



DOES THE ACTIVATION OF ROOT CANAL DRESSINGS IMPROVE THEIR FILLING QUALITY ON TEETH WITH SIMULATED INTERNAL ROOT RESORPTION?

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ABSTRACT

Aims: This study aims to evaluate, by micro-computed tomography, the filling capacity of two root canal dressings (RCD) - Bio-C Temp and Ultracal - after different activation protocols in teeth with simulated internal root resorption.

Materials and methods: Eighty single-rooted bovine teeth were sectioned in the cervical portion, standardizing the roots at 16 mm. Then, the canals were prepared by the apex-crown technique until instrument #80 using 2mL of 2.5% sodium hypochlorite solution at each instrument change. Afterward, the roots were sectioned longitudinally, and internal root resorptions were simulated using a diamond bur 1016 at 5 mm from the root apex. Hemiroots were joined and fixed with cyanoacrylate, scanned in micro-computed tomography (micro-CT) to assess total canal volume and simulated internal resorption, and then divided by stratified randomization into experimental groups according to RCD and method of activation (n = 10): Ultracal/Syringe; Ultracal/PUI, Ultracal/XP Endo Finisher, Ultracal Easy Clean, Bio-C Temp/Syringe, Bio-C Temp/PUI, Bio-C Temp/XP Endo Finisher and Bio-C/Easy Clean. Another scanning was performed to assess the volume of voids after RCD activation methods. The ANOVA and Tukey tests compared the activation methods. Student's T-test compared the RCDs within each activation method. Initial root canal volume values were similar for all groups (P > 0.05).

Results: There was no difference between activation protocols (P > 0.05). Higher volumes of void spaces were observed for Bio-C Temp compared to Ultracal after all activation methods (P < 0.05), except for Easy Clean (P > 0.05).

Conclusion: It can be concluded that the agitation methods tested for the Bio-C Temp and Ultracal pastes did not improve the filling of bovine teeth with simulated internal root resorption.

KEYWORDS: Root canal dressing. Passive ultrasonic irrigation. Easy Clean. XP Endo Finisher. Calcium hydroxide. Bioceramic.

INTRODUCTION

The hard tissues are subject to physiological remodeling, characterized by the balance between resorption and neoformation of

mineralized tissue. However, when there is an error between these phenomena, the hard tissue can respond with a predominance of mineralized matrix deposition,

resulting in pathologies that form hard tissue, or the resorption of the mineralized matrix will occur, causing a series of structural disorders that affect these tissues¹.

Tooth resorption is presented as a physiological or pathological process that occurs internally (derived from the pulp) or externally (derived from the apical periodontium). According to the American Association of Endodontists Guide, root resorption is a condition associated with a physiological or pathological process resulting in the loss of dentin, cementum, or bone².

External resorption starts at the external root surface of the tooth. It is associated with factors such as a periapical lesion, pressure caused by orthodontic treatment, and fast-growing tumors³. Dental trauma and infectious processes, such as dental caries, periodontal infection, deep restorative preparations, improper orthodontic movement, bruxism, and iatrogenic procedures, are the leading causes of this disorder⁴.

Internal root resorption results from the resorption of the inner surface of the pulp cavity. The location of internal resorption can occur in any region of the pulp cavity that presents vital pulp and could be in the pulp chamber or the root canal⁵. Frequently, it is necessary to use a root canal dressing (RCD) to neutralize any microorganisms and reduce the inflammatory process resulting from a case of internal root resorption. Sometimes, more appointments are needed to change the root canal dressing and control the signs and symptoms of infection⁶. Therefore, the correct insertion of the medication is essential in these "anatomical defects" cases to reach more areas and get more excellent disinfection of the root canal system. In this context, several devices and protocols have been researched to promote the best filling of the root canal by root canal dressing, especially in teeth with anatomical complexities, including those with internal root resorption.

Due to the importance of completely filling the root canal to

improve the action of root canal dressings, the objective of the present study is to evaluate, using computed microtomography, the quality of filling of root canals with simulated internal resorption using two root canal dressings (Bio -C Temp and Ultracal) with different insertion methods (syringe, PUI, XP Endo Finisher, and EasyClean).

MATERIALS AND METHODS

This study was sent to the Research Commission of Faculty of Dentistry of UFRGS (COMPESQ) and received approval under the number 37426.

Sample preparation

Eighty single-rooted bovine teeth were selected. The crown was removed with a double-sided diamond disk (Komet, Santo André, SP- Brazil) under abundant irrigation to standardize the roots with 16mm. Afterward, the canals were instrumented by the step-back technique to K-File instrument #80 in 15 mm. After using each instrument, the canals were irrigated with 2 mL of 2.5% sodium hypochlorite (NaOCl). After preparation, the canals were irrigated with 5 mL of 17% ethylenediaminetetraacetic acid (EDTA) for 5 min to remove the smear layer and finally irrigated with 10 mL of distilled water. The canals were dried with size #80 absorbent paper cones (MK Life Products, Porto Alegre, RS, Brazil).

The roots were sectioned longitudinally with a double-sided diamond disk (Komet, Santo André, SP- Brazil) under abundant irrigation, obtaining two hemi-roots. The length of the roots was determined, and the middle-third area was delimited, ensuring that resorption was simulated at the exact location. For simulating the resorptive lesion, a 1016 diamond burr (KG Sorensen) was used at high rotation, and only half of

its active part touched the inner surface of the canal in each hemi-root. After performing the resorptive lesions, the hemi-roots were repositioned and fixed with cyanoacrylate (Super Bonder). Subsequently, the teeth were fixed at the apex on a silicone base with 30 mm of diameter and 10 mm of height for analysis of the canal volume after chemical-mechanical preparation.

The samples were positioned in the micro-computed tomography (Shimadzu; Shimadzu do Brasil, Barueri, Brazil) and scanned. The settings were 70 kV X-ray tube voltage, 800 mA anode current, and voxel size of 0.019mm/pix. The scanning with 1024x1024 pixels originated 4800 slice numbers, obtained with acquisition intervals of 1° over a total of 360° rotation, and the average scan time ranged from 45 to 60 minutes. The image set was exported in DICOM file format for analysis in the CTAN software (CT-Analyser Version 1.13 Bruker Micro-CT, Konitch, Belgium). The canal and resorption volume from the most apical layer of the root to its most cervical portion were measured. Then, the region of interest (ROI) corresponds to the areas to be considered in the volume calculation. After measuring the canal and resorption volume, the samples did not present differences. So, the samples were randomly assigned to the experimental groups.

Experimental Groups

The roots were distributed into eight groups (n=10) according to the root canal dressing and the activation protocol performed: Ultracal/Syringe, Ultracal/PUI, Ultracal/XP Endo Finisher, Ultracal Easy Clean, Bio-C Temp/Syringe, Bio-C

Table 1. Volume (in mm³) of root canal and simulated internal root resorption before RCDs activation protocols and empty spaces volume after protocols.

	Syringe	PUI	XP EndoFinisher	Easy Clean
Ultracal Before	4.61 ± 2.88 A	4.60 ± 2.15 A	4.28 ± 1.32 A	3.83 ± 1.36 A
Ultracal After	0.61 ± 0.25 Aa	0.57 ± 0.22 Aa	0.84 ± 0.24 Aa	0.94 ± 0.20 Aa
Bio-C Temp Before	3.93 ± 1.40 A	4.04 ± 1.73 A	4.22 ± 2.10 A	4.27 ± 1.54 A
Bio-C Temp After	0.96 ± 0.23 Ab	1.15 ± 0.29 Ab	1.41 ± 0.30 Ab	1.19 ± 0.24 Aa

Different upper letters in the line indicate significant differences between activation protocols for each of the root canal dressings after one-way ANOVA testing ($P < 0.05$). Different lower letters in the column indicate significant differences between the final volumes according to each activation protocol after Student's t test ($P < 0.05$)

Temp/PUI, BioC Temp/XP Endo Finisher, and Bio-C/Easy Clean.

The RCD was inserted into the canals, as recommended by the manufacturers, with a NaviTip needle (Ultradent) up to be visualized at the canal opening. The Ultracal/Syringe and Bio-C Temp/Syringe groups were used as a control (without activation).

To perform the PUI, an ultrasonic insert E1 Irrisonic (0.20 mm in diameter; Helse Dental Technology, São Paulo, Brazil) coupled to the ultrasonic device (Piezon 150, Electron Medical Systems, Nyon, Switzerland), set to 10% power (30 Hz) introduced in the canal previously filled with the medication. The tip was inserted 1 mm below the working length (WL), and the movement up and down, without touching the root walls, was performed for 20 seconds.

In the XP Endo Finisher group, prior to its insertion in the canals, the instrument was cooled with refrigerant gas (Endo-Frost; Roeko, Langenau, Germany) inside a plastic tube. It was then coupled to the X-Smart Plus motor (Dentsply Maillefer) and driven at a speed of 800 rpm and torque of 1 Ncm for 20 seconds at 1mm short of the WL as instructed by the manufacturer, with up and down movements with light pressure against the walls without removing the

instrument entirely from inside the root canal.

The use of the EasyClean device followed the exact speed specifications and torque described for the XP Endo Finisher. Activation was performed for 20 seconds, 1mm short of the working length, with up and down movements.

After carrying out the protocols, the cervical portion of the canals was sealed with cotton and temporary sealing material (Cavit, 3M ESPE, Seefeld, Germany) and stored for 15 days in an oven at 37°C. The filling quality of the root canal and the volume of voids in the root canal space were evaluated after a new micro-CT

scanning according to the previously described parameters.

Statistical Analysis

The collected data were exported in a spreadsheet (Microsoft Office Excel 2007, Microsoft Corporation, Redmont, WA, USA) and statistically analyzed using the BioEstat 4.0 program (Instituto Mamirauá, AM, Brazil). A Shapiro-Wilk test was used to verify the data distribution. A normal distribution was observed, and one-way ANOVA and Tukey's post-hoc tests were used to compare activation protocols within each type of medication. A Student T-test was used to compare the volume of voids between the two RCD after each

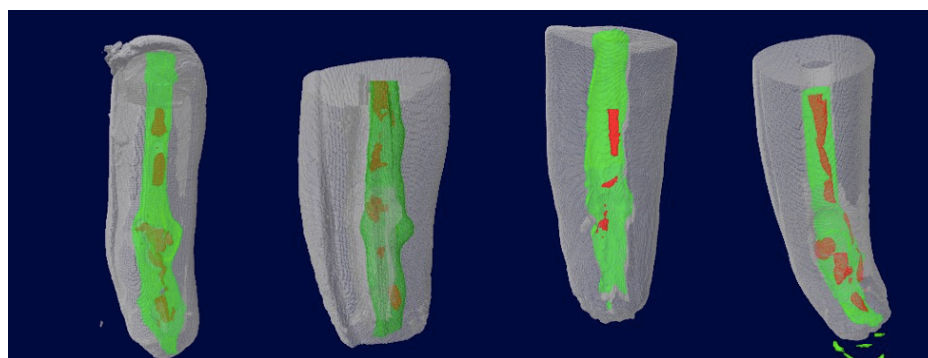


Figure 1. Overlap images when Ultracal was used as RCD. Green color represents the root canal without filling and in red the empty spaces after three-dimensional reconstruction. In order, from left to right, activation protocols are represented: syringe, PUI, XP Endo Finisher and Easy Clean.

activation protocol. The significance level used was 5%.

RESULTS

Initial root canal volume values were similar for all groups ($P > 0.05$). Regardless of the intracanal medication evaluated, the activation did not promote better filling of root canals with simulated internal resorption ($P > 0.05$).

When comparing the volume of empty spaces inside the root canal and the simulated lesion after each protocol, a more significant number of empty spaces was observed when Bio-C Temp was used compared to calcium hydroxide paste (Ultracal) for all groups ($P < 0.05$) except for EasyClean group ($P > 0.05$). **Table 1** presents the root canal volume (in mm³) before insertions and empty spaces after applying the protocols.

Figures 1 and 2 presented illustrative images of samples from experimental groups (before and after). The green color represents the canal before filling, and in red color the empty spaces after three-dimensional reconstruction.

DISCUSSION

The root canal dressing plays an essential role in the disinfection

process of the root canal system, especially in the treatment of root resorptions. Its effectiveness depends on the complete filling of the medication into the canal and the resorption defect. The aim of this study was to evaluate, using computed microtomography, the quality of filling of root canals with simulated internal resorption using two root canal dressings and three different activation methods.

An essential factor for the beginning of the experimental part is the standardization of the initial volumes of the samples. Statistical analysis showed similar initial volumes of the root canals for the groups that Ultracal and Bio-C Temp were used ($P > 0.05$). Such similarities occurred due to the stratified randomization process to divide the experimental groups' roots. Some methodologies have been employed to simulate conditions of internal root resorption. Among them, we can mention the method of acid demineralization and the use of a burr⁷⁻¹⁰. Due to the difficulty of executing the acid demineralization, this study used a round diamond burr #1016 to create the cavity. Half of the burr penetrated the hemiroots generating the concavity that would simulate the resorptive process. Thus, lesions with

more uniform and well-delineated features were obtained.¹¹

Micro-computed tomography (micro-CT) is a non-destructive three-dimensional method for analysis.^{12,13} Considered the gold standard for in vitro research, it allows volumetric analysis of the materials and the filling capacity of the materials through the analysis of the interface dentin and material, as its high resolution allows observing the presence of defects, voids, and empty spaces.¹⁴

The antibacterial effect of calcium hydroxide-based and bioceramic pastes occurs through direct contact with microorganism's biofilm that remained after the root canal preparation. Activating these root canal dressings seems to enhance their antibacterial effect due to their greater penetration into the dentinal tubules.¹⁵ A study that evaluated the ultrasonic activation of calcium hydroxide on *Enterococcus faecalis* biofilm found that activation increased the penetration inside the dentinal tubules and its antibacterial effect.¹⁶ The use of sonic (EndoActivator) and ultrasonic activation promoted better filling of simulated lateral canals with calcium hydroxide-based medication regardless of the evaluated root third.¹⁷

Another study found that Ultracal has higher viscosity when compared with Bio-C Temp, which may explain the present study's findings that presented fewer empty spaces for the Ultracal group.¹⁸

A previous study that compared the penetration of calcium hydroxide with two different vehicles, propylene glycol, and distilled water, with three methods of insertion, the Lentulo spiral,

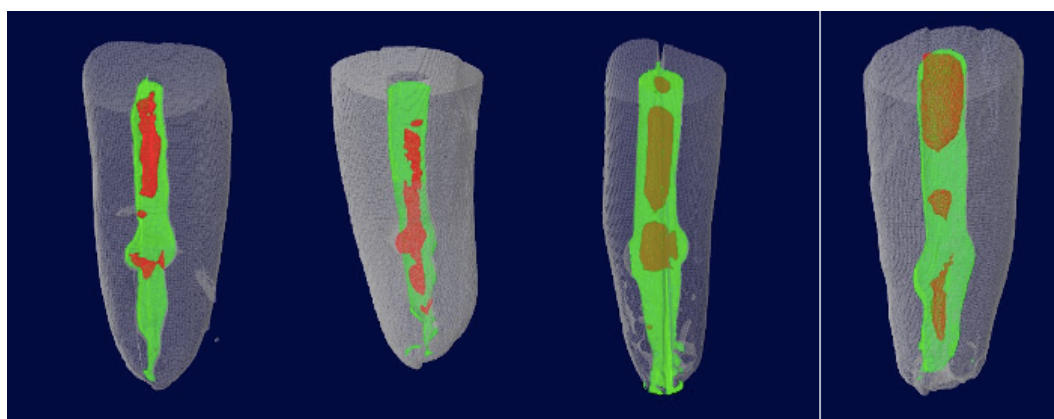


Figure 2. Overlap images when Bio-C Temp was used as RCD. Green color represents the root canal without filling and in red the empty spaces after three-dimensional reconstruction. In order, from left to right, are activation protocols are represented: syringe, PUI, XP Endo Finisher and Easy Clean

sonic agitation, and ultrasonic agitation, showed a significant difference between the vehicles, with better filling with propyleneglycol.¹⁹

When comparing the two medications employed, more significant voids were observed in the Bio-C Temp groups ($P < 0.05$). The best filling of the calcium hydroxide paste can be explained by its excellent flow, higher than Bio-C Temp, as presented in a previous study.¹⁹ Good flow capacity is an essential particularity for root canal dressing, especially in teeth with irregularities, such as cases of internal root resorption.

CONCLUSION

In the present study, the activation methods of intracanal medications did not differ in terms of the filling quality of root canals of bovine teeth with resorptions simulated roots. Root canals filled with Bio-C Temp paste showed more empty spaces than the Ultracal paste, except when EasyClean was used. More studies are necessary to evaluate the efficacy of these methods on intratubular penetration and antimicrobial activity.

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