



# Stereomicroscope Analysis of the Cleaning Capacity of an Abrasive-Expansive System in Oval Canals: A Laboratory Study

Naito JN, Coelho LAS\*, Alcalde MP, Kato AS, Duarte MAH and Vivan RR

Department of Dentistry, Endodontics and Dental Materials, University of São Paulo, Brazil

**\*Corresponding author:** Letycia Accioly Simões Coelho Department of Dentistry, Endodontics and Dental Materials, Bauru School of Dentistry, University of São Paulo, Bauru, São Paulo, Brazil, Tel: +55-19-997179067; Email: letycia.coelho@usp.br

## Research Article

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## Abstract

**Background:** The aim of this study was to evaluate, by means of a stereomicroscope, the influence on the removal of smear layer obtained by the XP-endo Finisher and Tornado Disinfection Kit systems during the final agitation of the irrigating solution, in conservative preparations.

**Materials and methods:** Ten extracted human lower premolars were chemically-mechanically prepared with the ProDesign Logic 2 NiTi rotary system (25/.05) and 2.5% NaOCl. The same specimens were submitted to three different protocols of agitation of the irrigating solution: Conventional irrigation, XP-endo Finisher and Tornado Disinfection Kit. For this, a closed system was made, the roots were cleaved and three holes were made in each third of the root canal and filled with dentinal debris to take initial photos under a stereomicroscope. The amount of debris was rated using a 4-point scoring system. The data obtained were submitted to the Wilcoxon, Kruskal-Wallis and Dunn tests ( $p < 0.05$ ).

**Results:** In the analysis of the effectiveness of each protocol, it was possible to observe a statistically significant difference in the removal of debris in all thirds for all protocols ( $p < 0.05$ ). Regarding the difference in score found before and after application of the protocol, a significant difference was observed between the apical and the middle third in the Tornado Disinfection Kit group ( $p < 0.05$ ) and there was no difference between the same third for different groups ( $p > 0.05$ ).

**Conclusion:** Based on the methodology and the results presented, it was concluded that both evaluated protocols improved the cleaning of root canal recesses in all thirds, with no difference between them.

**Keywords:** Root Canal Preparation; Bicuspid; Smear Layer

## Introduction

The biomechanical preparation of the root canal system involves cleaning and decontamination through mechanical instrumentation concomitant with irrigating solutions [1], capable to control the root canal infection [2]. But despite this, reconciling root canal system cleaning with dentin preservation has been difficult to achieve [3].

Therefore, the new proposal to avoid excessive pericervical dentin wear is the use of instruments with smaller diameters [4], such as the ProDesign Logic 2 System (Bassi Endo, Belo Horizonte, MG, Brazil), which is an instrument manufactured in NiTi thermally treated and which has a maximum cervical diameter of 1.0 mm, becoming cylindrical instead of conical when it reaches this diameter [5].

These systems, despite advances in endodontic treatment techniques, still do not completely eliminate dentinal debris [6] due to the complexity of the root canal system [7], making endodontic irrigation even more important for proper cleaning and decontamination [8].

The conventional technique, usually performed with syringes and needles, has failed to remove the smear layer and clean the most apical portions of the root canal system [9]. And, to increase irrigation efficiency, other techniques for agitating irrigating solutions have been investigated.

XP-endo Finisher 25./00 (FKG, La Chaux-de-Fonds, Switzerland) is made from a unique NiTi alloy (MaxWire) and has a straight shape in the martensitic phase, but assumes a “spoon shape” when reaches body temperature, in the austenite phase [10]. According to the manufacturer, when it reaches this shape, the instrument is able to remove the debris present in the anatomical complexities of the root canal (FKG 2015).

Another system is the Tornado Disinfection Kit (MedicNRG, Kibbutz Afikim, Israel). It consists of two rotary instruments made of stainless steel (Gentlefile Red and Gentlefile Brush) [11], which promote an abrasion process on the dentin walls. They are driven by an automated and non-customizable handpiece, running at 6,500 rpm [12] and performing a quick and short entry and exit movement. Knowing the importance of maintaining dentin for a good rehabilitation prognosis, it became important to investigate whether the use of abrasive-expansive systems for agitating the irrigating solution could complement root canal debridement, promoting better cleaning rates in recesses through an analysis in stereomicroscope.

The aim of the present study was to verify whether the use of the XP-endo Finisher and Tornado Disinfection Kit systems were able to improve the removal of dentin debris in recesses after conservative preparation of the root canal of single-rooted maxillary premolars, performing a stereomicroscope analysis. The null hypothesis is that there will be no difference in the removal of dentinal debris promoted by the different agitation systems of the irrigating solution.

## Material and Methods

### Sample Calculation

For sample calculation, G \* Power v3.1 for Mac (Heinrich Heine, Universität Düsseldorf, Dusseldorf, Germany) was used and the ANOVA test of repeated measures was selected. Data from a previous study that evaluated agitation of the irrigating solution (13) were used. An alpha type error of

0.05, a beta power of 0.80 and an N2/N1 ratio of 1 were also stipulated. A total of 8 specimens were indicated as the ideal size needed to notice significant differences. A sample of 10 specimens was used, considering a 20% risk of sample loss.

### Selection of Specimens

Before starting this study, it was reviewed and approved by the Research Ethics Committee (n° 42281921.3.0000.5417). Ten maxillary premolars extracted with a single root canal, intact crown and complete apex were initially selected based on radiographs taken in the buccolingual and mesiodistal directions (Microimagem, Indaiatuba, São Paulo) and stored in a 0.1% thymol solution.

### Chemical-Mechanical Preparation

Access to the pulp chamber was made with diamond burs at high speed, under refrigeration, and an exploration of the canal was performed with a K-file n°10 and n°15 (Dentsply Maillefer, Baillagueis, Switzerland) to recognize its internal anatomy.

After this initial recognition, the incisal surface of the crowns were ground using a double-sided diamond disc (KG Sorensen, Cotia, Brazil) until, when inserting the K-file n°10 in the root canal, its tip was visualized in the apical foramen under stereomicroscope magnification x30 (Carl Zeiss Vision GmbH, Hallbergmoos, Germany), standardizing the sample length at 16mm. This measurement was considered the actual length of the tooth and the working length (WL) was determined by reducing this measurement by 1 mm.

The root canal was filled with 2.5% sodium hypochlorite (NaOCl) solution and a ProDesign Logic 2 25/.05 instrument (BassiEndo) was introduced in a rotary motion (400rpm and 2N). During instrumentation, after three movement cycles (insertion + removal), the instrument was removed from the canal, cleaned with gauze soaked in alcohol, and the process was repeated until instrumentation was completed. At the end, the canal was washed with 10 ml of distilled water, totaling a final volume of 25 ml of irrigating solution. Each instrument was used on 3 teeth and then discarded. The preparation of all root canals was performed by a single operator.

### Stereomicroscope Analysis

After chemical-mechanical preparation, the root canals were dried with an absorbent paper point and a 25/.05 calibrated gutta-percha cone (BassiEndo) was inserted into the root canal up to the WL. Two longitudinal grooves were made on the mesial and distal walls using double-sided diamond discs (KG Sorensen) operated on a pneumatic

motor without reaching the root canal space.

Then the roots were enveloped in heavy body silicone (Optosil Comfort Putty; Heraeus Kulzer GmbH, Ha-nau, Alemanha) up to the level of the cemento-enamel junction (CEJ) and placed in a muffle. After the silicone had set, the specimens were divided into two parts with a spatula nº 36 (SSWhite Duflex, Rio de Janeiro, Brazil). The half that best presented conditions to evaluate the internal surface in a stereomicroscope was selected.

With a diamond bur 2137F (KG Sorensen) high rotation, a hole of approximately 0.5 mm in diameter was created inside the canal in each of the thirds. The specimens were subsequently washed in running water for 1 minute to remove debris. Dentinal debris was created from the grinding of extracted teeth and was mixed with distilled water and added into the root canal space, filling the created holes.

Then, the specimens were analyzed under a stereomicroscope. After locating the holes, an image for each third was obtained at 50x magnification.

The halves of each specimen were reassembled and stabilized with resin (Topdam; FGM, Joinville, Brazil). The specimens were re-inserted into the heavy body silicone mold and into the muffle to increase stability and prevent leakage of solutions used in the final irrigation protocols.

### Distribution of Groups

The same 10 samples were used to apply the 3 chemical-mechanical preparation protocols: Conventional Irrigation (CI) – The root canal was irrigated with 40 mL of 2.5% NaOCl using a 5 mL disposable syringe (Ultradent Products Inc.) and a 30-gauge NaviTip needle (Ultradent Products Inc.).

Tornado Disinfection Kit (TDK) – The root canal was irrigated with 5 mL of 2.5% NaOCl and the irrigating solution was initially stirred with GentleFile Red (MedicNRG), gently inserting it into the canal, with a rotational movement with 6,500 rpm with its own contra-angle until resistance was obtained and then it was activated using a gentle in-and-out movement with light apical pressure and lasting 5 seconds. The canal was irrigated and filled again with a 2.5% NaOCl solution and the procedure was repeated until the instrument reached the WL. Then, the canal was again filled with the irrigating solution and the GentleFile Brush (MedicNRG) instrument was introduced and activated for 30 seconds. Each instrument was used on one tooth and then discarded.

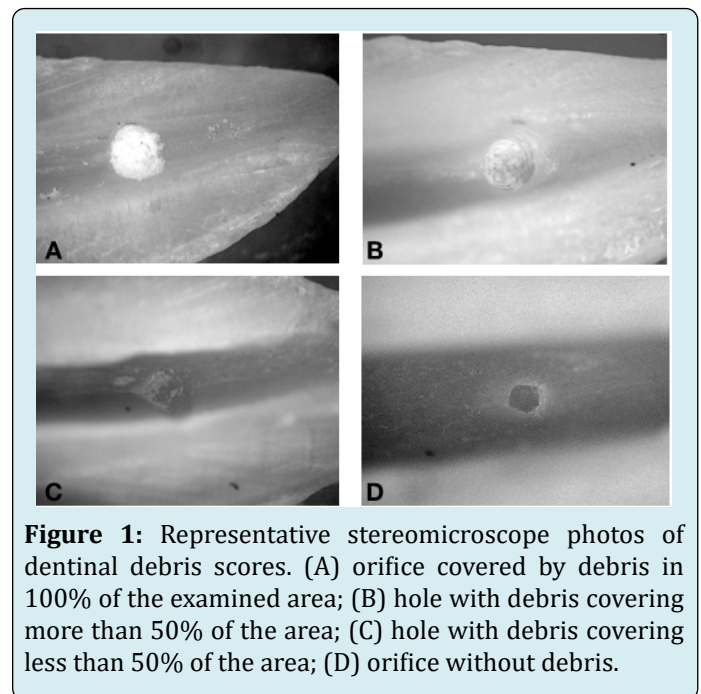
XP-endo Finisher (XPF) - The root canal was irrigated with 5 mL of 2.5% NaOCl and the solution stirred with XP-

endo Finisher (FKG Dentaire). The instrument was placed on a contra-angle (VDW Silver; VDW, Munich, Bavaria, Germany) and inserted into the canal without rotation. After that, rotation was started (800 rpm and 1 Ncm), and the instrument activated for 1 min using slow and smooth movements of 7 to 8 mm in the long axis direction from the tooth to the WL. Each instrument was used on one tooth and then discarded.

All groups were irrigated at the end with 5mL of distilled water to remove NaOCl. At the end, a total of 45 mL of irrigating solution was obtained. After the protocols of agitation of the irrigating solution with NaOCl, the specimens were submitted to analysis in a stereomicroscope (Carl Zeiss Vision GmbH), following the same parameters used previously.

### Rating Criteria

The images were saved and coded according to the group (G1, G2 or G3), the tooth (1-10) and the level (C, M, A) to which it corresponds. All images were loaded into Microsoft Office PowerPoint application (Microsoft Corporation, Redmond, WA). Two independent examiners, calibrated and blinded to the study, analyzed and classified the images using a 4-score scoring system adapted from GAMBARINI and LASZKIEWICZ (2002) (14) as follows: (A) hole covered by debris in 100 % of the examined area; (B) hole with debris covering more than 50% of the area; (C) hole with debris covering less than 50% of the area; (D) orifice without debris (Figure 1).



**Figure 1:** Representative stereomicroscope photos of dental debris scores. (A) orifice covered by debris in 100% of the examined area; (B) hole with debris covering more than 50% of the area; (C) hole with debris covering less than 50% of the area; (D) orifice without debris.

## Statistical Analysis

The reliability of three examiners for classifying the degree of cleanliness of the holes in the dentin ranged from good to excellent (Kappa coefficients ranged from 0.59 to 0.82). The Wilcoxon test was used to compare cleaning ability before and after using the cleaning protocol. Kruskal-Wallis and Dunn tests were used to compare cleaning ability between cleaning protocols. The significance level was set at  $\alpha = 5\%$  (GraphPad Prism, San Diego, United

States).

## Results

Table 1 shows the median and percentile values of the root canal score before and after the irrigation protocols. It is possible to verify a statistical difference in cleaning before and after irrigation in all groups and for all root canals ( $p < 0.05$ ).

Group	Period	A			M			C		
		25%	Median	75%	25%	Median	75%	25%	Median	75%
Conventional irrigation	Before	4	4 <sup>a</sup>	4	4	4 <sup>a</sup>	4	4	4 <sup>a</sup>	4
	After	2	2 <sup>b</sup>	3	2	2 <sup>b</sup>	3	2	2 <sup>b</sup>	2,75
XP-Endo Finisher	Before	4	4 <sup>a</sup>	4	4	4 <sup>a</sup>	4	4	4 <sup>a</sup>	4
	After	2	2 <sup>b</sup>	3	1	2 <sup>b</sup>	2	1	2 <sup>b</sup>	2
Tornado Disinfection Kit	Before	4	4 <sup>a</sup>	4	4	4 <sup>a</sup>	4	4	4 <sup>a</sup>	4
	After	2	3 <sup>b</sup>	4	1	1,5 <sup>b</sup>	2	1,25	2 <sup>b</sup>	2,75

**Table 1:** Median and percentile of the score of dentinal debris before and after irrigation protocols in the apical (A), middle (M), and cervical (C) thirds.

Table 2 shows the median and percentile values of the root canal score difference before and after the irrigation protocols. When comparing the thirds in the same group, a

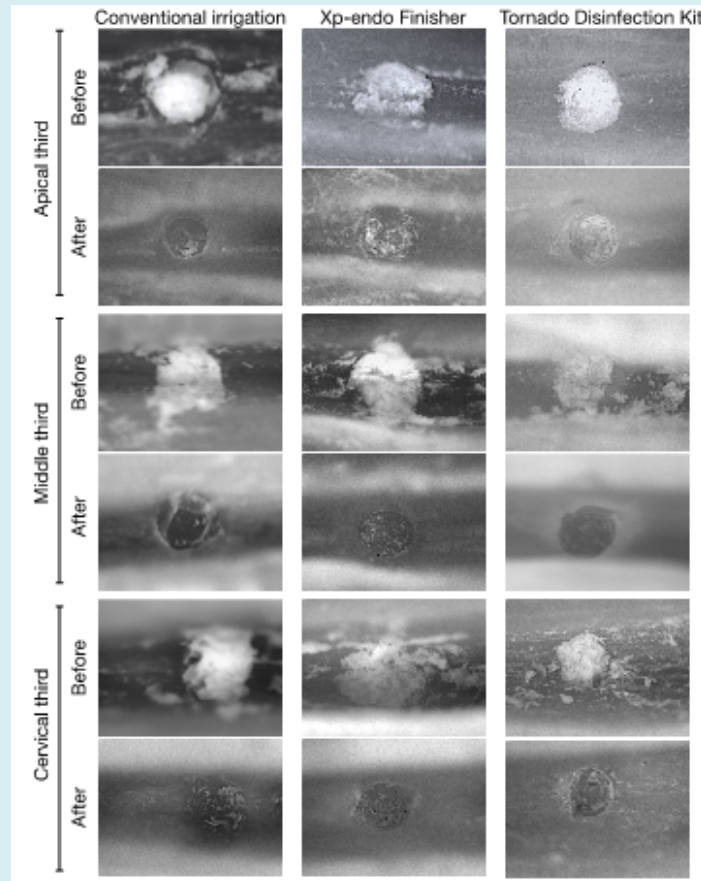
statistically significant difference was verified between the apical and middle thirds in the Tornado Disinfection Kit group ( $p < 0.05$ ).

Group	A			M			C		
	25%	Median	75%	25%	Median	75%	25%	Median	75%
Conventional irrigation	1	2 <sup>aA</sup>	2	1	2 <sup>aA</sup>	2	1,5	2 <sup>aA</sup>	2
XP-Endo Finisher	1	2 <sup>aA</sup>	2	2	2 <sup>aA</sup>	3	2	2 <sup>aA</sup>	3
Tornado Disinfection Kit	0	1 <sup>a*</sup>	2	2	2,5 <sup>a*</sup>	3	1,25	2 <sup>a</sup>	2,75

**Table 2:** Median and percentile of Difference in dentinal debris scores before and after irrigation protocols in the apical (A), middle (M), and cervical (C) thirds.

In Figure 2, it is possible to see representative photos of the ability to remove dentinal debris from the holes created

in all thirds of the root canal, after applying the irrigation protocols.



**Figure 2:** Representative stereomicroscope photos by third of the groups before and after irrigation.

## Discussion

This study aimed to verify whether the use of expansive systems, XP-endo Finisher and Tornado Disinfection Kit, would be able to improve the removal of debris after agitation of irrigating solutions, when conservative preparations of root canals are performed. Based on the results, the null hypothesis was denied, as all protocols demonstrated improvement in cleanliness in all thirds.

In the evaluation of the ability to remove debris before and after the application of the irrigation protocols, a statistically significant difference was observed between the thirds in all groups ( $p < 0.05$ , Table 1), demonstrating that all the protocols used are capable of improving cleaning in areas of root canal recesses and confirming the importance of root canal irrigation as an aid in the cleaning process [15].

The alternating use of sodium hypochlorite (NaOCl) and EDTA has been recommended to remove the organic and inorganic portion, respectively [16]. However, in the present research, only sodium hypochlorite solution was used, since, in a pilot study, the properties of EDTA led to the removal of

debris in a marked way, preventing the evaluation of the real effect of protocols of agitation of the irrigation solutions.

Comparing the thirds before and after irrigation for the same group, the Tornado Disinfection Kit showed greater removal of debris in the middle third compared to the apical third. In the apical third, the root canal space is smaller than that found in the cervical and middle thirds [16]; therefore, cleaning ability may be decreased.

The specimen preparation procedures were adapted from the method used by Kato, et al. [13] and the use of the same teeth for all experimental groups ensured sample homogeneity, reducing bias and consequently inaccurate or invalid results [17]. In addition, to replicate the clinical conditions, a closed apical system was created to simulate the clinical conditions, since the presence of periapical tissues and possible air trapping in the apical region can hinder the penetration of solutions in this region [18].

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Irrigation methods that use syringes and needles have been shown to be incapable of reaching areas of difficult access [20]. Thus, the activation of irrigation solutions by several methods has been proposed to enhance their action and penetration [1,21]. Furthermore, there is no consensus on which solution should be activated to remove smear layer [16]. Some researchers agitated EDTA [22], NaOCl only [23], or both [24].

Previous studies have demonstrated better efficacy of the XP-endo Finisher and Tornado Disinfection Kit [9,14,25] in removing dentinal debris compared to conventional irrigation after 2.5% NaOCl and 17% EDTA agitation. However, in the present study, no difference was observed regarding the cleaning capacity of the root canals between the irrigation protocols used for any of the thirds ( $p < 0.5$ , Table 2). This can be explained by the applied methodology and mode of action of these instruments.

The evaluation of this study was in holes created in the dentin that function as recesses and that were not included in the biomechanical preparation. Both instruments, Tornado Disinfection Kit and XP-endo Finisher, work by an expansive action method and if the instrument used for the activation of the solution touches the walls of the root canal, more dentinal debris can form during this process [26], accumulating in untouched areas.

The cleaning capacity was examined based on a numerical evaluation scheme for dentinal debris, through a stereomicroscope evaluation of the coronal, middle and apical parts of the canals. However, it should be taken into account that stereomicroscope evaluations have some limitations, as this method only allows the evaluation of limited areas of the canal wall. To overcome this potential limitation, the analysis was limited to the holes created, which were photographed and subsequently analyzed for each third of the canal. Another limitation of stereomicroscope evaluations is the attribution of scores to classify the degree of cleanliness, which can be a very subjective parameter, depending on the different interpretations of each examiner [19,15] of debris and smear layer. A proper calibration process was performed before image classification [27,28]. Kappa values from 0.59 to 0.8 were obtained, demonstrating agreement between examiners, which is important for the reliability of the results obtained [29].

Although none of the applied protocols were able to leave root canals with smaller apical sizes free of dentinal debris, the results reveal that they improved the cleaning

of recesses in all thirds. This demonstrates the need and importance of irrigating with a greater volume of irrigating solution during endodontic treatment, at the same time that more techniques should be investigated in order to achieve canals completely free of debris.

This study has limitations related to its laboratory nature and the fact that it was restricted to only one anatomical type of root canal. Results were obtained for oval canals with relatively straight roots and further studies are needed to include other types of teeth, including those with curved roots and isthmus areas. However, in the absence of randomized clinical trials, in vitro laboratory studies are important. Given the above, there is a need for caution and common sense in extrapolating the results of the present study to the clinic.

## Conclusion

Based on the results and proposed methodology, it can be concluded that both evaluated protocols improved the cleaning of root canal recesses in all thirds, with no difference between them.

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