

## Original Article

# Comparison of full rotation and reciprocating movements in regaining apical patency during endodontic retreatment

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### ABSTRACT

**Background:** This study aimed to compare the continuous rotation and reciprocating movements of rotary files in achieving apical patency in root canal retreatment.

**Materials and Methods:** This *in vitro*, experimental study evaluated 64 extracted mandibular molars. The teeth were prepared up to F3 with ProTaper Universal and obturated using lateral compaction technique. The teeth were divided into four groups ( $n = 16$ ) based on the mesiobuccal canal curvature (Schneider's method) and type of rotational movement. Groups 1 and 2 included straight canal teeth retreated with WaveOne Gold and ProTaper Universal Retreatment system, respectively. Groups 3 and 4 included teeth with moderately curved root canals retreated with WaveOne Gold and ProTaper Universal, respectively. Apical patency was ensured by observing the tip of a hand K-file at the apical foramen. Data were analyzed using the Fisher's exact test.  $P < 0.05$  was considered statistically significant.

**Results:** Apical patency was successfully achieved in all 16 teeth in group 1 (100%) and 15 teeth in group 2 (93.75%). No significant difference was noted between continuous rotation and reciprocating movements in straight canals ( $P = 1.00$ ). Apical patency was successfully achieved in 15 teeth in group 3 (93.75%) and 12 teeth in group 4 (75%). No significant difference was noted between continuous rotation and reciprocating movements in moderately curved canals either ( $P = 0.333$ ).

**Conclusion:** Both continuous rotation and reciprocating movements are equally effective in achieving apical patency in straight or moderately curved mesiobuccal canal of mandibular molars.

**Key Words:** Retreatment, root canal preparation, rotation

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## INTRODUCTION

Root canal treatment is not always successful. Despite all advances in endodontic diagnosis and treatment, undesired outcomes are still a common occurrence.<sup>[1]</sup> Substandard treatments often lead to failure. However, ideal treatments may also fail in some cases mainly due to microbial contamination. Microbial contamination of the root canal system can extend into the peri-radicular and periapical tissues.

Elimination of this contamination requires re-cleaning and disinfection of the root canal system.<sup>[2]</sup>

Nonsurgical root canal retreatment has some problems such as presence of root filling material in the canal that serves as a mechanical barrier against irrigating solutions, intracanal medicaments and mechanical root canal cleaning.<sup>[3]</sup> Furthermore, the presence of root filling material prevents achieving

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and maintaining root canal patency. Thus, one of the main goals of endodontic retreatment is to completely eliminate the root canal filling materials to access the apical foramen and enable complete re-cleaning and re-shaping of the entire root canal system.

The patency maneuver refers to establishing a communication path between the access cavity and peri-radicular space through the apical foramen. According to Buchanan,<sup>[4]</sup> apical patency refers to passively moving a small K-file through the apical constriction to prevent accumulation of debris in the apical part of the canal.<sup>[5]</sup> This also leads to better distribution of irrigating solutions in the apical third of the canal and achieving a better apical seal by gutta-percha.<sup>[5,6]</sup>

The results of previous studies on achieving an apical patency have been controversial. Some believe that apical patency is not necessarily required in root canal treatment,<sup>[7]</sup> while some others reported that apical preparation and accessing the peri-radicular space (by obtaining patency) is a major factor preventing treatment failure in primary root canal treatment or retreatment. It has been reported that achieving apical patency is correlated with lower postoperative pain.<sup>[8]</sup> Authors that believe that apical patency is not necessary mainly assessed primary endodontic treatment of teeth with vital pulp, which are free from microbial contamination and have a sound peri-radicular tissue.<sup>[9]</sup> In such cases, it is recommended to prepare the root canal 1–2 mm shorter than the radiographic apex and maintain a pulp stump at the apical end.<sup>[10]</sup>

Since failed root canal treatments are often associated with periodontitis or peri-radicular abscess, accessing the peri-radicular area in such cases for the elimination of microbial contamination plays a pivotal role in determining the treatment success.<sup>[11,12]</sup>

Several materials have been proposed for obturation of root canals. Gutta-percha and sealer are most commonly used for this purpose. Previously, manual files along with heat and/or solvent were commonly used for removal of gutta-percha from the canal. Other tools such as ultrasonic, laser, and nickel–titanium (NiTi) rotary files have also been used for this purpose. Rotary files were first used for cleaning and shaping of the canal in primary endodontic treatment. However, at present, they are increasingly used for removal of root filling material due to their high efficacy, safety and high-speed,

compared with other methods especially when used in combination with solvent.<sup>[13]</sup> The friction heat generated by file rotation is another reason for higher speed and efficacy of rotary files. In addition, rotary files can more effectively remove physical barriers in the canal and obtain apical patency more efficiently and with higher level of safety.<sup>[3,13]</sup>

Several rotary files have been compared for their ability in removal of gutta-percha from the root canal system. ProTaper Universal is a NiTi rotary file commonly used for endodontic treatment and retreatment. ProTaper files with triangular cross-section, cutting edges and a relatively cutting tip have variable taper along the file length. Thus, they are faster than manual files in removal of gutta-percha from the root canal. This file system has continuous rotation movement.<sup>[14]</sup> The ProTaper Universal Retreatment system has three files with variable degrees of taper and tip size, designed for the removal of gutta-percha in three steps, from the coronal, middle and apical thirds, in an orderly manner.<sup>[15]</sup>

In the recent years, rotary files with reciprocating movement have also been used in endodontic treatment. Several studies have been conducted aiming to compare the properties and performance of the conventional rotary files with continuous rotation movement and rotary files with reciprocating movement. Evidence shows advantages such as longer clinical service due to less cyclic fatigue, lower flexural stresses, less root canal deformation, and faster root canal preparation for the latter group.<sup>[16,17]</sup> WaveOne and Reciproc are two main rotary file systems with reciprocating movement.<sup>[18]</sup> WaveOne Gold also has a reciprocating movement similar to that of WaveOne but with different dimensions and geometry. It has improved physical properties such as 80% higher flexibility, 50% higher resistance to cyclic fatigue, and 23% higher efficacy than WaveOne.<sup>[16,18]</sup> These files have also been used for endodontic retreatment. This study aimed to assess and compare the continuous rotation and reciprocating movements in achieving apical patency in endodontic retreatment of mandibular molars.

## MATERIALS AND METHODS

This *in vitro*, experimental study evaluated 64 mandibular molars extracted for purposes not related to this study. The study was approved by the

Ethics Committee of Dental School of Islamic Azad University, Khorasgan Branch (23810201962093). Sample size was calculated to be 16 in each group according to a pilot study on 12 teeth assuming  $\alpha = 0.05$ , study power of 80%, and the efficacy of WaveOne Gold and ProTaper Universal in obtaining patency to be 100% ( $n = 12$ ) and 67% ( $n = 8$ ), respectively.

The extracted mandibular molar teeth with mature apices, no root resorption, no calcification, and no fracture were enrolled. Furthermore, teeth without mesiobuccal canal patency for any reason or undetectable apical foramen were excluded.

The collected teeth were first immersed in 5.25% sodium hypochlorite solution for disinfection and then underwent periapical radiography to exclude teeth with root resorption, calcification or fracture. Of the collected 64 eligible teeth, 32 had straight and 32 had moderately curved (mean degree of curvature of  $16^\circ$ ) mesiobuccal canal, determined according to the Schneider's method.<sup>[19]</sup> The teeth were stored in saline at  $4^\circ\text{C}$  until the experiment.

All teeth were prepared by the same operator (senior postgraduate student of endodontics). Access cavity was prepared using a #141 fissure bur with a noncutting tip (Jota, Switzerland). First, the mesiobuccal canal path was prepared using hand K-files (Mani, Japan) with a size corresponding to the canal diameter (#10 or #15). A periapical radiograph was obtained when the file tip reached the apex. Working length was determined 1 mm shorter than the radiographic apex. In order to obtain a coronal reference and also for straight positioning of rubber stops of the files, the crown was cut at the mesiobuccal area.

Next, the root canal was prepared by ProTaper Universal rotary file system according to the manufacturer's instructions by the single-length technique. For this purpose, SX, S1, S2, F1, and F2 files were used in an orderly manner to clean and shape the root canal. Eventually, F3 file was considered as the master apical rotary file. Root canal irrigation was performed between filings using 5.25% sodium hypochlorite solution and saline. A hand-piece driven by an electric endodontic motor with a controlled torque (Xsmart Plus, Dentsply Maillefer, Germany) was also used. The speed and torque of the device were adjusted according to the

manufacturer's instructions, which were 300 rpm and 4 N/cm, respectively for ProTaper Universal. After final irrigation, drying of root canals with paper points (Gapadent Ltd., Korea) and dry reaming, the canals were filled with gutta-percha and AH-26 sealer (Dentsply Maillefer, USA) using lateral compaction technique. To ensure optimal quality of filling, a periapical radiograph was obtained in buccolingual direction.

The canal orifice was temporarily restored with Coltosol (Coltene, Altstätten, Switzerland) with 3 mm thickness and the apices were sealed with wax. The teeth were incubated (Memmert Oven INB200, Germany) at  $37^\circ\text{C}$  and 100% humidity for 1 month.

Next, endodontically treated teeth were randomly divided into four groups of 16 as follows:

Group 1: Teeth with straight mesiobuccal canals retreated with WaveOne Gold

Group 2: Teeth with straight mesiobuccal canals retreated with Retreatment ProTaper Universal

Group 3: Teeth with moderately curved mesiobuccal canals retreated with WaveOne Gold

Group 4: Teeth with moderately curved mesiobuccal canals retreated with Retreatment ProTaper Universal

All teeth underwent retreatment as follows:

First, the temporary restoration was removed by a #3 carbide round bur (Jota, Switzerland) and low-speed hand-piece. Next, a #3 Gates-Glidden drill (Mani, Japan) was used to remove 2 mm of gutta-percha from the canal orifice. Afterward, 2 drops of chloroform (Golchai, Iran) as solvent were dripped into the canal orifice and allowed to work for 1 min. Next, the teeth in groups 1 and 3 underwent endodontic retreatment using small size WaveOne Gold file with #20 tip size and 7% taper (Dentsply Maillefer, Switzerland) with maximum speed of 350 rpm and 5 N/cm torque with up-and-down movements within 3 mm range and gentle apical pressure according to the manufacturer's instructions. The file was proceeded into the canal to the working length. Each file was discarded after being used for 3 canals. In addition, the files were replaced with a new file if wear or flute opening was noticed.

The teeth in groups 2 and 4 underwent endodontic retreatment using ProTaper Universal Retreatment

rotary system with D1, D2, and D3 files (Dentsply Maillefer, Switzerland) with maximum speed of 500 rpm and 4 N/cm torque with the crown-down technique according to the manufacturer's instructions. D1 file was first used for the coronal third of the canal. Then, D2 was used for the middle third and D3 was finally used for the apical third until D3 reached the working length.

The files were replaced as explained for the WaveOne Gold system. A gauze dipped in alcohol was used to clean the file flutes during the process. The apical part of the canal in all four groups was prepared using a file with #20 tip size (D3 file of Retreatment ProTaper Universal has a tip size of 20 and 7% taper similar to the small file of WaveOne Gold). The files in the two systems were standardized as such.

Apical patency of all teeth was then evaluated one by one using a #15 hand K-file (Mani, Japan). The success criterion was observation of the file tip at the apical foramen.

Data were analyzed using the Fisher's exact test through SPSS version 22 (SPSS Inc., IL, USA) at 0.05 level of significance.

## RESULTS

Table 1 presents the efficacy of ProTaper Universal and WaveOne Gold in achieving apical patency in endodontic retreatment of straight canals. As shown, in the use of ProTaper Universal, apical patency was achieved in 93.75% of the cases. This rate was 100% for WaveOne Gold. The difference in this respect was not significant between the two file systems ( $P = 1.00$ ).

Table 2 presents the efficacy of ProTaper Universal and WaveOne Gold in achieving apical patency in endodontic retreatment of moderately curved canals. As shown, ProTaper Universal was successful in achieving apical patency in 75% of the teeth with moderately curved canals. This rate was 93.75% for the WaveOne Gold. The difference in this respect was not significant between the two file systems ( $P = 0.333$ ).

Table 3 presents the frequency of procedural errors in endodontic retreatment of teeth in use of ProTaper Universal and WaveOne Gold rotary systems.

## DISCUSSION

This study compared the continuous rotation and reciprocating movements of rotary files in

**Table 1: Efficacy of ProTaper Universal and WaveOne Gold in achieving apical patency in endodontic retreatment of straight canals**

File system	Apical patency	n (%)
ProTaper Universal	Absence	1 (6.25)
	Presence	15 (93.75)
WaveOne Gold	Absence	0 (0)
	Presence	16 (100)

**Table 2: Efficacy of ProTaper Universal and WaveOne Gold in achieving apical patency in endodontic retreatment of moderately curved canals**

File system	Apical patency	n (%)
ProTaper Universal	Absence	4 (25.0)
	Presence	12 (75.0)
WaveOne Gold	Absence	1 (62.25)
	Presence	15 (93.75)

achieving apical patency in endodontic retreatment. The results showed that both file systems were completely capable of achieving apical patency in straight canals with no significant difference between them ( $P = 1.00$ ). In moderately curved canals, reciprocating movement had higher efficacy in achieving apical patency than the continuous rotation movement; however, this difference did not reach statistical significance ( $P = 0.333$ ). This superiority can be attributed to the inherent properties of the reciprocating movement, which is similar to the balanced force rotation of manual files (back and forth reciprocating rotation), and better maintains the centering ratio of the file in the original canal path and reaching the apical foramen.<sup>[20]</sup> The success rate in achieving apical patency was 100% in straight canals retreated with reciprocating movement of WaveOne Gold file.

To the best of the authors' knowledge, no similar previous study is available comparing continuous rotation and reciprocating movements of files in achieving apical patency in endodontic retreatment. One previous study assessed the apical patency in endodontic retreatment using reciprocating movement of a rotary file versus hand files.<sup>[3]</sup> They reported 100% success rate of reciprocating movement in achieving apical patency, which was in agreement with our findings.

Molar teeth with straight and moderately curved mesiobuccal canals were evaluated in our study. Most previous studies on endodontic retreatment used single-root and single-canal teeth.<sup>[3,21]</sup> However,

**Table 3: Frequency of procedural errors in endodontic retreatment of teeth in use of ProTaper Universal and WaveOne Gold rotary systems**

Type of error	Straight canals		Moderately curved canals	
	ProTaper, n (%)	WaveOne Gold, n (%)	ProTaper, n (%)	WaveOne Gold, n (%)
Zippering	1 (100.0)	0	1 (25.0)	0 (0.0)
Ledge	0 (0.0)	0	2 (50.0)	1 (100.0)
Separated instrument	0 (0.0)	0	1 (25.0)	0 (0.0)

the main problem in obtaining patency in endodontic treatment or retreatment is related to curved canals. Our study showed that by an increase in canal curvature, the difference between the continuous rotation and reciprocating movements, and the frequency of procedural errors increased as well.

In terms of mechanical properties, ProTaper files have a convex, triangular cross-section and due to variable taper along their cutting blade as well as the presence of sharp edges (with positive cutting angles around 60° in size), they have a tendency to remove more dentin from the external wall of the curved canals.<sup>[22,23]</sup> Such a tendency for proceeding in a straight path, in combination with lower flexibility than WaveOne Gold, explain further deviation from the canal curvature. For instance, the frequency of root canal path obstruction due to ledge formation in moderately curved ProTaper group was twice the rate in moderately curved WaveOne Gold group. In all four groups, all cases of zippering occurred in use of ProTaper system. WaveOne Gold files undergo heating followed by gradual cooling (heat treatment process) in their manufacturing process, which improves their physical properties and confers higher flexibility and resistance to cyclic fatigue to these files compared with other NiTi alloys.<sup>[16]</sup>

Chloroform solvent was used prior to the use of both systems in this study. It seems that WaveOne Gold files are more dependent on softening of gutta-percha (by the activity of chloroform) than ProTaper Universal, for two reasons. The first reason is due to the lower cutting efficiency of WaveOne Gold, which was explained earlier. The second reason is due to the direction of movement of debris. In use of ProTaper Universal, as the file proceeds towards the apex, extrusion of debris (gutta-percha) occurs toward the coronal, which enhances the penetration of the file.<sup>[15]</sup> Since the solvent has a limited penetration depth into gutta-percha, as the WaveOne Gold proceeds towards the apex, its speed decreases, which also explains the longer time required for obtaining apical patency by this file system. In order to speed up

the process of removal of gutta-percha from the canal with WaveOne Gold, it is recommended to refresh chloroform solvent in the canal as the file proceeds into the canal. However, considering the toxicity of chloroform and risk of its extrusion through the apical foramen, necessary measures should be taken to prevent such accidents. Further studies are required regarding apical patency in root canal treatment by the use of other rotary file systems. In addition, in order to assess the role of apical patency in clinical success of endodontic retreatment, the outcome of endodontic retreatment in teeth with apical periodontitis (with/without apical patency) should be compared in future studies.

## CONCLUSION

Within the limitations of this *in vitro* study, the results showed that both continuous rotation and reciprocating movements were equally effective in achieving apical patency in straight or moderately curved mesiobuccal canals of mandibular molars. By an increase in degree of canal curvature, the reciprocating movement was more successful than the continuous rotation for this purpose, but not significantly.

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## Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

## REFERENCES

1. Siqueira Jr. JF. Aetiology of root canal treatment failure: Why well-treated teeth can fail. *Int Endod J* 2001;34:1-6.
2. Agrafioti A, Koursoumis AD, Kontakiotis EG. Re-establishing apical patency after obturation with gutta-percha and two novel calcium silicate-based sealers. *Eur J Dent* 2015;9:457-61.
3. Trierveiler Paiva RC, Solda C, Vendramini F, Vanni JR, Baldissarelli Marcon F, João Fornari V, *et al.* Regaining apical patency with manual and reciprocating instrumentation during retreatment. *Iran Endod J* 2018;13:351-5.

4. Buchanan LS. The art of endodontics: Cleaning and shaping the root canal system. The apical preparation. Part IV of a four-part series on cleaning and shaping root canals. *Dent Today* 1994;13:50, 52.
5. Mohammadi Z, Jafarzadeh H, Shalavi S, Kinoshita JI. Establishing apical patency: To be or not to be? *J Contemp Dent Pract* 2017;18:326-9.
6. Vera J, Hernández EM, Romero M, Arias A, van der Sluis LW. Effect of maintaining apical patency on irrigant penetration into the apical two millimeters of large root canals: An *in vivo* study. *J Endod* 2012;38:1340-3.
7. Machado R, Ferrari CH, Back E, Comparin D, Tomazinho LF, Vansan LP. The impact of apical patency in the success of endodontic treatment of necrotic teeth with apical periodontitis: A brief review. *Iran Endod J* 2016;11:63-6.
8. Yaylali IE, Demirci GK, Kurnaz S, Celik G, Kaya BU, Tunca YM. Does maintaining apical patency during instrumentation increase postoperative pain or flare-up rate after nonsurgical root canal treatment? A systematic review of randomized controlled trials. *J Endod* 2018;44:1228-36.
9. Holland R, Sant'Anna Júnior A, Souza Vd, Dezan Junior E, Otoboni Filho JA, Bernabé PF, *et al.* Influence of apical patency and filling material on healing process of dogs' teeth with vital pulp after root canal therapy. *Braz Dent J* 2005;16:9-16.
10. Ricucci D. Apical limit of root canal instrumentation and obturation, part 1. Literature review. *Int Endod J* 1998;31:384-93.
11. Ricucci D, Langeland K. Apical limit of root canal instrumentation and obturation, part 2. A histological study. *Int Endod J* 1998;31:394-409.
12. Souza RA. The importance of apical patency and cleaning of the apical foramen on root canal preparation. *Braz Dent J* 2006;17:6-9.
13. Garg A, Nagpal A, Shetty S, Kumar S, Singh KK, Garg A. Comparison of time required by D-RaCe, R-Endo and Mtwo instruments for retreatment: An *in vitro* study. *J Clin Diagn Res* 2015;9:ZC47-9.
14. Al-Gharrawi HA. Efficacy of ProTaper rotary instruments in removing filling materials during root canal retreatment. *Mustansiriyah Dent J* 2009;6:1-7.
15. Giuliani V, Cocchetti R, Pagavino G. Efficacy of ProTaper universal retreatment files in removing filling materials during root canal retreatment. *J Endod* 2008;34:1381-4.
16. 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;38:541-4.
17. Berutti E, Chiandussi G, Paolino DS, Scotti N, Cantatore G, Castellucci A, *et al.* Canal shaping with WaveOne primary reciprocating files and ProTaper system: A comparative study. *J Endod* 2012;38:505-9.
18. Webber J. Shaping canals with confidence: WaveOne GOLD single-file reciprocating system. *Int Dent* 2015;6:6-17.
19. Schneider SW. A comparison of canal preparations in straight and curved root canals. *Oral Surg Oral Med Oral Pathol* 1971;32:271-5.
20. Berutti E, Paolino DS, Chiandussi G, Alovisei M, Cantatore G, Castellucci A, *et al.* Root canal anatomy preservation of WaveOne reciprocating files with or without glide path. *J Endod* 2012;38:101-4.
21. Akbulut MB, Akman M, Terlemez A, Magat G, Sener S, Shetty H. Efficacy of twisted file adaptive, reciproc and ProTaper universal retreatment instruments for root-canal-filling removal: A cone-beam computed tomography study. *Dent Mater J* 2016;35:126-31.
22. Alberto Rubino G, de Miranda Candeiro GT, Gonzales Freire L, Faga Iglecias E, de Mello Lemos É, Luiz Caldeira C, *et al.* Micro-CT evaluation of gutta-percha removal by two retreatment systems. *Iran Endod J* 2018;13:221-7.
23. Schäfer E, Vlassis M. Comparative investigation of two rotary nickel–titanium instruments: ProTaper versus RaCe. Part 1. Shaping ability in simulated curved canals. *Iran Endod J* 2004;37:229-38.