EFECTIVENESS OF THE WAVEONE AND PROTAPER D SYSTEMS FOR REMOVING GUTTA-PERCHA WITH OR WITHOUT A SOLVENT


Department of Endodontics, Dental Research Center, São Leopoldo Mandic University, Campinas, SP, Brazil.

INTRODUCTION

Although endodontic treatments have a high success rate, they sometimes require a second intervention. Endodontic retreatment requires the complete removal of the filling material and access to the apical foramen for adequate cleansing and refilling of the root canal system. Conventional techniques using Gates-Glidden and manual files have been losing their popularity due to the need for solvents. More current techniques...
using motors facilitate endodontic retreatment and reduce working time.

Reciprocating systems were introduced with the aim of improving resistance to fracture, since the reciprocating motion reduces the cyclic and torsional fatigue to which the instrument is submitted. Furthermore, the instruments in these systems are made from an alloy subjected to a thermal treatment, known as M-Wire and considered more resistant than the conventional NiTi alloy. The WaveOne system (Dentsply Maillefer, Ballaigues, Switzerland) was designed specifically for use in reciprocating motion. It comprises three instruments: small (21.06), primary (25.08 in three first millimeters) and large (40.08 in three first millimeters). Reciprocating systems were not originally designed for use in retreatment procedures; nevertheless, Rios et al. compared the efficacy of two reciprocating systems and one rotary system in removing filling material from straight canals. They observed that the reciprocating systems and the rotary system tested were equally effective in removing filling material. Others studies have also compared reciprocating files in retreatment.

Zuolo et al. compared the effectiveness of a reciprocating system and a rotary system to that of a manual instrumentation technique in removing filling material from root canals. Chloroform was used as a solvent in all groups. The authors concluded that the operative time involved in using the reciprocating system with a solvent was significantly shorter than that required by the other systems tested. In spite of these results, no consensus has been reached to date on the effectiveness of reciprocating systems for endodontic retreatment procedures. The use of a solvent as an aid in removing the filling mass is also somewhat controversial. Some authors have suggested that its use could increase working time due to the formation of a residual slurry which adheres to the canal walls, whereas others do not confirm these results. Some authors point out that a solvent may be responsible for improved cleanliness of the root canal system, whereas others do not observe this correlation. Tagger’s hybrid filling technique was chosen to plasticize gutta-percha and produces good adaptation of the filling material to the canal walls. The purpose of this study was to evaluate the effectiveness of the WaveOne reciprocating system, with or without the use of a solvent, and compare it to that of the ProTaper D rotary system in removing filling material from straight canals. The time required by each retreatment technique was also determined and compared.

MATERIALS AND METHOD
Specimen preparation
All the specimens used in this study were obtained from the tooth bank at the Dental Research Center, São LeopoldoMandic University, Campinas, SP, Brazil. The study protocol was reviewed and approved by the Research Ethics Committee of the same institution (protocol no. 2012/0420). Forty extracted human mandibular premolars were used for this study. All teeth had a single, straight, flattened canal, a completely formed root and no calcification or internal resorption. The teeth were selected based on an evaluation of apical radiographs taken in orothoradial and mesiodistal direction. The teeth were preserved in a 0.1% thymol solution.

Initial endodontic treatment
A single operator instrumented the canals using the rotary technique. Pre-flaring was performed with Gates Glidden burs (Dentsply Maillefer) and the SX and S1 files of the ProTaper Universal rotary system. Apical preparation was performed with ProTaper S1, S2, F1 and F2 files. The canal was irrigated with 2 mL 2.5% sodium hypochlorite after each instrument change. Once the instrumentation was completed, the canal was irrigated with 17% EDTA (Fórmula e Ação) after each instrument change. The canals were dried with absorbent paper points and filled with ProTaper F2 gutta-percha cones (Dentsply Maillefer), accessory cones (Dentsply Maillefer), and AH plus sealer (Dentsply Maillefer) using Tagger’s hybrid technique, 1 mm short of the apical foramen. Filling quality was confirmed with periapical radiographs taken in the orothoradial and mesiodistal direction.
The coronal access was sealed with Cavit G temporary filling material (3M Espe, Seefeld, Germany), and the teeth were stored under 100% humidity for 30 days for subsequent removal of the root canal filling.

**Endodontic retreatment**

The 40 teeth were randomly divided into 4 groups with 10 specimens assigned to each group using a computerized algorithm. The crowns were removed and the roots were standardized at 16 mm to avoid any possible interferences related to canal access and crown anatomy. After filling the teeth, they were stored at 100% humidity for 30 days to ensure complete setting of the endodontic cement. After removing the temporary seal, the filling material was removed using one of the following techniques:

**Group 1, filling removal with ProTaper D** – The filling material was removed using ProTaper D1 and D2 retreatment files, in that order, up to the established working length. The files were driven by an X-Smart electrical motor (Dentsply Maillefer) in continuous rotation at a constant speed of 500 rpm for instrument D1, and 400 rpm for instrument D2, with a torque of 4 Ncm. After applying the last rotary instrument, canal patency was confirmed by introducing a #10 manual file up to the foramen.

**Group 2, filling removal with ProTaper D + chloroform** – The filling material was removed using a technique similar to that employed in Group 1; however, after using the D1 file, 0.1 mL chloroform (Fórmula e Ação) was placed in the canal with a micropipette (Digipet, Curitiba, PR, Brazil). The D2 instrument was then applied up to the working length.

**Group 3, filling removal with WaveOne** – Filling material removal was performed with the WaveOne primary instrument driven by the X-Smart Plus electrical motor in WaveOne system mode, according to the manufacturer’s instructions, with the reciprocating handpiece used with pecking motion. This instrument was inserted in 3 mm steps, always accompanied by irrigation, until the working length was reached. Canal patency was confirmed by inserting a #10 manual file up to the foramen.

**Group 4, filling removal with WaveOne + chloroform** – In this group, 0.1 mL chloroform was placed at the canal orifice, and the WaveOne primary instrument was then applied as in Group 3. Each file of the ProTaper system was discarded after use in 5 canals, and each file of the WaveOne system was discarded after use in 4 canals.

After each use, the instruments were thoroughly cleaned by removing any filling material residue. The irrigating solution used during retreatment was 2.5% sodium hypochlorite, with a total 20 mL per specimen. All teeth were retreated by a single operator. Filling material removal was considered completed when no filling material residue was observed on the endodontic instruments or detected inside the root canal with the operating microscope under 12.5X magnification.

The actual time spent on the removal procedure was measured and recorded for each specimen with a digital stopwatch. The stopwatch was started at the beginning of the filling removal procedure and stopped when it ended.

**Filling removal evaluation**

After completing the filling removal procedures, grooves were made along the long axis of the tooth in bucolingual direction, and the grooves were deepened with a diamond disc up to the vicinity of the canal wall. The specimens were then cleaved into two halves, mesial and distal, and both halves were assessed.

All of the specimens thus obtained were coded and photographed with a Canon T3I camera (Canon, Inc., Taichung City, Taiwan) and an F1.4 50 mm lens (Nagasaki Canon Inc., Nagasaki, Japan) coupled to an operating microscope set at a 5X magnification. Image Tool 3.00 software (University of Texas Health Science Center, San Antonio CA, USA) was used to measure both the canal area and the filling material remainder area, given in square pixels (Fig. 1). The data were converted into percentages to allow a comparison among techniques employed and among specimens with different areas.

**Statistical analysis**

The Kruskal-Wallis test was used to compare the amount of remaining filling material and the time required for the filling removal procedure in the different study groups (p < 0.05).
RESULTS
All teeth examined showed some amount of residual filling material inside the canals. The amount of filling remainder in each group is shown in Table 1. There was no significant difference between groups regarding the amount of residual filling material (p > 0.05). Table 2 shows that the operative time required in Group 3 was significantly longer than that required in groups 1, 2 and 4 (p < 0.05). There was no significant difference between groups 1, 2 and 4 as regards operative time.

DISCUSSION
The complete removal of filling material from the root canal system is one of the main objectives of nonsurgical endodontic retreatment. Only by attaining this goal can the apical foramen be accessed and the action of endodontic instruments and irrigating solutions used during instrumentation be effective, preventing the necrotic tissue and microorganisms from remaining inside the canal3.

We chose to work with mandibular premolars because they are flattened mesiodistally and have a greater buccolingual dimension, making it harder for endodontic instruments to touch all of the dentinal walls20. Thus, adequate removal of the filling material in these canals is also rendered more difficult21, a fact that cannot be ignored when comparing the effectiveness of filling removal techniques.

The use of a solvent as an aid in removing the filling mass is somewhat controversial. A solvent can facilitate penetration of the instrument into the filled canal24,25, but its use may result in the formation of a thin and hard-to-remove layer of filling material adhered to the dentinal walls11,12. Chloroform is the most widely used solvent, and it is ability to dissolve gutta-percha is superior to that of most other solvents25. Furthermore, it can be safely used in endodontic procedures owing to its limited toxicity.

None of the techniques employed in this study was effective in completely removing filling material, confirming the results obtained in previous studies9,10,21,23. However, the working time required in Group 3 was significantly longer than that required in groups 1, 2 and 4.

The first instrument (D1) in Group 1 (ProTaper D without solvent) has a working tip which makes it easier for it to penetrate the filling mass. The following instrument (D2) penetrates the filling material and causes it to be removed en bloc. This may explain the shorter working time recorded for this system compared to Group 3 (WaveOne without solvent). However, it is important to note that, owing to its working tip, instrument D1 may only be used safely in straight canals; its use in curved canals may cause deviations from the canal’s original path.

![Fig. 1: Evaluation of filling material remainder.](image)

Table 1: Means and standard deviations of residual filling material (expressed as percentage area) on canal walls after application of the filling material removal methods.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Proportion (%) of residual material in relation to canal total area</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>3.08 (2.11)</td>
</tr>
<tr>
<td>2</td>
<td>2.08 (1.25)</td>
</tr>
<tr>
<td>3</td>
<td>1.45 (0.86)</td>
</tr>
<tr>
<td>4</td>
<td>2.52 (3.28)</td>
</tr>
<tr>
<td>p value</td>
<td>0.2431</td>
</tr>
</tbody>
</table>

Table 2: Means and standard deviations of the time (in seconds) required for the filling removal procedure in the different study groups (p < 0.01).

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>285.40</td>
<td>327.50</td>
<td>676.00</td>
<td>372.70</td>
</tr>
<tr>
<td>(64.33)a</td>
<td>(49.14)b</td>
<td>(218.36)b</td>
<td>(141.95)a</td>
</tr>
</tbody>
</table>

Different letters indicate significant statistical difference (p < 0.01).
Even though a solvent softens gutta-percha, no statistically significant difference was observed between Group 1 (ProTaper D without solvent) and Group 2 (ProTaper D with solvent) as regards operative time, confirming the results of previous studies\textsuperscript{12,13}. This may be explained by the effectiveness of the ProTaper D system in removing the filling mass, rendering it unnecessary to use a solvent to soften the gutta-percha\textsuperscript{12}. These results differ from those of the study conducted by Takahashi et al.\textsuperscript{11}, in which using a solvent increased the working time required by the ProTaper D system to remove the filling material.

The longer working time was recorded for Group 3 (WaveOne without solvent). This may be explained by the difficulty, perceived by the operator, in introducing the WaveOne primary instrument into the filling mass. The use of a solvent with this system (Group 4) softened the gutta-percha, rendering instrument penetration easier, thus significantly reducing working time.

Even though the solvent used here proved beneficial in reducing operative time with the WaveOne system, the use of solvents in general should be undertaken in a controlled manner owing to the risk of extrusion into the periapical region. Furthermore, studies have shown that single-file systems working in reciprocating motion produce significantly more debris then systems working in continuous rotation during the canal instrumentation phase. This could therefore be hypothesized that combining the use of solvents with reciprocating systems might aggravate the risk of extrusion.

Comparing the effectiveness of a manual instrumentation technique to that of the Mtwo rotary system (VDW, Munich, Germany) and of the Reciproc (VDW) reciprocating system in removing filling material with the use of chloroform, Zulo et al.\textsuperscript{10} observed that operative time was significantly shorter in the reciprocating system than in the other techniques. In contrast, our study found no significant difference in operative time between the ProTaper D and WaveOne systems (with solvent). This discrepancy is probably related to the fact that Zulo et al.\textsuperscript{10} used a sequence of 4 instruments of the Mtwo system, in addition to Mtwo R instruments (15.05 and 25.05), to reinstrument the canals, whereas we used a sequence of only 2 instruments of the ProTaper D system in the present study.

Considering that reciprocating systems are specifically designed to reduce the taper-lock effect, hence imparting greater safety to the instrumentation procedure\textsuperscript{6,7}; and, further, that three clockwise and counterclockwise motions are required to complete a whole turn of the instrument inside the canal, it could be assumed that reciprocating systems would be in disadvantage compared to rotary systems in terms of filling removal operative time. This alleged disadvantage seemed to have been reflected in our results, since the working time for Group 3 (WaveOne without solvent) was the longest. On the other hand, reciprocating systems are more resistant to fracture, and thus safer, particularly in retreatment of curved canals. We conclude that the WaveOne system and the ProTaper D system were equally effective, with or without a solvent, in removing filling material. Removing the filling material from the canals took significantly longer in Group 3 (WaveOne without solvent) than in the other groups.

CORRESPONDENCE
Dr. Aline Godoy
Av. Dr. Renato de Toledo Porto, número 481-Santa Marta, São Carlos-SP Brasil.
aline_god@hotmail.com

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Acta Odontol. Latinoam. 2016 ISSN 1852-4834
Vol. 29 Nº 3 / 2016 / 262-267


