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

Ana Paula M. Colombo, Carlos E. Fontana, Aline Godoy, Alexandre S. De Martin, Augusto S. Kato, Daniel G-P. Rocha, Rina A. Pelegrine, Carlos E. S. Bueno

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

ABSTRACT

Endodontic retreatment requires complete removal of the filling material and access to the apical foramen. The purpose of this study was to evaluate the effectiveness of the WaveOne reciprocating system and compare it to the ProTaper D rotary system, with or without the use of a solvent, in removing filling material from root canals. The time required for each filling removal technique employed was also determined and compared. Forty extracted human mandibular premolars with a single, straight, flattened canal were prepared and filled. They were divided into four groups (n = 10): Group 1: ProTaper D NiTi rotary instruments; Group 2: ProTaper D NiTi rotary instruments, with a solvent; Group 3: WaveOne primary instrument; and Group 4: WaveOne primary instrument, with a solvent. The teeth were then split along their long axis and photographed using an operating microscope with 5X magnification. The amount of remaining filling material was assessed with Image Tool software. The results were compared using the Kruskal-Wallis test ($p < 0.05$). There was no significant difference between groups regarding the amount of residual filling material ($p > 0.05$). Operative time was significantly longer in Group 3 than in groups 1, 2 and 4 ($p < 0.05$). The WaveOne system and the ProTaper D system were equally effective, with or without a solvent. The time required to remove the filling material from the canals was significantly longer in Group 3 than in the other groups.

Key words: *Gutta-Percha; root canal; reciprocating.*

EFICIÊNCIA DOS SISTEMAS WAVEONE E PROTAPER D NA REMOÇÃO DE GUTA-PERCHA COM OU SEM USO SOLVENTE

RESUMO

No retratamento endodôntico, a completa remoção do material obturador e o acesso ao forame apical são necessários para permitir a limpeza do sistema de canais. O propósito deste estudo foi avaliar a eficácia do sistema reciprocante WaveOne e compará-la ao sistema rotatório ProTaper Universal, com ou sem o uso de solvente, na remoção do material obturador.O tempo necessário a cada técnica empregada foi determinado e comparado. Quarenta pré-molares inferiores humanos extraídos com canal único, reto e achatado foram preparados e obturados. Foram então divididos em quatro grupos (n = 10) de acordo com o sistema utilizado, como segue. Grupo 1: ProTaper D Niti; Grupo 2: Sistema ProTaper D com solvente; Grupo 3: Sistema WaveOne instrumento Primary; e Grupo 4: Sistema WaveOne instrumento Primary com solvente, sendo o tempo registrado. Os dentes foram clivados longitudinalmente e fotografados utilizando microscópio operatório com aumento de 5 vezes.A quantidade de material remanescente foi avaliada com o uso do software Image Tool 3.0. Os resultados foram comparados utilizando o teste de Kruskal-Wallis($p < 0.05$). Em relação aos resultados, não houve diferença significativa entre os grupos quanto à quantidade de material obturador residual ($p > 0.05$). O tempo operatório no Grupo 3 foi significativamente maior do que nos grupos 1, 2 e 4 ($p < 0.05$).O sistema WaveOne foi tão efetivo quanto o ProTaper D, com ou sem solvente.tempo necessário à desobturação dos canais no Grupo 3 (WaveOne sem solvente) foi significativamente maior do que nos demais grupos.

Palavras-chave: *Guta-percha; canal radicular; movimento reciprocante.*

INTRODUCTION

Although endodontic treatments have a high success rate, they sometimes require a second intervention[1,2]. 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[3].

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[4] with the aim of improving resistance to fracture, since the reciprocating motion reduces the cyclic and torsional fatigue to which the instrument is submitted[5,6] .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[7]. 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 milimeters) and large (40.08 in three first millimeters)[8].

Reciprocating systems were not originally designed for use in retreatment procedures; nevertheless, Rios et al.[9] 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 [26,27].

Zuolo et al.[10] 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[11], whereas others do not confirm these results[12,13]. Some authors point out that a solvent may be responsible for improved cleanliness of the root canal system [14], whereas others do not observe this correlation[13,15].

Tagger's hybrid filling technique was chosen to plasticize gutta-percha and produces good adaptation of the filling material to the canal walls[16].

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 orthoradial and mesiodistal direction. The teeth were preserved in a 0.1% thymol solution (Fórmula e Ação, São Paulo, SP, Brazil).

The crowns were removed with a diamond disc (KG Sorensen, Cotia, SP, Brazil), and root length was standardized at 16 mm. A #10 K-type file (Dentsply Maillefer) was then inserted into the canal until it could be seen at the apical foramen with an operating microscope (D. F. Vasconcelos, São Paulo, SP, Brazil) at 5X magnification. The working length was determined 1 mm short of this measurement.

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 (Fórmula e Ação) after each instrument change. Once the instrumentation was completed, the canal was irrigated with 17% EDTA (Fórmula e Ação) for 3 minutes followed by 5 mL 2.5% sodium hypochlorite.

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[16], 1 mm short of the apical foramen. Filling quality was confirmed with periapical radiographs taken in the orthoradial 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[11,14,21]. After filling the teeth, they were stored at 100% humidity for 30 days to ensure complete setting of the endodontic cement[22,23]. 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[11,17,18] , and each file of the WaveOne system was discarded after use in 4 canals[19].

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[10].

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 canal[3].

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 walls[20]. Thus, adequate removal of the filling material in these canals is also rendered more difficult[21], 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 canal[24,25], but its use may result in the formation of a thin and hard-to-remove layer of filling material adhered to the dentinal walls[11,12]. Chloroform is the most widely used solvent, and it is ability to dissolve gutta-percha is superior to that of most other solvents[25]. 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 studies[9,10,21,23]. 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.

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.

Groups	Proportion (%) of residual material in relation to canal total area
1	3.08 (2.11)
2	2.08 (1.25)
3	1.45 (0.86)
4	2.52 (3.28)
p value	0.2431

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

Group 1	Group 2	Group 3	Group 4
285.40 (64.33)[a]	327.50 (49.14)[a]	676.00 (218.36)[b]	372.70 (141.95)[a]

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[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[12]. These results differ from those of the study conducted by Takahashi et al.[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. It 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, Zuolo et al.[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 Zuolo et al.[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[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

REFERENCES

1. Ricucci D, Siqueira JF Jr. Recurrent apical periodontitis and late endodontic treatment failure related to coronal leakage: a case report.. J Endod 2011; 37: 1171-1175.
2. Vieira AR, Siqueira JF Jr, Ricucci D, Lopes WS. Dentinal tubule infection as the cause of recurrent disease and late endodontic treatment failure: a case report. J Endod 2012; 38: 250-254.
3. Torabinejad M, Corr R, Handysides R, Shabahang S. Outcomes of nonsurgical retreatment and surgery: a systematic review. J Endod 2009; 35: 930-937.
4. Yared G. Canal preparation using only one Ni-Ti rotator instrument. Int Endod J 2008; 41: 339-344.
5. Gavini G, Caldeira CL, Akisue E, Candeiro GT, Kawakami DA. Resistance to flexural fatigue of Reciproc R25 files under continuous rotation and reciprocating movement. J Endod 2012; 38: 684-687.
6. Kim HC, Kwak SW, Cheung GS, Ko DH, Chung SM, Lee W. Cyclic fatigue and torsional resistance of two new nickel-titanium instruments used in reciprocation motion: Reciproc versus WaveOne. J Endod 2012; 38: 541-544

7. Plotino G, Grande NM, Testarelli L, Gambarini G. Cyclic fatigue of Reciproc and WaveOne reciprocating instruments. Int Endod J 2012; 45: 614-618.
8. Webber J, Machtou P, Pertot W, Kutter S, Ruddle C, West J. The WaveOne single-file reciprocating system. Roots 2011; 1:28-33. http://www.endoexperience.com/documents/WaveOne.pdf
9. Rios MA, Villela AM, Cunha RS, Velasco RC, De Martin AS, Kato AS, Bueno CE. Efficacy of 2 reciprocating systems compared with a rotary retreatment system for gutta-percha removal. J Endod 2014; 40: 543-546.
10. Zuolo AS, Mello JE Jr, Cunha RS, Zuolo ML, Bueno CE.Efficacy of reciprocating and rotary techniques for removing filling material during root canal retreatment. Int Endod J 2013; 46: 947-943.
11. Takahashi CM, Cunha RS, De Martin AS, Fontana CE, Silveira CF, da Silveira Bueno CE. In vitro evaluation of the effectiveness of ProTaper universal rotary retreatment system for gutta-percha removal with or without a solvent. J Endod 2009; 35: 1580-1583.
12. Kfir A, Tsesis I, Yakirevich E, Matalon S, Abramovitz I.The efficacy of five techniques for removing root filling material: microscopic versus radiographic evaluation. Int Endod J 2012; 45: 35-41.
13. Hülssmann M, Bluhm V. Efficacy, cleaning ability and safety of different rotary NiTi instruments in root canal retreatment. Int Endod J 2004; 37: 468-476.
14. Ferreira JJ, Rhodes JS, Pitt Ford TR. The efficacy of gutta-percha removal using Profiles. Int Endod J 2001; 34: 267-274.
15. Wilcox LR. Endodontic retreatment with halothane versus chloroform solvent. J Endod 1995; 21: 305-307.
16. Tagger M, Tamse A, Katz A, Korzen B. Evaluation of the apical seal produced by a hybrid root canal filling method, combining lateral condensation and thermatic compaction. J Endod 1984; 10: 299-303.
17. Marques da Silva B, Baratto-Filho F, Leonardi DP, Henrique Borges A, Volpato L, Branco Barletta F. Effectiveness of ProTaper, D-RaCe, and Mtwo retreatment files with and without supplementary instruments in the removal of root canal filling material.Int Endod J 2012; 45: 927-932.
18. Abramovitz I, Relles-Bonar S, Baransi B, Kfir A.The effectiveness of a self-adjusting file to remove residual gutta-percha after retreatment with rotary files. Int Endod J 2012; 45: 386-392.
19. Bürklein S, Schäfer E. Apically extruded debris with reciprocating single-file and full-sequence rotary instrumentation systems. J Endod 2012; 38: 850-852.
20. Alves FR, Rôças IN, Almeida BM, Neves MA, Zoffoli J, Siqueira JF Jr. Quantitative molecular and culture analyses of bacterial elimination in oval-shaped root canals by a single-file instrumentation technique.Int Endod J 2012, 45: 871-877.
21. Masiero AV, Barletta FB. Effectiveness of different techniques for removing gutta-percha during retreatment. Int Endod J 2005; 38: 2-7.
22. Ersev H, Yılmaz B, Dinçol ME, Dağlaroğlu R.The efficacy of ProTaper Universal rotary retreatment instrumentation to remove single gutta-percha cones cemented with several endodontic sealers.Int Endod J 2012; 45: 756-762.
23. Bramante MB, Fidelis NS, Assumpção TS, Bernardinelli N, Garcia RB, Bramante AS, Moraes IG. Heat release, time required, and cleaning ability of Mtwo R and ProTaper universal retreatment systems in the removal of filling material. J Endod 2010; 36: 1870-1873.
24. Dezan Júnior E, Holland R, Lopes HP. Retratamento endodôntico: avaliação da qualidade de resíduos após a desobturação com ou sem o uso de solvente. Rev Bras Odontol 1995; 52: 2-5.
25. Barletta FB, de Sousa Reis M, Wagner M, Borges JC, Dall'Agnol C. Computed tomography assessment of three techniques for removal of filling material. Aust Endod J. 2008 34:101-105.
26. Hunter KR, Doblecki W, Pelleu GB Jr. Halothane and Eucalyptol as alternative to chloroform for softening gutta-percha. J Endod 1991; 17: 310-313.
27. Silva EJ, Orlowsky NB, Herrera DR, Machado R, Krebs RL, Coutinho-FilhoTde S. Effectiveness of rotatory and reciprocating movements in root canal fillingmaterial removal. Braz Oral Res. 2015; 29:1-6.