open dentinal tubules ready for the subsequent cementing of the post.

As for the method to determine the percentage of detritus found in the dentinal tubules, photography eliminates the subjectivity of some previous studies, where evaluators grouped or gave a rating based on the amount of remaining debris¹⁰. The method of percentage makes a more objective comparison to that obtained in that study.

The use of SEM has recently been questioned due to limitations of two-dimensional images²², but an ideal experimental model for evaluating debris is not currently available²³.

The use of different irrigants, their time of activation, the size of preparations that will receive the posts and the characteristics of the root canal could account for the differences in the effects of S and US activation.

As a limitation of this type of study, it should be mentioned that the level of effect is not standardized, so results may vary from one study to another, depending on this specific data.

Furthermore, with respect to the methodology, only activation methods using CHX as irrigant at a constant time are compared.

We suggest to conduct additional studies that may allow to extrapolate more information to the clinical field. Experimental designs should be standardized in order to compare results more effectively.

Studies comparing other irrigants, alone or in combination, activated or inactivated at different lengths of time, are also necessary.

CONCLUSION.

There are significant differences between different intracanal cleaning protocols with respect to their efficiency in removing debris from the root canal, when they are compared by SEM. The use of activation proved to be more efficient than the use of the irrigant without activation.

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Activación sónica versus ultrasónica en la limpieza del canal radicular posterior a la preparación del lecho para poste. Estudio *in vitro*

Resumen: Objetivo: Comparar la eficacia de 3 protocolos de limpieza intraconducto utilizados previo a la cementación de pernos protésicos. Materiales y métodos: A 40 dientes anteriores se les realizó un tratamiento endodóntico en mano, mediante la técnica de condensación lateral. Luego de dos semanas, se realizó la desobturación de los mismos retirando la cantidad de gutapercha que otorgue el espacio necesario para alojar un poste. A continuación, los dientes fueron divididos aleatoriamente en grupos; superficie radicular tratada con clorhexidina (CHX) activado con ultrasonido (US) (grupo I), con clorhexidina activado con instrumental sónico (S) (grupo II), con clorhexidina sin activación (grupo

III) y sin ningún tratamiento (grupo IV). Todos los dientes se fracturaron longitudinalmente obteniendo 2 secciones. Se microfotografió el tercio medio del conducto radicular con microscopio electrónico de barrido (MEB) y se midió la superficie contaminada con detritus usando ImageJ 1.47. Se analizó con test Kruskall-Wallis usando GraphPad-Prism 5.01. Resultados: La mediana del porcentaje de área contaminada del Grupo I fue 20,06%, Grupo II de 19,3%, Grupo III de 36,05% y Grupo IV de 56,45%. Conclusión: Existen diferencias significativas entre los distintos protocolos de limpieza intraconducto en la eficacia de eliminación de detritus del conducto radicular, siendo los protocolos activados más eficientes.

Palabras clave: *Detritus, Irrigación activada, Sónico, Ultrasónico, Clorhexidina.*

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