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Efficacy of WaveOne Gold and ProDesign RT systems in removing filling material: a micro-CT analysis

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ABSTRACT

The remaining filling material after retreatment can harbor bacteria and organic tissues that can influence the outcome of the therapy. ***Aim:*** *The aim of this study was to evaluate, by micro-CT, the amount of filling material remaining in the root canal after its removal using WaveOne Gold or ProDesign RT.* ***Material and Method:*** *Forty human mandibular canines were instrumented with the ProTaper Next system up to the X2 instrument (25.06) and filled with gutta-percha cones and AHPlus. Teeth were divided into 2 groups (n=20): WaveOne Gold 25.07 (WOG) and ProDesign RT 25.08 (PRT) for filling removal, after which they were scanned in a micro-CT device to quantify the volume of remaining filling material. The data were subjected to log^{10} transformation, Student's t-test was performed to account for multiple observations per sample, significance was set at 5%.* **Results:** *Student's t-test showed that there was no difference between the two systems regarding the volume of remaining filling material in the thirds: apical (p = 0.392), middle (p = 0.065), or cervical (p = 0.918).* ***Conclusion:*** *Remaining filling material was present in all groups and both systems were similar in removing root filling material in mandibular canines.*

Keywords: *micro CT- root canal retreatment - reciprocal systems - rotary systems.*

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Eficácia dos sistemas WaveOne Gold e ProDesign RT na remoção material obturador: uma análise micro-CT

RESUMO

A permanência de material obturador após o retratamento pode abrigar bactérias e tecidos orgânicos que podem influenciar o resultado da terapia. ***Objetivo:*** *O objetivo deste estudo foi avaliar, por micro-CT, a quantidade de material obturador remanescente no canal radicular após a desobturação com WaveOne Gold e ProDesign RT.* ***Material e Método:*** *Quarenta caninos inferiores humanos foram instrumentados com o sistema ProTaper Next até o instrumento X2 (25.06) e obturados com cones de guta-percha e AHPlus. Os dentes foram divididos em dois grupos (n=20): WaveOne Gold 25.07 (WOG) e ProDesign RT 25.08 (PRT) e escaneados em micro-CT para quantificação do volume de material obturador remanescente. Os dados foram submetidos à transformação log^{10}, o teste t de Student foi realizado para contabilizar múltiplas observações por amostra, a significância foi fixada em 5%.* ***Resultados:*** *O teste t de Student mostrou que não houve diferença no volume de material obturador remanescente entre os dois sistemas nos terços: apical (p = 0,392), médio (p = 0,065) ou cervical (p = 0,918).* ***Conclusão:*** *O material obturador remanescente estava presente em todos os grupos e ambos os sistemas foram semelhantes na remoção do material obturador radicular nos caninos inferiores.*

Palavras-chave: *micro CT - retratamento do canal radicular - sistemas reciprocantes - sistemas rotatórios.*

INTRODUCTION

Nonsurgical endodontic retreatment is the first choice when endodontic treatment has failed. The remaining filling material may harbor necrotic tissue and microorganisms responsible for endodontic failure[1]. Efficient removal of filling material, new cleaning and shaping, irrigation, and access to the apical foramen are critical to the health of the periapical tissues[2].

Studies have evaluated the percentage of root canal filling material removed with rotary and reciprocating systems, with rates ranging from 59.4% to 96.9[3-6]. Due to the anatomical complexity of the root canal system and the limitation of instrument design, complete removal of the root canal filling material can be difficult or even impossible[7–10], especially in the apical region.

The WaveOne Gold (WOG - Dentsply-Sirona, Ballaigues, Switzerland) reciprocating system, which is made of a heat-treated M-wire alloy, has shown good results in removing filling material[11] although it has not been recommended for use in retreatment. The ProDesign RT (PRT - Bassi / Easy Equipamentos Odontológicos, Belo Horizonte, Brazil) rotary system was developed for removing filling material from root canals. It is made of a CM alloy and has a triple helix cross-section. According to the manufacturer, PRT files remove approximately 90% of endodontic filling material without the use of solvents.

Micro-CT enables three dimensional (3D) evaluation of the amount of remaining filling material due to its precision for enabling visualization of morphological features with specimen preservation[5,11,12]. The aim of this study was to use micro-CT to evaluate the amount of remaining filling material after retreatment of human mandibular canines using the WOG or PRT systems and the null hypothesis is that there is no difference between the systems in root canal filling removal.

MATERIAL AND METHOD

G*Power 3.1 software (Heinrich Heine College, Duesseldorf, Germany) was used to calculate power with a power of $\beta = 95\%$ and $\alpha = 5\%$, and a t test for independent samples was applied. The ideal sample size for each group should be at least 10 teeth, but 10 additional samples were added per group to compensate for possible loss.

Forty mandibular canines with moderately curved roots (10° to 20°) were selected from a pool of 432 teeth. All specimens were scanned in micro-CT (SkyScan 1173, Bruker, Kontich, Belgium) at 70 kV and 114 mA, with a 1-mm-thick aluminum filter, exposure time 320 milliseconds, pixel size 12.1 μm, rotation step 0.8°, and rotation 360° along the vertical axis. The files were then reconstructed into a three-dimensional data set using the software NRecon v1.6.1.0 (Bruker micro-CT), with beam hardening correction 50%, ring artifact correction 10, and smoothing 5. The volume of interest extended from the cementoenamel junction to the root apex, resulting in the acquisition of 600 to 700 axial slices per sample. CTAn v.1.14.4 and CTVol v.2.2.1 software (Bruker Micro-CT) were used to evaluate root canal morphology in terms of volume, surface area and 3D configuration. Teeth were then paired based on the anatomical similarities of preoperative canal volume, canal length of approximately 18 mm, canal surface area and 3D configuration.

This study included teeth with a single canal and complete root formation, and excluded teeth with pulp calcifications, resorptions, root fractures or canals whose patency was not achieved. Teeth were washed under running water, the root surface was cleaned ultrasonically, and kept hydrated in saline solution until the start of the experiment. Tooth length was standardized to 18 mm by partially crowns removal with a diamond disk (FKG Dentaire, La Chaux-de-Fonds, Switzerland). Each tooth was radiographed in the mesiodistal and buccolingual directions to verify for presence of a single canal and the degree of curvature of the roots. Periapical radiographs were performed with an X-ray unit (Procion, Ribeirão Preto, Brazil) coupled to a digital sensor (Elite - Schick, São Paulo, Brazil), with a distance of 10 cm between tooth and film, using the following exposure parameters: 0, 08s; 70 kV, 8 mA. To measure root canal length, a K# 10 hand file (Dentsply Maillefer, Ballaigues, Switzerland) was inserted in the tooth under an optical microscope at 20× magnification until the tip of the file was visible through the apical foramen. Working length (WL) was determined by subtracting 1 mm from this measurement.

The canals were instrumented at WL using the ProTaper Next system (Dentsply-Sirona) up to the X2 instrument (25.06). Patency was maintained with a #10 K instrument extended 1 mm beyond WL. Root canal instrumentation was performed by a single operator according to the manufacturer's

recommendations for speed and torque, using an electric motor (Dentsply-Sirona) under a surgical microscope with 8x magnification. At each instrument change, irrigation was performed with 5 mL of 2.5% NaOCl (Fórmula e Ação, São Paulo, Brazil). The smear layer was removed at the end of instrumentation with 17% EDTA (Fórmula e Ação, São Paulo, Brazil) agitated for 3 minutes with the EasyClean instrument (Bassi / Easy).

The teeth were dried with absorbent paper and filled using Tagger Hybrid Technique[13], with an X2 cone (Dentsply-Sirona) and AHPlus (Dentsply-Sirona). To assess the quality of the filling, new radiographs were taken with the same parameters in the mesio-distal and bucco-lingual directions. The crowns were sealed with Coltosol (Whalent, Cuyaho, OH) and stored at 100% humidity and 37 °C for 30 days. After this period, the teeth were paired with micro-CT for specimens based on the volume of the original filling material. The teeth were divided into 2 groups according to the system. In the WOG 25.07 group (n = 20), the filling material was removed with the instrument in a reciprocating motion using the WaveOne ALL program driven by a 6:1 contra-angle handpiece (Sirona, Bensheim, Germany) powered by an electric motor (VDW Silver - VDW GmbH, Munchen, Germany). In the PRT 25.08 group (n = 20), the Easy SI endodontic motor (Bassi/Easy) was used to remove the filling material in a rotary motion at a speed of 900 rpm and torque 4N.

In both groups, the instruments were used with reciprocating motion with an amplitude of 3 mm and with a brushing motion until the WL was reached. Patency was maintained with a K #15 hand file. After each of the three in-and-out movements of the automated instruments, they were removed and cleaned with sterile gauze soaked in 70% alcohol. Each instrument was used only once and then discarded. Irrigation was performed with 20 mL of 2.5% sodium hypochlorite (Fórmula e Ação), using a 21 mm Navitip 30G needle (NaviTip, Ultradent, South Jordan, USA). The final irrigation protocol consisted of 5mL of 2.5% NaOCl using a disposable syringe (Injex Indústrias Cirúrgicas Ltda) and a Navitip 30 G needle.

Micro-CT analysis

After obturation and removal of the filling material, a new microtomographic scan was performed to evaluate the amount of filling material remaining in the canals along the entire length with a SkyScan 1173 X-ray device (Bruker micro-CT) with the same parameters as described above.

Images were reconstructed using the CTAn v.1.15 software (Bruker micro-CT), and the volumes of obturation material (mm3) were determined according to the obturation and retreatment procedures. All measurements were performed for the entire canal volume and for each third: cervical, middle, and apical. Subsequently, 3D models were created and visualized using the software CTVol v.2.3 (Bruker microCT).

Statistical analysis

The percentage of the volume of filling material remaining after instrumentation was determined for each thir and the entire root canal. The data were subjected to $\log^{10}$ transformation before statistical analysis. The data obtained were analyzed for their coefficient of variation and passed the D'Agostino & Pearson normality test, thus assuming a homogeneous distribution of the data. Student's t-test was performed to account for multiple observations per sample. All analyses were performed using IBM SPSS version 25.0 software (IBM Corp. Armonk, USA), with $p < 0.05$.

RESULTS

Microtomographic images showed residual filling material in all specimens (Fig. 1). Student's t-test showed that there was no statistical difference in the volume of remaining filling material between the two systems, either in the apical (p = 0.392), middle (p = 0.065) or cervical (p = 0.918) thirds (Table 1) but in the intragroup evaluation, differences were found (p=0.013).

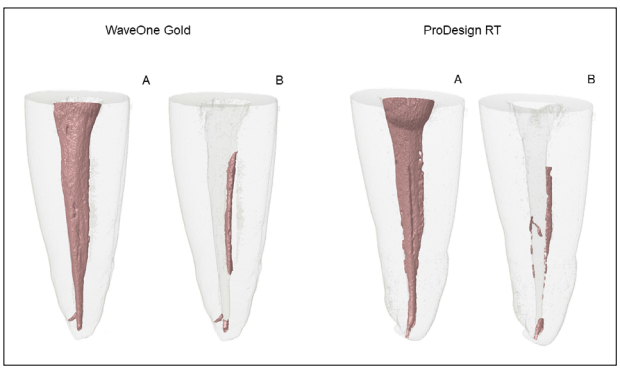

Fig. 1: Images of representative micro-CT reconstructions of the root canals in mesiodistal view showing the remaining filling material before (A) and after retreatment (B).

Table 1. Mean value (standard deviation) of the volume (mm^3) of initial filling material (IFM) and remaining filling material (RFM), and mean value (standard deviation) of the percentage (%) of the volume of the filling material remaining after treatment with the PRT and WOG instruments.

	WaveOne Gold 25/.07			ProDesign RT 25/.08		
Thirds	IFM	RFM	%	IFM	RFM	%
Apical	0.98(0.23)	0.03(0.06)	2.82(6.44)	1.12(0.37)	0.04(0.05)	3.65(4.13)
Medium	2.30(0.42)	0.02(0.04)	0.74(1.52)	2.56(0.65)	0.04(0.05)	1.56(2.39)
Cervical	4.39(1.00)	0.02(0.04)	0.86(1.24)	4.38(0.98)	0.04(0.05)	2.07(2.12)

Notes: Student's t test accounting for multiple observations per sample was performed. * $p > 0.05$.

DISCUSSION

Efficiency in removing filling material from root canals may depend on variables such as diameter and taper of the endodontic instrument, type of alloy, heat treatment, cross-section, and kinematics of movement[14]. Therefore, the objective of this study was to evaluate the ability to remove filling of two systems with different characteristics and kinematics: Wave One Gold and ProDesign Logic RT.

ProDesign Logic RT is a rotary system with multiple instruments (#30.10; #25.08 and #20.06). It has a CM-wire treatment and a triple helix section, and fixed taper that gives it a greater volume of metallic mass, favoring contact with the canal walls[15]. Wave One Gold is a reciprocating single file system (#20.07; #25.07; #35.06 and #45.05) made of NiTi with special gold heat treatment, with parallelogram-shaped cross-section and variable taper that decreases in the cervical direction[5]. Despite the differences between the instruments in terms of manufacturing process, kinematics and taper, no significant difference in the removal of filling material in the cervical, middle, and apical thirds was found in the present study ($p > 0.05$). Therefore, the null hypothesis was accepted.

Although ProDesign Logic RT (25.08) has a larger taper than Wave One Gold Primary (25.07), there was no difference in the amount of filling material removed ($p>0.05$) between the tested systems. This result confirms previous studies showing that Wave One Gold Primary (25.07) has the same effectiveness in removing filling material as reciprocating systems with a larger taper such as Reciproc (25.08) and Reciproc Blue (25.08), and rotary systems such as Protaper Gold F2 (25.08)[14]. One reason that may explain why the Wave One Gold instrument and the ProDesign Logic RT have similar ability to remove filling material is that the WOG has a parallelogram cross-section with two cutting edges and asymmetric motion, which may have reduced the percentage of remaining filling material[16]. The absence of significant differences between the systems for extrusion and intracanal filling material removal may also be associated with the standardized conditions of root canal anatomy, irrigation, and working length[3,6,8,9,23]. In these conditions, studies have shown that differences in taper, tip and cross-sectional shape, as well as the operation mode and the number of instruments used, fail to promote significant differences in filling removal[3,6,8,9,23].

The difference in kinematics between the two systems studied did not affect the effectiveness of filling material removal. Previous studies have also found no difference in ability to remove filling material between rotary and reciprocating systems[17-19]. Moreover, a systematic review[20] concluded that reciprocating and rotary systems have similar retreatment capabilities. However, some studies have shown better performance with reciprocating systems[21,22], while others have shown better performance with rotary systems[23,24]. This divergence in results could be due to the method used to evaluate the removal, the endodontic sealer, and/or the filling technique used.

Although the ProDesign Logic RT system provides a sequence of three instruments, only the 25.08 instrument was used in the current study, in order to approximate the diameter of the WOG 25.07 instrument and improve the comparison parameters. The PRT 30.10 instrument could be more effective because instruments with a larger tip diameter may remove more filling material than instruments with smaller diameters[14].

Some limitations regarding the methodology of this study should be highlighted. Straight roots were used to facilitate specimen standardization and adequate specimen pairing. Oval canals were

selected because this type of anatomy presents challenges for chemical-mechanical preparation and nonsurgical retreatment. AH-Plus epoxy-based endodontic sealer was used due to its excellent sealing ability, dimensional stability and flowability. Micro-CT is the assessment method commonly used in non-surgical endodontic retreatment studies[5,22].

Studies show that additional irrigation with agitation techniques improves the removal of filling material[23,25,26]. A previous study using oval canals of mandibular premolars compared the efficacy of the XP-Endo Finisher R and R1-Clearsonic inserts in removing filling material remnants from oval canals using micro-CT and concluded 82.1% and 64.6% in the entire canal for XP-Endo Finisher R and R1-Clearsonic ($P < 0.05$)[9]. Another study showed similar results with Photon-induced photoacoustic streaming (PIPS) using XP-Endo Finisher and Passive ultrasonic irrigation (PUI) to remove residual root canal filling material from oval canals. Filling material was removed up to size X4 using ProTaper Next system, and the supplementary procedures were performed. The authors demonstrated that PIPS could reduce residual root canal filling materials to a similar extent as PUI and XPF[27]. Therefore, the results of the current study should be evaluated with caution as only conventional irrigation with a syringe was used, which is the most common irrigation system worldwide.

CONCLUSIONS

The ProDesign RT and WaveOne Gold systems significantly reduced filling material in single-rooted canines with oval canals with similar results, although a residual amount of filling material remained following the use of both instrument systems. Further studies are needed to evaluate instruments that can compensate for the limitations of mechanical root canal preparation.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest regarding the research, authorship and/or publication of this article.

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