Single file reciprocating systems: A systematic review and meta-analysis of the literature: Comparison of reciproc and WaveOne

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Abstract

The introduction of single-file nickel-titanium (NiTi) reciprocating systems has been a major breakthrough in the field of endodontics. Thus, the aim of this study was to compare the available reciprocating systems, Reciproc and WaveOne, using a meta-analysis with different parameters. A comprehensive electronic literature search for Reciproc and WaveOne using PubMed and Google scholar was initially conducted in September 2014 and updated in September 2016. Inclusion and exclusion criteria were then established. Twenty-six studies were qualified for the systematic review, and only three studies were considered for the meta-analysis using cyclic fatigue resistance as the main parameter. The time to fracture for the Reciproc and WaveOne systems ranged from 119.7 sec to 156.4 sec and 74.8 sec to 99.6 sec, respectively. The pooled difference in mean time to fracture was longer for the Reciproc system by 45.6 sec. This difference was statistically significantly at \( P \) value < 0.001. In conclusion, our study supports the finding that Reciproc is more resistant to cyclic fatigue than WaveOne. However, with regard to other parameters, mixed results were obtained. Well-designed randomized clinical trials comparing both systems under the same experimental conditions should be done in future studies.

Key words: Cyclic fatigue, meta-analysis, Reciproc, systematic review, WaveOne

INTRODUCTION

Canal shaping is an integral part of endodontic treatment because it removes bacteria and facilitates further successful irrigation and obturation.¹² Evolution of endodontic shaping instruments has occurred over time, which has proven to be beneficial for maximizing debridement and decreasing procedural errors.²³ The use of stainless steel hand files and H and K-files were the conventional shaping method.³ These hand files were replaced by rotary systems. This was because of their troublesome use when shaping curved canals and owing to several disadvantages, including both rigidity that may cause many iatrogenic errors (transportations, ledges, and zipping) and the tendency to result in lengthy root canal treatment procedures.²³

To overcome these difficulties, in 1988, Walia et al. introduced nickel–titanium (NiTi) files in endodontics.⁴ He reported that NiTi had greater access to this article online

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elast flexibility than stainless steel. This finding was later supported by others, and it was proven that NiTi superelasticity was an advantage in curved canals because it reduced forces on the walls, enhanced centering ability, and led to less iatrogenic errors. This flexibility is due to the property of the NiTi alloy, which can undergo transformation between the austenitic and martensitic phases. The NiTi alloy can regain its original shape (austenite) after the application of stress or heat (martensite) in a characteristic called the “shape memory effect.”

Most of the NiTi rotary systems move in a continuous rotation. However, as in many other systems, the NiTi rotary system appears to have some drawbacks. When rotating in curved canals, it may lead to cyclic fatigue, which is file separation and fracture due to repeated tensile-compressive forces being applied to the file in maximum curved areas. In some cases, using NiTi files can also be time consuming because they may require multiple exchanges of file sizes; some of these files need prior glide path preparation done with hand files. This led to the revolution of single-file NiTi reciprocating systems, which has been adopted by Dr. Yared. He has also introduced the Reciproc system. The single-file NiTi system consists of three files, including the R25 (ISO 25; 8%), R40 (ISO 40; 6%), and R50 (ISO 50; 5%); it has respective paper points and gutta-percha and a specific motor (VDW.SILVER) which was made in Munich, Germany. This concept has many advantages over the conventional rotary NiTi systems: (1) greater time efficiency because it requires only a single file to prepare all the canals with no requirement for prior glide path preparation; (2) single files are made from M-wire (heated NiTi alloy) that give them the greatest flexibility and cyclic fatigue resistance; and (3) reciprocating systems, which move in rotating reciprocation movements (balanced force) with large rotating angles. One movement is counter-clockwise, which engages and cuts dentin, and the other is clockwise, which disengages the file from the dentin to avoid taper lock and relieves stress on the file. This type of movement prevents file breakage and increases its resistance to both cyclic and torsional fatigue.

Another competitive single file NiTi reciprocation system, WaveOne, has also been launched. This system was introduced in 2011 by the Dentsply/Maillefer Company (Ballaigues, Switzerland), and consists of three single-use files, including small (ISO 21; 6%), primary (ISO 25; 8%), and large (ISO 40; 8%). This system also has the same M-wire and reciprocal movement features as Reciproc. Therefore, the aims of this systematic review and meta-analysis were to review the literature and compare the two reciprocating systems, Reciproc and WaveOne, with cyclic fatigue resistance, bending resistance, centering ability, cutting efficiency, canal debridement, clinical efficiency, and reusability cyclic fatigue resistance as the main parameters. This will help to provide the best available information to dentists in general, and endodontists in specific, to understand the differences between both the systems, and help them to decide whether to use Reciproc or WaveOne in cleaning and shaping the root canal system.

MATERIALS AND METHODS

Prior to the literature search, a research question was defined following the population, intervention, comparison, and outcome (PICO) format: “Does WaveOne single file NiTi system (intervention) compared to Reciproc single file NiTi system (comparison) have longer time to fracture (outcome) when shaping root canals?” A comprehensive electronic literature search for Reciproc and WaveOne using PubMed and Google scholar was initially conducted in September 2014 and updated in September 2016. All the resulting titles and abstracts were screened for topic relevance. Inclusion and exclusion criteria were then established. The articles were selected on the basis of following keywords: (1) Reciproc versus WaveOne; (2) Reciproc and WaveOne; and (3) WaveOne; or (4) Reciproc.

Inclusion criteria

- Original peer reviewed studies
- In-vitro and in-vivo studies
- Studies comparing Reciproc versus WaveOne or a comparison of WaveOne versus Reciproc or other NiTi systems
- Articles published in English
- Success reported as reduced cyclic fatigue.

Exclusion criteria

- Studies comparing only Reciproc with other systems
- Studies comparing only WaveOne with other systems
- Studies comparing single file reciprocating systems with another NiTi rotary system, and data do not clearly show the difference between Reciproc and WaveOne
- Effects of Reciproc or WaveOne in retreatment cases.
Data extraction

The electronic database literature search resulted in a total of 197 citations. Two of the authors independently reviewed the articles against the checklist to assess evidence for efficacy of therapy or prevention [Table 1]. Disagreement was resolved by consensus. The process of article selection and review is detailed in Figure 1. This systematic review was prepared according to the PRISMA guidelines. Relevant data was then extracted from the final 26 articles selected for the systematic review. Meta-analysis was performed using a random effects model to calculate the pooled time to fracture. To measure publication bias, a funnel plot was graphed, and the Fail-Safe N and Begg and Mazumdar rank correlation tests were conducted. StatsDirect software (StatsDirect Ltd, Cheshire, UK) 2.7.8 was used for the statistical analysis.

RESULTS

Twenty-six studies qualified for the systematic review [Table 2]. Because of the extreme heterogeneity of the final selected articles, only three studies were considered for the meta-analysis using cyclic fatigue resistance as the main parameter. The three studies selected for meta-analysis and their results are summarized in Table 3.

The time to fracture for the Reciproc and WaveOne systems ranged from 119.7 s to 156.4 s and 74.8 s to 99.6 s, respectively. The pooled difference in mean time to fracture was longer for the Reciproc system by 45.6 s. This difference was statistically significant at $P < 0.001$ [Figure 2; Table 3].

The Fail-Safe N is 256 and the Begg and Mazumdar’s Kendall tau with continuity correction showed a nonsignificant correlation with $P$ value (one-tailed) $= 0.50$, which indicates that publication bias was nonexistent in this analysis.

DISCUSSION

It has been shown that endodontic NiTi reciprocating instruments are safe and effective for preparing even the most severe curved root canals in much less chair time.[19]
| Author                      | Year | Sample Size (Per group) | Parameter                                      | Conclusion                                                                                                                                 |
|-----------------------------|------|-------------------------|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Ozyurek                     | 2016 | 20                      | Cyclic fatigue                                | WaveOne primary showed the lowest cyclic fatigue resistance compared to WaveOne Gold and Reciproc. WaveOne Gold was the most resistant.        |
| Magalhaes RR et al.         | 2016 | 12                      | Torsional behavior after clinical use         | No significant difference in the reduction of torsional resistance was observed between the two systems.                                  |
| Topcuoglu et al.            | 2016 | 40                      | Cyclic fatigue                                | Reciproc had higher cyclic fatigue resistance than WaveOne primary in apical curvatures but not coronal ones.                           |
| Coelho et al.               | 2016 | 15                      | Glide Path on the centric ability of canals preparation | No significant difference was found between both the files in regards to centric ability to prepare the canals, and establishing glide path seems not necessary and increased the total instrumentation time. |
| Kherlakian et al.           | 2016 | 70                      | Postoperative pain and intake of analgesics   | No significant differences were found between the tested groups (Reciproc, WaveOne, and ProTaper Next). Reciprocating systems were found to be similar in regards to the incidence of postoperative pain and analgesic intake compared to continues rotation system. |
| Uzun et al.                 | 2016 | 15                      | Apical extrusion of debris                    | Reciproc was associated with less apical extrusion of debris compared to all tested groups including WaveOne.                          |
| Pedulla et al.              | 2016 | 20                      | Torsional and cyclic fatigue resistance       | Cyclic fatigue resistance of the new Hyflex EDM OneFile was significantly higher than Reciproc and WaveOne. Under the condition of this study, no significant difference was found between Reciproc and WaveOne. |
| de Almeida-Gomes et al.     | 2016 | 5                       | Cyclic fatigue                                | Both Reciproc and WaveOne demonstrated cyclic fatigue resistance compared to other tested groups. However, no significant difference was found between Reciproc and WaveOne. |
| Higuera et al.              | 2015 | 15                      | Cyclic fatigue                                | Reciproc significantly show higher cyclic fatigue resistance compared to WaveOne but not Twisted File (TF adaptive M-L1).               |
| Helvacioglu-Yigit et al.    | 2015 | 15                      | Dentinal crack formation after canals preparation | No significant differences between Reciproc and WaveOne in crack formation at the apical 3 mm level. No significant difference in cracks formation was found at 6 and 9 mm levels between both reciprocating systems and untreated controls. |
| Carvalho Mde et al.         | 2015 | 10                      | Cleaning effectiveness                        | The two reciprocating instruments presented similar effectiveness for root canal cleaning.                                              |
| De Meireles et al.          | 2015 | 13                      | Apical transportation and centering ability   | No significant difference between systems in apical transportation. Reciproc and WaveOne promoted minimal apical transportation and remained relatively centralized within the root canal. |
| Gergi et al.                | 2015 | 30                      | Dentinal crack formation after canals preparation | Reciproc produced more cracks compared to WaveOne and twisted files adaptive (TFA) rotation system. TFA caused significantly less cracks than the other two systems. |
| De-Deus et al.              | 2015 | 20                      | Apical extrusion of debris                    | No significant difference was found in the amount of the debris extruded between the two reciprocating systems.                         |
| Dagna et al.                | 2014 | 40                      | Cyclic fatigue                                | Reciproc was the most fatigue resistant. Reciproc and WaveOne instruments respected the original canal curvatures with no significant difference between them. |
| Saber et al.                | 2014 | 20                      | Shaping ability                               |                                                                                                                                         |
Our systematic review resulted in 26 studies that fulfilled our inclusion and exclusion criteria. These studies investigated different parameters and compared the Reciproc and WaveOne systems. When considering the shaping ability, Saber et al. concluded that Reciproc and WaveOne instruments respected the original canal curvatures with no significant differences between them. However, Reciproc was significantly faster for preparing root canals[19] and demonstrated statistically higher cutting efficiency than WaveOne.}\[19]\] Lim et al.\[20\].
reported that a glide path larger than #15 should be established before using the WaveOne file.\textsuperscript{[20]} In contrast, Coelho et al. reported no significant differences between both the files in regard to maintaining centric ability with or without glide path can be demonstrated, and that glide path seems to be unnecessary and would only result in increased working time.\textsuperscript{[21]}

Carvalho et al. found that both the systems presented similar cleaning effectiveness, whereas Topcu et al. reported that WaveOne performed better canal debridement than Reciproc.\textsuperscript{[22,23]} De-Deus et al. evaluated the amount of apical extruded dentin and found that there were no significant differences between the two reciprocating instruments.\textsuperscript{[24]} In contrast, others found that Reciproc was associated with less apical debris extrusion compared to several other systems including WaveOne.\textsuperscript{[25]} In regards to postoperative pain and analgesic intake, there was no significant difference between Reciproc and WaveOne systems.\textsuperscript{[26]} In addition, reciprocating systems also showed no significant difference when compared to continuous rotation systems.\textsuperscript{[26]} Both the instruments appeared safe for reuse because they showed no microcracks during instrumentation unless they were reused for up to five canals.\textsuperscript{[18]} However, Helvacioglu-Yigit et al. have shown that significant differences can be noticed only at the apical 3 mm of the prepared canals between the reciprocating systems and untreated controls,\textsuperscript{[27]} whereas others support that Reciproc indeed can cause more dentinal cracks compared to WaveOne.\textsuperscript{[28]} Whether these cracks can carry any clinical significance or not is a question that needs to be answered. Moreover, no statistically significant differences were found between files with regard to instrument fracture and spiral distortion.\textsuperscript{[14]} De Meireles et al. reported that both systems showed similar results with regard to apical transport and both remain centered during canal preparation.\textsuperscript{[29]}

It is clear that there is disagreement between reports in the literature. It also can be noted that studying different parameters may be advantageous for studying and comparing different systems. However, in the present meta-analysis, only three studies fulfilled the inclusion and exclusion criteria.\textsuperscript{[20-22]} All of them stated that Reciproc was more cyclic fatigue resistant than WaveOne. One study showed that Reciproc had lower torsional resistance than WaveOne.\textsuperscript{[32]} Another study showed that cyclic fatigue resistance was not reduced after immersion in sodium hypochlorite with Reciproc being the most fatigue resistant.\textsuperscript{[31]} These two single-file reciprocating systems appear to differ significantly in the way to achieve more cyclic fatigue resistance. Both systems are made from the same M-wire NiTi alloy, which gives them the greatest cycle fatigue resistant, however, they both have different cross sections consisting of S-shape and concave triangular for Reciproc and WaveOne, respectively. The resulting sample size after reviewing articles and applying the inclusion and extrusion criteria was too small for acceptable statistical power because of the heterogeneity of the experimental conditions. This is one limitation of the study. Most of the included studies involved \textit{in-vitro} tests, which is also a limitation because they did not mimic the real patient’s oral environment.

\textbf{CONCLUSIONS}

Our study appears to support the concept that Reciproc is more resistant to cyclic fatigue than WaveOne. However, with regard to other parameters, mixed results were found. Well-designed randomized clinical
trials comparing the shaping ability, clinical efficiency, and reusability of Reciproc and WaveOne under the same experimental conditions should be conducted in future studies.

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**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Mayer BE, Peters OA, Barbakow F. Effects of rotary instruments and ultrasonic irrigation on debris and smear layer scores: A scanning electron microscopic study. Int Endod J 2002;35:582-9.
2. Peters OA. Current challenges and concepts in the preparation of root canal systems: A review. J Endod 2004;30:559-67.
3. Yared G. Canal preparation with only one reciprocating instrument without prior hand filing: A new concept. Int Dent J 2012;2:78-87.
4. Walia HM, Brantley WA, Gerstein H. An initial investigation of the bending and torsional properties of Nitinol root canal files. J Endod 1998;24:346-51.
5. Bergmans L, Cleynenbeugel JV, Wevers M, Lambrechts P. Mechanical root canal preparation with NiTi rotary instruments. Am J Dent 2001;14:324-33.
6. Kandaswamy D, Venkateshbabu N, Porsidi I, Pradeep G. Canal-centering ability: An endodontic challenge. J Conserv Dent 2009;12:3-9.
7. Bryant ST, Thompson SA, al-Omari MA, Dummer PM. Shaping ability of Profile rotary nickel-titanium instruments with ISO sized tips in simulated root canals: Part 1. Int Endod J 1998;31:275-81.
8. Bindl A, Barbakow F. The Lightspeed technique: Experiences with a rotary canal preparation system. Endod Prac 1999;2:210-4.
9. Schwartz S, McSpadden J. The Quanteo rotary nickel titanium instrumentation system. Endod Prac 1999;2:214-9.
10. Peters OA, Paque F. Current developments in rotary root canal instrumentation technology and clinical use: A review. Quintessence Int 2010;41:479-88.
11. Ruddle CJ. The shaping movement wave of the future. Endod Pract 2011;4.
12. Bryant ST, Thompson SA, al-Omari MA, Dummer PM. Shaping ability of ProFile rotary nickel-titanium instruments with ISO sized tips in simulated root canals: Part 2. Int Endod J 1998;31:282-9.
13. Arias A, Perez-Higuera JJ, de la Macorra JC. Differences in cyclic fatigue resistance at apical and coronal levels of Reciproc and WaveOne new files. J Endod 2012;38:1244-8.
14. Pirani C, Paolucci A, Ruggeri O, Bossu M, Polimeni A, Gatto MR, et al. Wear and metallographic analysis of WaveOne and reciproc NiTi instruments before and after three uses in root canals. Scanning 2014;36:517-25.
15. Saber SE, Nagy MM, Schauer F. Comparative evaluation of the shaping ability of WaveOne, Reciproc and OneShape single-file systems in severely curved root canals of extracted teeth. Int Endod J 2015;48:109-14.
16. Berutti E, Chiandussi G, Paulino DS, Scotti N, Cantatore G, Castellucci A, et al. Effect of canal length and curvature on working length alteration with WaveOne reciprocating files. J Endod 2011;37:1687-90.
17. Berutti E, Paulino DS, Chiandussi G, Alovisi 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.
18. Park SK, Kim YJ, Shon WJ, You SY, Moon YM, Kim HC, et al. Clinical Efficiency and Reusability of the Reciprocating Nickel-Titanium Instruments According to the Root Canal Anatomy. Scanning 2014;36:246-51.
19. Plotino G, Giansiracusa Rubini A, Grande NM, Testarelli L, Gambarini G. Cutting efficiency of Reciproc and waveOne reciprocating instruments. J Endod 2014;40:1228-30.
20. Lim YJ, Park SJ, Kim HC, Min KS. Comparison of the centering ability of WaveOne and Reciproc and nickel-titanium instruments in simulated curved canals. Restor Dent Endod 2013;38:21-5.
21. Coelho MS, Fontana CE, Kano AS, de Martin AS, da Silveira Bueno CE. Effects of Glide Path on the Centering Ability and Preparation Time of Two Reciprocating Instruments. Iran Endod J 2016;11:33-7.
22. Topeu KM, Karatas E, Ozsu D, Ersoy I. Efficiency of the Self Adjusting File, WaveOne, Reciproc, ProTaper and hand files in root canal debridement. Eur J Dent 2014;8:326-9.
23. Carvalho Mde S, Junior EC, Bitencourt Garrido AD, Roberti Garcia Lda F, Franco Marques AA. Histological evaluation of the cleaning effectiveness of two reciprocating single-file systems in severely curved root canals: Reciproc versus WaveOne. Eur J Dent 2015;9:50-6.
24. De-Deus G, Neves A, Silva EJ, Mendonca TA, Lourencio C, Calixto C, et al. Apically extruded dentin debris by reciprocating single-file and multi-file rotary system. Clin Oral Investig 2015;19:357-61.
25. Uzun I, Guler B, Ozuyrek T, Tunc T. Apical extrusion of debris using reciprocating files and rotary instrumentation systems. Niger J Clin Pract 2016;19:71-5.
26. Kherlakian D, Cunha RS, Ehrhardt IC, Zuolo ML, Kishen A, da Silveira Bueno CE. Comparison of the Incidence of Postoperative Pain after Using 2 Reciprocating Systems and a Continuous Rotary System: A Prospective Randomized Clinical Trial. J Endod 2016;42:171-6.
27. Helvacioglu-Yigit D, Aydemir S, Yilmaz A. Evaluation of dentinal defect formation after root canal preparation with two reciprocating systems and hand instruments: An in vitro study. Biotechnol Biotechnol Equip 2015;29:368-73.
28. Gengi RM, Osta NE, Naaman AS. Dentinal crack formation during root canal preparations by the twisted file adaptive, Reciproc and WaveOne instruments. Eur J Dent 2015;9:508-12.
29. de Meireles DA, de Brito TC, Marques AA, Garrido AD, Garcia LF, Sponchiado EC Jr. Micro-computed tomography evaluation of apical transportation and centring ability of Reciproc and WaveOne systems in severely curved root canals. Int Endod J 2015;48:814.
30. Plotino G, Grande NM, Testarelli L, Gambarini G. Cyclic fatigue of Reciproc and WaveOne reciprocating instruments. Int Endod J 2012;45:614-8.
31. Pedulla E, Grande NM, Plotino G, Palmiero F, Gambarini G, Rapisarda E. Cyclic fatigue resistance of two reciprocating nickel-titanium instruments after immersion in sodium hypochlorite. Int Endod J 2013;46:155-9.
32. Dagna A, Poggio C, Beltrami R, Colombo M, Chiesa M, Bianchi S. Cyclic fatigue resistance of OneShape, Reciproc, and WaveOne: An in vitro comparative study. J Conserv Dent 2014;17:250-4.
33. Ozuyrek T. Cyclic Fatigue Resistance of Reciproc, WaveOne, and WaveOne Gold Nickel-Titanium Instruments. J Endod 2016;42:1536-9.
34. Magalhaes RR, Braga LC, Pereira ES, Peixoto IF, Buono VT, Bahia MG. The impact of clinical use on the torsional behavior of Reciproc and WaveOne instruments. J Appl Oral Sci 2016;24:310-6.
35. Topeucoglu HS, Duzgun S, Akti A, Topeucoglu G. Laboratory comparison of cyclic fatigue resistance of WaveOne Gold, Reciproc and WaveOne files in canals with a double curvature. Int Endod J 2016. [Epub ahead of print].
36. Pedulla E, Lo Savio F, Boninelli S, Plotino G, Grande NM, La Rosa G, et al. Torsional and Cyclic Fatigue Resistance of a New Nickel-Titanium Instrument Manufactured by Electrical Discharge Machining. J Endod 2016;42:156-9.
37. de Almeida-Gomes F, de Matos HR, Nunes RF, Arrais AM, Ferreira-Maniglia C, de Morais Vittoriano M, et al. Cyclic fatigue resistance of different continuous rotation and reciprocating endodontic systems. Indian J Dent Res 2016;27:278-82.
39. De-Deus G, Leal Vieira VT, Nogueira da Silva EJ, Lopes H, Elias CN, Moreira EJ. Bending resistance and dynamic and static cyclic fatigue life of Reciproc and WaveOne large instruments. J Endod 2014;40:575-9.

40. 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.