Efficacy of ProTaper Instruments during Endodontic Retreatment

Abstract

Introduction: The effectiveness of ProTaper Universal and ProTaper Retreatment rotary instruments was compared to the Hedström files in the removal of filling material from root canals. Materials and Methods: Thirty-six extracted human mandibular premolars with a single straight root canal were shaped and filled with gutta-percha and AH Plus. The specimens were stored for 6 months at 37°C and at 100% relative humidity, and then randomly divided into three groups: PTU - removal of filling material performed with ProTaper Universal instruments; PTR - removal of filling material performed with ProTaper Retreatment instruments; HF – removal of filling material performed with Gates-Glidden burs, Hedström files and solvent. After the filling material removal and diaphanization, the specimens were longitudinally sectioned and images of the canal surfaces were scanned. The remaining areas of filling material were measured (Image Tool 3.0), and data was analyzed statistically (Kruskal-Wallis and Dunn tests). The time required for filling removal in each group was also recorded (one-way ANOVA and Tukey’s HSD test). Results: All groups presented remnants of filling material; PTU had the smallest amount and HF group presented the highest mean value ($P < 0.05$) in all the thirds. The cervical third had the smallest amount of material when compared with the other thirds ($P < 0.05$). HF group required a longer mean time, presenting significant difference ($P < 0.05$). Conclusion: Considering the time required and the amount of the filling removal, ProTaper Retreatment were not superior to ProTaper Universal, but both rotary instruments were more effective and less time-consuming than Hedström manual files.

Keywords: Gutta-percha, ProTaper universal, ProTaper retreatment, root canal retreatment, rotary instruments

Introduction

The main cause of failure in root canal treatment is the persistence of infection due to insufficient cleaning and consequently inadequate filling of the root canal system.$^{[1,2]}$

The nonsurgical root canal retreatment should be the preferred treatment option after an ineffective endodontic therapy, when is possible to improve the disinfection and properly fill the root canal, aiming to reestablish healthy periapical tissues.$^{[3‑5]}$

Ideally, the root canal retreatment intends to remove completely the root canal obturation. However, the residual filling material is a constant concern.$^{[6,7]}$ Among the residual gutta-percha and cement, there might be present some necrotic tissue or bacteria, potentially causing persistent inflammation and pain.$^{[4,8]}$

Various types of motor-driven instruments, made from nickel-titanium (NiTi) alloys in different designs and variable tapers, have been successfully used in cleaning and shaping of the root canals. One of the main advantages of these instruments is the capacity to remove dentin and debris in a coronal direction, resulting in less extrusion of filling material through the apical foramen.$^{[9]}$ Therefore, several studies have evaluated the action of rotary instruments in removing gutta-percha, which has been shown effective, safe, and time-saving.$^{[6,10‑14]}$

The ProTaper Universal™ (PTU) (Dentsply Maillefer, Ballaigues-Switzerland) rotary system is primarily intended for root canal preparation; however, it has also been recommended for the removal of root canal fillings, presenting satisfactory results and significantly less time as compared to manual instruments.$^{[4,15]}$ The ProTaper Retreatment® (PTR) (Dentsply Maillefer, Ballaigues-Switzerland) system was later introduced, consisting of a set of three instruments with different lengths, multiple and progressive tapers, and different apical diameters: D1 (size 30.09 taper 16 mm length, active tip), D2 (size 25.08 taper and 18 mm), and D3 (size 20.07 taper and 18 mm)...

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22 mm), recommended for removing filling material from the cervical, middle, and apical thirds of the root canal, respectively.

Previous studies have compared the efficiency of PTU and PTR with different rotary and others manual instruments.[1,3,5,12‑14,16‑19] Therefore, the aim of this study was to evaluate the effectiveness of the rotary systems PTR and PTU during the removal of filling material in comparison with manual Hedström files (Dentsply Maillefer, Ballaigues-Switzerland).

Material and Methods

Shaping and root canal filling

Thirty-six extracted human mandibular premolar teeth with mature apices, with the length between 18 and 22 mm were selected. Preoperative mesiodistal (M-D) and buccolingual (B-L) radiographs were taken to verify the presence of a single straight visible canal with no calcifications or resorptions. After the coronal access, a size 10 stainless steel K-file (Dentsply Maillefer, Ballaigues, Switzerland) was inserted into the root canal until the tip of the instrument was first visible at the apical foramen and deducted 1 mm to obtain the working length (WL).

The root canals were prepared with ProFile. 04 Taper rotary instruments, driven by an electric motor TC Motor 3000 (Nouvag Ag, Goldach, Switzerland) at 350 rpm, in a crown-down technique up to a size 30 at WL. During the shaping procedures, root canals were irrigated with 2.5% sodium hypochlorite solution. Then, the root canals were dried with paper points and obturated with gutta-percha cones (Dentsply– Ltd., Petrópolis-RJ, Brazil) and AH Plus sealer (Dentsply Maillefer, Ballaigues, Switzerland) using a hybrid thermomechanical compaction technique.[20]

The teeth were radiographed in B-L and M-D directions to verify the quality of the filling (length, density of filling, and absence of voids). Then, the coronal access was tempozirized with glass ionomer restorative cement (Vidrion R, SS White, Rio de Janeiro-RJ, Brazil) and the teeth stored at 37°C in 100% relative humidity for 6 months, allowing the setting of the sealer and mimicking a clinical condition. The same operator performed all the endodontic and retreatment procedures; each set of files was used for the preparation of four teeth.

Retreatment procedures

The specimens were randomly divided into three groups (n = 12). The coronal restoration was removed using high-speed round burs. The root filling material in each group was removed in a crown-down technique with the following instruments:

PTU Group-PTU™ rotary instruments (Dentsply Maillefer) at 350 rpm. Only finishing instruments were used in the sequence: F5 (size 50, 0.05 taper), F4 (size 40, 0.06 taper), F3 (size 30, 0.09 taper), F2 (size 25, 0.08 taper) or up to the first instrument that reached the WL, and apical widening was performed with F3, F4, and finalized with F5 (size 50, 0.05 taper).

PTR Group-PTR instruments (Dentsply Maillefer) at 350 rpm. The instruments were used in the following sequence: D1 (size 30, 0.09 taper), D2 (size 25, 0.08 taper), and D3 (size 20, 0.07 taper); for apical repreparation instruments, F2, F3, F4, and F5 were used.

HF Group‑Hedström manual files and Gates-Glidden burs (Dentsply Maillefer, Ballaigues, Switzerland). Sizes 3, 2, and 1 were used to remove filling material from the cervical and middle thirds of the root canals. Then, 0.1 ml of solvent (Eucalyptol, Biodinamica, Ibiporã, Brazil) was placed into the root canal to soften the gutta-percha. Hedström manual files were used with a filing motion (1–2 mm push and pull), up to the size that reached the WL. Apical repreparation was then performed with Hedström files until size 50 at WL until no additional root canal filling material could be recovered on this file.

Operating time

Operating time was divided into time to reach the working length (T1), time to remove the material from apical third (T2), and total time (T3 = T1 + T2).

Residual filling measurement

The specimens were decalcified in hydrochloric acid by the diaphanization technique described by Schirrmeister et al.[4] The cleared teeth were sectioned longitudinally in the M-D direction with a scalpel blade number 15 (AdvantiVe, Taiwan, China). The two segments were scanned with a Microtek ScanMaker 9800 × L (Taiwan, China) scanner with a resolution of 1200 DPI. The images obtained were captured in JPG format, and the ImageTool 3.0 software (UTHSCSA – University of Texas Health Science Center – San Antonio, Texas, USA) was used to measure the area (mm²) of the residual filling material in each third [Figure 1].

Statistical analysis

The data corresponding to the operating time and also the quantity of remaining filling material on the dentinal walls per third of the different experimental groups were tabulated to perform statistical analysis. The Kolmogorov–Smirnov and Levene test showed a nonnormal distribution for the mean values of the filling remnants (P < 0.05), so it was applied the non-parametric tests (Kruskal–Wallis and Dunn). The variable time presented a normal distribution (Kolmogorov–Smirnov P > 0.05), and it was performed one-way ANOVA and Tukey tests. The level of significance applied for all tests was set at P < 0.05.
Results

Filling material remaining

Tables 1-3 present the data corresponding to the area of filling material remaining on the canal walls of the three groups. All the canals presented residual filling material. The PTU group showed the smallest amount of filling material, and the HF group showed the highest mean value for the quantity of remnant, being statistically different ($P < 0.05$) in all thirds. There was no significant difference between the PTU and PTR groups.

The cervical third presented a significantly smaller amount of residual filling material ($P < 0.001$) compared to the other thirds, regardless the instrument used; there was no significant difference between the apical and middle thirds ($P > 0.05$).

The simultaneous comparison among groups × thirds × filling material remnants [Table 3] showed that the HF group presented the higher amount of filling material when compared with the other groups in all the thirds ($P < 0.05$). The PTU group was not statistically different from PTR group.

Time

The Graph 1 shows the time for retreatment among PTR, PTU, and HF groups. The HF group differed significantly from the other groups ($P < 0.001$) regarding the time required to reach the working length (T1) and also the total time for retreatment (T3). The time required for retreatment after reaching the WL (T2) was similar among the three groups ($P > 0.05$).

Discussion

The removal of the filling materials during the nonsurgical endodontic retreatment intends to allow an effective debridement and the action of irrigating solutions on the microorganisms that are causing the posttreatment disease.\textsuperscript{[3,14]} However, different studies have shown that is nearly impossible to achieve the complete removal of
the filling material, regardless the different instruments and protocols already proposed for the root canal retreatment.\cite{6,10,12,17}

The present results also showed that none of the tested techniques were capable of producing canal walls completely free of material. The evaluation of the remaining filling by high-resolution images obtained from longitudinally sectioned roots is well established in the literature.\cite{6,10,12,17} and it has proved to be more reliable than radiographic methods.\cite{12,21}

The use of hand instruments for the filling removal is very common,\cite{17} but it is time-consuming and also presents limited results. In addition, the use of a solvent usually results in a thin layer of dissolved material on the canal walls, which penetrates into the dentinal tubules, being difficult to remove thus leading to a greater amount of remaining filling materials.\cite{22} However, the use of solvents is recommended to facilitate penetration of hand instruments into the gutta-percha and prevent ledgering or perforating when performing manual retreatment in curved root canals.\cite{8} On the other hand, previous studies\cite{14,12,17} have suggested that there is no need to use solvents with rotary instruments because the gutta-percha is plasticized due to friction, and the WL can be easily reached.

The difference in time for retreatment between the PTU and PTR groups was not significant; however, it was observed that both rotary systems were significantly faster than the manual instrumentation not only to achieve the WL (T1) but also for the total time required for the procedures (T3). These results are in agreement with previous studies that showed reduced procedural time with rotary instruments, compared to the manual retreatment.\cite{3,9,14,16,17}

Although the rotary instruments make the filling removal easier and faster, they do not guarantee completely material-free walls.\cite{6,10,11,17} In the present study, the PTU and PTR groups presented a similar amount of filling material in all the thirds, and there was no statistical difference between the two rotary instruments. In the meantime, the Hedström group presented significantly greater areas of remnants, when compared with PTU and PTR groups, corroborating previous studies.\cite{13,9,11,16}

In this study, the crowns were not removed to simulate the clinical situation,\cite{13,15} also allowing the evaluation of the cervical third. Overall, the lesser amount of remaining filling was observed in the cervical third compared to the apical and middle thirds ($P < 0.001$). This was also observed within each group, but with no statistical difference. These results are in agreement with Vale et al.,\cite{3} which found significantly less residual filling in the cervical third, regardless the different tested retreatment techniques.

Só et al.\cite{18} found that in the middle and cervical thirds, the association of Gates-Glidden burs and manual files presented significantly less amount of residual material compared to ProTaper instruments. Differently, in the present results, it was observed that PTU and PTR were slightly more efficient in cleaning the cervical third compared to HF group. This could be related to the root canal anatomy, to the instruments features and to the fact that, different from the Gates-Glidden burs, the NiTi rotary instruments are meant to brush the root canal walls, which might have improved the cleaning. The convex triangular cross-section and the greater taper of PTR instruments had proved to be more effective in the cleaning of cervical and middle thirds when compared to other rotary retreatment systems, such as D-RaCe (FKG Dentaire, La Chaux-de-Fonds-Switzerland) and M-Two (VDW, Munich-Germany).\cite{13} However, a study of Rechenberg and Paqué\cite{23} in which the root canals were retreated using an association of Gates-Glidden and ProFile rotary instruments (Dentsply Maillefer) proved that both placing and removal of an endodontic filling are highly influenced by the cross-sectional root canal shape: According to the authors, during the retreatment procedures, the filling material can be transported to the noninstrumented flattened areas of the root canals.

As suggested in the previous studies,\cite{1,3,9,11,16} apical refinement is needed when PTR instruments are used because the D3 instrument has a diameter of size 20 at the tip. Although the 0.07 taper of a D3 instrument could perform an apical cleaning similar to size 40 SafeSider instrument,\cite{12} this instrument is designed only to reach the WL; thus, additional instrumentation is recommended to improve the removal of filling material in the apical third.\cite{13}

The apical size of re-preparation might also influence the cleaning in the apical third. Hülsmann and Bluhm\cite{11} showed less apical cleaning with ProTaper F3 when compared to a size 45 manual file. These results could be explained by the smaller diameter of the F3 ProTaper instrument (size 30), even if they present greater taper than the manual files. On the other hand, some studies reported that the apical cleaning of a ProTaper F3 was similar to a manual Hedström size 45,\cite{18} to size 40 rotary instruments such as ProFile, Hero, GT, and K3,\cite{15} and even significantly more effective than a size 35 manual file while removing filling material in the apical third.\cite{16} Aiming to prevent bias, in the present study, a manual size 50 Hedström file was the last instrument in the HF group, whereas, in the other two groups, the apical repreparation was performed up to a same size instrument, an F5 ProTaper. Even if the HF group presented greater amount of remaining filling, no significant difference was observed among the three groups in the apical third.

Before the introduction of the PTR instruments, the use of PTU showed a high incidence of fracture when using the shaping instruments (S1-S3) for the retreatment procedures.\cite{4} Therefore, only PTU Finishing instruments have been used for the filling removal.\cite{14,11,15} In this study, plastic deformation of some instruments was observed, and
they were replaced (two F2, 2nd use; one F2, 6th use; one F4, 2nd; one F4, 9th use, and one D1, 4th use); however, no fractures occurred in any group, corroborating previous authors.[11]

PTR instruments, such as other NiTi retreatment instruments, were introduced to make the filling removal faster and safer. The D1 instrument presents an active tip, facilitating the initial penetration into the filling material, and also a long pitch length, allowing higher cutting efficiency and a more efficient removal of debris. The other two PTR instruments (D2 and D3) present different features: They are more flexible, present longer lengths because they are meant to reach the apical third, and present shorter pitch lengths, since the lower volume of material does not require a substantial cutting efficacy.[24] Although the PTR features are consistent with their intended clinical application, due to their small apical tip diameter, a further apical preparation is required to improve cleanliness and shaping.[1, 13, 16] Moreover, since the time required and the amount of filling removal provided by the PTR and PTU was similar, it might be assumed that using only the PTU instruments for both filling removal and repreparation, could simplify the procedures by reducing the number of instruments, and also be less expensive for the clinician. Nevertheless, both tested rotary instruments showed to be safe in retreatment procedures since there was no loss of WL, deviations or perforations of the root canal, which is in agreement with previous studies.[1, 3, 9, 16]

Conclusion

Within the experimental conditions, it was observed that rotary instruments were more effective than Hedström manual files, considering both the time required for the retreatment as the amount of the filling removal; PTR and PTU rotary instruments were similarly effective.

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Conflicts of interest

There are no conflicts of interest.

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