



THE EFFECTIVENESS OF ROTARY AND RECIPROCATING TECHNIQUES IN CURVED ROOT CANALS RETREATMENT: A MICRO-CT ANALYSIS

Ana Paula Silva¹, Lilian Bottaro Purper¹, Carolina Bender Hoppe¹, Lucas Siqueira Pinheiro¹, Vania Regina Camargo Fontanella¹, Fabiana Soares Grecca¹

¹ Federal University of Rio Grande do Sul

CORRESPONDING AUTHOR: lucaspinheiroodonto@gmail.com

ABSTRACT

Introduction: Different NiTi rotary systems have been developed to improve efficiency and retreatment success rates. **Aim:** To evaluate the Protaper Universal retreatment system and WaveOne instrument in removing the filling material from curved canals during retreatment. **Materials and Methods:** Thirty mesial root canals of extracted human mandibular molar teeth were randomly allocated into 2 groups (n=15). In the PT group, retreatment was performed with ProTaper Universal Retreatment according to the manufacturer's instructions. In the WO group, was used WaveOne Primary. ProTaper Universal F2 and F3 were used to achieve the apical diameter in both groups. The samples were scanned by micro-computed tomography pre and postoperatively to evaluate the filling material remaining. The percentage of material filling was compared between groups using Student's T test and in the same group among thirds was compared using Kruskal-Wallis followed by Dunn's post hoc test. **Results:** The filling material remaining was not statistically different between the groups ($p \geq 0.05$). The apical third presented a greater amount of remaining filling material when compared with the cervical third for both groups ($p < 0.05$). **Conclusion:** Rotary and reciprocating techniques can effectively, but not completely, remove the filling materials from the root canal system. The apical third presented a more significant amount of remaining filling material.

KEYWORDS: Endodontics. Micro-computed tomography. Root canal retreatment.
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INTRODUCTION

The goals of root canal retreatment are to eliminate the contamination, to treat the infection process, and to re-establish healthy periapical tissues^{1,2}. The steps and the

requisites for successful retreatment consist of removing the previous filling material, negotiate the apical foramen, re-prepare, and re-obturate the canals attempting to overcome the deficiencies of prior treatment².

Many techniques have been proposed for the removal of filling materials of the root canal system including hand-operated files and engine-driven instruments as ultrasonic files, Gates-Glidden, and rotary nickel-titanium (NiTi) systems,

which may be combined with heat or chemical solvents²⁻⁷. Furthermore, the removal of gutta-percha, using hand instruments with or without solvent can be a tedious and time-consuming process^{1,8,9}. Somma et al.² reported that NiTi rotary instruments are more efficient than hand instrumentation for retreatment because they reduce the clinical time and operator/patient fatigue.

Different NiTi rotary systems have been developed to improve efficiency and retreatment success rates. The ProTaper NiTi retreatment rotary system including three instruments (D1, D2, and D3) is designed for removing filling materials from the coronal, middle, and apical portions of the root canal, respectively^{9,10}. They have a convex cross-section and D1 has a working tip that facilitates its initial penetration into filling materials.

The reciprocating kinematics has emerged as a result of the evolution of mechanized systems¹¹, simplifying endodontic procedures and maintaining safety and effectiveness. This movement is indicated for both root canal preparation and removal of filling material for retreatment purposes and are used in single instrument techniques^{10,12-14}.

Several methods have been used for the quantification of filling material remaining after endodontic retreatment¹². Micro-computed tomographic (micro-CT) images offer a noninvasive and reproducible technique for the 3-dimensional (3D) evaluation of debris left inside root canals^{5,13,15,16}. Therefore, this technique is considered the gold standard for identifying and quantify filling remnants⁶.

The purpose of this in vitro study is to evaluate using micro-CT the effectiveness of Protaper Universal retreatment system, and Wave One instrument in removing

filling material of curved root canals during retreatment.

MATERIALS AND METHODS

This study was approved by the Research Board from the Faculty of Dentistry, Federal University of Rio Grande do Sul.

Thirty extracted human mandibular molar teeth were selected. Crown access, preparation, and filling of root canals were performed by undergraduate students from Dental School of Federal University of Rio Grande do Sul. The working length was performed with radiographs inserting a size 15 K-file in the root canals and was defined as being 1 mm shorter than the apex.

The teeth were prepared manually using the step-back technique, and the final apical instrument was defined between # 25 and # 30. After each file, during the preparation, the root canals were rinsed with 1 mL of 1% sodium hypochlorite (NaOCl), delivered with a syringe and 30-gauge needle (NaviTip, Ultradent, South Jordan, UT, USA) inserted to 2 mm short of the entire working length (WL). Subsequently the conclusion of preparation, the canals were irrigated with a final sequence of 3 mL of 17% EDTA for 3 min and 1 mL of 1% NaOCl and were dried using paper points. The filling was performed by cold lateral condensation technique using tapered gutta-percha (Dentsply Maillefer, Ballaigues, Switzerland) and zinc oxide

eugenol sealer (Dentsply Maillefer, Ballaigues, Switzerland).

Final radiographs were taken, and the 30 mesial root canals (15 mesiobuccal and 15 mesio-lingual) were randomly allocated into 2 groups (n=15), according to the degree (17) and the radius of canal curvature (18). Curvatures between 20° and 40° and a radius shorter than 10 mm comprised the samples.

The samples were stored at 37 ° C and 100% humidity for 06 months. After, the groups were nominated as follows:

Group 1 (PT): ProTaper Universal Retreatment instruments were used according to the manufacturer’s instructions. The preparations of the cervical, middle and apical thirds were performed by D1, D2, and D3 files, respectively, until the WL. ProTaper Universal F2 and F3 instruments were used to prepare and to achieve the apical diameter.

Group 2 (WO): A reciprocating Wave One Primary file with a size 25.08 was used in a reciprocating, slow in-and-out pecking motion according to the manufacturer’s instructions, until the WL. ProTaper Universal F2 and F3 instruments were used to prepare and to achieve the apical diameter also in a reciprocating motion.

PT and WO instruments were discarded after preparing 4 canals. Both groups were instrumented using a 6:1 contra-angle handpiece (Sirona, Bensheim, Germany) powered by a torque-limited electric motor

Table 1. Median (percentile 25 and 75) of percentage of residual filling material.

Group	Cervical	Middle	Apical
PT	1.98 (0.51-7.24) ^{aA*}	19.14 (10.61-35.98) ^{aAB}	56.57 (24.98-82.21) ^{aB}
WO	2.30 (0.90-15.20) ^{aA}	28.44 (7.02-45.63) ^{aAB}	76.07 (28.17-86.42) ^{aB}

*Different lowercase letters in columns indicate statistical difference between groups in the same thirds. Different capital letters on the same line indicate statistical difference between thirds in the same group.

(VDW.Silver Reciproc motor; VDW, Munich, Germany). One trained operator performed all root canal preparations. No solvent was used, and filling material removal was considered complete when there was no evident filling material on the flutes of the instrument.

Micro-CT scanning and evaluation

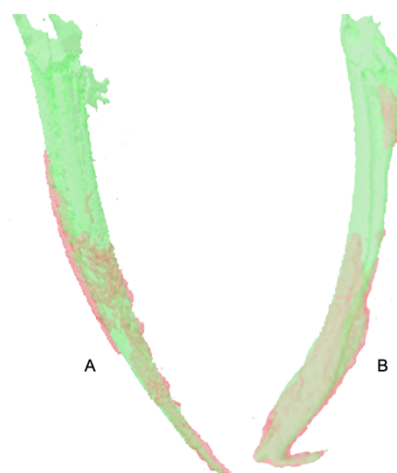
The samples were scanned before to and after instrumentation to evaluate filling material remaining using the micro-CT device (SkyScan 1174v2; Bruker-microCT, Kontich, Belgium) with the following parameters: 90 kV, 112 μ A, isotropic resolution of 12.8 μ m. The images were reconstructed (NRecon v.1.6.3 software, Bruker-microCT, Kontich), and the CTAn v.1.13.5.1 software (Bruker-microCT, Kontich) was used for measuring initial and residual volumes of dentin and filling material. The percentage of residual relative to the initial volume of the filling material was calculated. The calculus was performed for the canal thirds (cervical, middle, and apical). All the measurements and evaluations were performed by the same examiner, who was blinded for the stages of endodontic retreatment.

The non-parametric Kruskal-Wallis test and post hoc Dunn's test were applied to compare the thirds for removal of filling material in the same group. The Student's T test was used to compare WO and PT in the same third. The level of statistical significance was set at $P < 0.05$.

RESULTS

One WaveOne instrument suffered a fracture. The filling material remaining was not statistically different between PT and WO ($p \geq 0.05$). The apical third presented a greater amount of remaining filling material when compared with the cervical third for both groups ($p < 0.05$) (**Table 1**). Micro-CT reconstructions of mesial root canals of mandibular molars

Figure 1. Micro-CT reconstructions of mesial root canals of mandibular molars showing residual filling material (red) after using (A) ProTaper Universal retreatment (PT) and (B) WaveOne Primary (WO).



showing residual filling material are demonstrated in **Figure 1**.

DISCUSSION

The filling material removal is important for disinfection and to reduce the bacteria left inside the canal, while the removal of canal wall structure - transporting the original linear shape of the curved canal - can be the cause of an inadequate cleaning with the probability of persistent infection¹⁹. Thus, it is reasonable to suggest that remnants of filling material, especially in the apical portion, may compromise the outcome of retreatment in teeth with apical periodontitis, and efforts should be directed toward improving cleanliness²⁰.

None of the techniques completely removed the filling material from the canal walls. This result agrees with the outcomes of several previous studies that used different instruments and techniques^{5,6,10,12,15,21-26}. In addition, the third presented a greater percentage of residual filling material for both techniques in agreement with Fariniuk et al.²³.

The best results for filling removal were observed in the cervical third for both techniques. Independently of canal curvature, the cervical third is easily accessible. Whereas the apical third is a critical portion of the root canal. The

characteristics of this portion, such as a sharp and narrow curvature, make it difficult for the instrument to act along the root canal. Furthermore, during the removal procedure, the filling material could be pushed and compacted in the apical portion of the root canal, reducing the action of instruments, and increasing the mean percentage of residual filling material in this region¹⁵.

The effectiveness of removal filling material of reciprocating and rotary techniques was not statistically different between the groups, corroborating in a previous study^{15,24}. A systematic review observed that reciprocating and rotary systems exhibited similar abilities and retreatment files performed similarly to conventional ones in removing root filling material⁵.

PT instruments are specially designed to remove gutta-percha fillings¹⁹, and the fact that using more than one instrument in the root canal approach could have increased the chances for residual material to be removed. WO system has not been originally designed for retreatment, in this study, this system presented potential effectiveness for removal of filling material, with no statistical differences to other systems. Similar results between reciprocating systems and ProTaper Universal Retreatment were also observed²⁷.

The experimental design established the instrument F3 as a final

diameter preparation considering the root canal curvatures and to hold standardization between the groups. No solvents were used to prevent residual film formation and to evaluate the effectiveness of instruments in the filling materials removal. Besides, the solvent eucalyptol did not improve filling material removal from molar mesial canals and isthmuses⁶.

This study was performed using the mesial roots of mandibular molars, which have been shown to exhibit complex anatomy and the common presence of curvature^{18,28}. Despite the natural morphological variations of the teeth and to minimize variables inherent to anatomy, special carefulness was taken to ensure the comparability of the experimental groups. The samples were stratified concerning the angle and radius of curvature. The teeth with curvatures were chosen because they have a higher level of difficulty for treatment and retreatment.

Micro-CT imaging is recognizable as an excellent nondestructive high-resolution imaging method, which provides a highly accurate quantitative 3D analysis of filling material volume before and after instrumentation^{5,13,15,29}.

CONCLUSION

According to the results, rotary and reciprocating techniques can effectively, but not completely, remove the filling materials from the root canal system. The apical third presented a more significant amount of remaining filling material.

CONFLICTS OF INTEREST

The authors deny any financial affiliations related to this study or its sponsors.

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