

Clinical evaluation of two single-file reciprocating techniques

Massimo Galli¹
Hyeon-Cheol Kim²
Dario Di Nardo¹
Rodolfo Reda¹
Gabriele Miccoli¹
Francesca Romana Federici¹
Ayfer Atav Ates⁴
Luca Signorini⁵

¹ Sapienza, Università di Roma
² Pusan National University, Korea
³ Sapienza, Università di Roma
⁴ Ege University, Turkey
⁵ UniCamillus, Roma

Corresponding author: Dario Dinardo
email: dario_dinardo@hotmail.com

Abstract

The purpose of the present study was to evaluate the ability of two different single file-reciprocating techniques) to successfully treating 60 lower molar cases (n=30), with a 1 year follow up : Reciproc Blue (RB, VDW, Germany) vs EdgeOneR (EOR, EdgeEndo, USA). The present study followed the suggestions provided by the recent S3 guidelines edited by the European society of Endodontology, concerning clinical studies on root canal treatment. All cases were performed by the same clinician expert in both techniques, strictly following manufacturers' instructions. Patients were recalled for follow up after one week, 3 months and one year. Data were recorded and statistically analyzed.

Results showed that no statistically significant differences were observed in the distribution of the frequency of reaching the full working length between the EOR (99%), RC Blue (94%), groups ($p > 0.05$). A significant difference was noted in terms of postoperative pain ($p\text{-value} \geq 0.044$). After 7 days 16 patients from the RB and 10 patients from the EOR group referred moderate/severe pain and assumption of medications, even if no flare up was reported. After one year the survival rate of endodontically treated teeth for both groups was 100% with no statistically significant difference ($p\text{-value} \geq 0.05$) between them. Radiographic healing was not observed in two cases only (both from RB group). It can be concluded that single file reciprocation is a valid alternative to traditional rotary instrumentation and when combined to proper irrigation and obturation technique can provide excellent outcomes, allowing an efficient, easy and simple shaping procedure in the great majority of cases.

Key words: Nickel-titanium, Reciprocation, Outcome.

Introduction

Nickel-titanium instrumentation has currently become the golden standard for chemio-mechanical preparation of the root canal system by using continuous rotation or reciprocating motions (1-3). Single-file reciprocation technique was developed more than 15 years ago and currently is regaining interest among practitioners thanks to the development of innovative manufacturing processes, which currently produce heat-treated nickel-titanium (NiTi) instruments more flexible and resistant to cyclic fatigue (4-7). These improved mechanical properties are more important when only a single instrument is designed to prepare the root canal, especially in curved and complex

Authors

Massimo Galli - Sapienza, Università di Roma

Hyeon-Cheol Kim - 2. Pusan National University, Korea

Dario Di Nardo - Sapienza, Università di Roma

Rodolfo Reda - Sapienza, Università di Roma

Gabriele Miccoli - Sapienza, Università di Roma

Francesca Romana Federici - Sapienza, Università di Roma

Ayfer Atav Ates - Ege University, Turkey

Luca Signorini - UniCamillus, Roma



License

This work is licensed under a [Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License](https://creativecommons.org/licenses/by-nc-nd/4.0/).

Authors contributing to Oral and Implantology agree to publish their articles under the [Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License](https://creativecommons.org/licenses/by-nc-nd/4.0/), which allows third parties to copy and redistribute the material providing appropriate credit and a link to the license but does not allow to use the material for commercial purposes and to use the material if it has been remixed, transformed or built upon.

How to Cite

Massimo Galli, Hyeon-Cheol Kim, Dario Di Nardo, Rodolfo Reda, Gabriele Miccoli, Francesca Romana Federici, Ayfer Atav Ates, Luca Signorini.
A Comprehensive Multimethod Analysis of Mechanical Properties of two different heat treatments for endodontic Nickel-titanium instruments
Annali Di Stomatologia, 15(1), 98-103
<https://doi.org/10.59987/ads/2024.2.98-103>

anatomy. In such cases the single instrument which is designed with big dimensions in order to create a proper final shape (usually variable great tapers and minimum tip size 20 or 25) must be flexible enough to reach working length and resistant to both bending and torsional stress. Such an ideal compromise is not easy to reach, and this explains while NiTi rotary instruments have always been proposed with a sequence, in the majority of cases aiming at pre-enlarging the root canal first with smaller instruments and then creating the final shape with bigger ones. Such approach also distributes instrumentation stress amongst the various instruments, but it is obviously more costly and more time consuming (2).

On the contrary single file reciprocation techniques tend to simplify the procedure and ideally use one NiTi reciprocating file only. According to Reciprocal Blue (VDW, Munich, Germany) instruction for use (IFU) in the majority of cases a manual glide-path is not recommended. It is suggested that the design and mechanical properties of the instruments and the reciprocating motion allow Reciprocal Blue (RB) to safely reach working length without using other manual/rotary instruments. The smallest available reciprocating file (RB 25) is recommended for the most complex canals, including MB2. RB instruments have been used for some years and evaluated by many in vitro and clinical studies, with or without glide-path (9-11)

EdgeOne R Utopia (EOR) is a new reciprocating instrument developed by Edge Endo (Albuquerque, NM, USA) which is similar in design with RB (s-shaped cross section), but differs in the proprietary heat treatment. EOR is available also in a smaller size (EOR 20) which is specifically designed for the more complex curvatures and narrow, calcified canals (12). It also slightly differs in the reciprocating motion with suggested angles slightly bigger than the one proposed by VDW (60°-170° vs 30°-150°) even if in both motions one complete rotation of 360° is completed in several reciprocating movements, and the angle in the cutting direction is greater than the angle in the reverse direction, so that the instrument continuously progresses towards the apex. Moreover the cutting angle is smaller than deflection angle, thus reducing the risk of high torsional stress.

Even if the two instruments are similar, such differences in design, dimensions and motions may influence clinical performance, especially in difficult cases. When single-file reciprocating technique was introduced one of the major limitations was the stiffness of the instruments with greater tapers and tip dimensions 25 or more, which did not allow complete negotiation to the apex in severely curved and/or narrow canals. The introduction of new heat treated instruments like RB helped in minimizing this problem by improving flexibility (13-16), but no study has been published so far in a possible advantage of reducing the tip size with Reciprocal and Reciprocal-like instruments. Such solution has been already adopted with other reciprocating instruments which have a totally different design and cutting ability (i.e. WaveOne Gold, EdgeOneFire) with the introduction of a size 20 small reciprocating file in adjunct to the Primary (size 25) reciprocating file to improve negotiation the

more complex canals. Moreover, so far no clinical studies have been published regarding the new EOR Utopia instruments. The purpose of the present study was to evaluate the ability of two different single file-reciprocating techniques (RB vs EOR) to successfully treat lower molar cases, with a 1 year follow up.

Materials and Methods

The included 56 patients were healthy patients either males or females aged between 18 and 66 years old who had 60 mandibular first and second molar teeth diagnosed with pulp necrosis and apical periodontitis with or without radiographic evidence of periapical radiolucency. For each of the two groups 30 lower molar cases (100 root canals) were selected using a preliminary CBCT evaluation to ensure similarity in the canal morphology between the two groups. 60% of cases were vital cases without any radiographic lesions, while the remaining ones showing lesions were split between the two groups (n=12). Calcified canals or canals with severe abrupt apical curvatures were excluded from the study. All cases were performed by the same clinician expert in both techniques. All canals were instrumented following manufacturers' instructions (8,12), irrigated and obturated with the same techniques and re-evaluated after one week, three months and one year for survival and radiographic healing.

For the RB group after ensuring a straight-line access and estimating working length from a pre-operative radiograph, a manual glide-path using an ISO 10 K-file was created. Then the RB 25 instrument was introduced inside the canal and moved in a slow-in-and-out pecking motion and a light pressure in order to advance in the canal, till 2/3 of the estimated working length. RB instruments were activated using a VDW silver reciprocating motor with a 300 rpm speed and 30°-150° reciprocating angles. The instrument was removed from the canal after 3 pecks, flutes were cleaned and canal irrigated with NaOCl. Then precise working length was determined using a manual K-file and EAL, and canal instrumentation was completed by reaching working length with the same RB instruments and same operative technique. In those cases when the RB 25 instruments were not able to reach the working length, canal preparation was completed by improving glide path and using rotary instruments with smaller taper and sizes. Following root canal instrumentation a final irrigation protocol using two irrigating solutions (NaOCl and EDTA) activated by ultrasounds was performed. Canals were then dried and obturated with Reciprocal gutta-percha cones size 25 and bioceramic sealer (EndoSequence BC sealer, Brasseler, USA) using a cold hydraulic technique. All cases were completed in one visit and teeth were restored after one week. Patients were recalled for follow up after 3 months and one year.

For the EOR instruments (size 20) group the technique was very similar to the one described for the RB. The only differences were related to the motor, motion and the gutta-percha cones. A cordless Woodpecker AI motor (Guilin, China) motor with 60°-170° reciprocating angles and 300 rpm speed was used and Edge One-R



Figure 1. Molar case with Reciproc Blue.



Figure 2. Molar case with Edge One R Utopia.

utopia cones (size 20) were used as master cone. Irrigation, obturation, restoration and follow up followed the same procedures described for the RB group.

For each group the number and type of canals which were correctly negotiated to full working length using a single-file reciprocating technique was recorded. Any iatrogenic error including intracanal breakage, if present, was recorded. Immediately after root canal treatment patients were given an analgesic (ibuprofen 400mg) to be administered in case of moderate or severe pain. Patients were instructed to define the degree of post-operative pain using numerical rating scale (NRS) post-operatively after 7 days, using the numerical rating scale (NRS) categorized into four categories where 0 = no pain, 1–3 = mild pain, 4–6 = moderate pain and 7–10 = severe pain. Another follow up was scheduled after 3 months.

Clinical and radiographic healing was then assessed after 12 months. The endodontic treatment was considered successful if tooth was asymptomatic, not tender to percussion and has no sinus tract or swelling, and radiographically showed absence or reduction of the periapical radiolucency. All data were collected and statistically analyzed. Statistical analysis was performed with IBM SPSS Statistics for Windows. For nonparametric data, Mann–Whitney *U*-test was used to compare between the two groups. Fisher's exact test was used to compare the different outcome two groups. The significance level was set at $p \leq .05$.

Results

Results showed that no statistically significant differences were observed in the distribution of the frequency of reaching the full working length between the EOR (99%), RC Blue (94%), groups ($p > 0.05$). A significant difference was noted in terms of postoperative pain (p -value $\geq .044$). After 7 days 16 patients from the RB and 10 patients from the EOR group referred moderate/severe pain and assumption of medications, even if no flare up was reported. No relevant symptom (pain or swelling) was reported after 3 months and one-year for both groups, with the exception of one case where pain on chewing was still persistent. After one year the survival rate of endodontically treated teeth for both groups was 100% with no statistically significant difference (p -value $\geq .05$) between them. Radiographic healing was not observed in two cases only (both from RB group), even if one of them was asymptomatic.

Discussions

According to manufacturer's IFU RB and the reciprocating movement has opened a new option allowing instruments to be used without initial hand filing in the majority of cases (8). However, in the present study a manual glide path using an ISO k-file size 10 was performed with both groups to avoid the advantage of creating glide-path on canal instrumentation with the single-file reciprocating instrument (easier and less stressful negotiation) and to reduce the bias related to variable canal diameters (17,18). Results showed that RB were not able to reach working length in 6 canals (5 MB ones and one ML). In one case the

problem was related to a broken fragment which was bypassed manually, while in other one an apical ledge was created, and canal preparation was completed using precurved manual k-files up to size 25. EOR was not able to reach working length in one case. It is difficult to assess the clinical relevance of these findings because there could be some slight influence derived from root canal anatomy (dentin hardness and intracanal restrictions) which cannot be detected by CBCT. Nevertheless, it seems logical that a smaller and more flexible instrument has more chance to negotiate canals to working length when compared to a slightly bigger and more rigid one (19). A possible limitation of the present study is comparison of instruments with different tip sizes (even if design and tapers are similar), but in terms of clinical practice we are comparing the two smallest available instruments provided by the different manufacturers, which are, however, both specifically indicated in the IFU (instructions of use) to prepare the difficult canals chosen for this clinical study. In the present study in all the cases when single-file instruments did not reach working length canal preparation was completed with the aid of more k-files instruments and reciprocating/rotary glidepath instruments to create a wider, smoother glide-path and enlarge canals enough to allow to complete shaping procedures (20,21)

No statistically significant differences were noted on the survival rate. Both the techniques allowed a valid canal chemio-mechanical preparation and proper obturation which resulted in a survival rate of 100% of cases after one year. In terms of symptomatic and radiographic success only two cases did not show healing (or at least reduction of the initial lesion) and one of them showing pain on percussion/chewing was scheduled for retreatment, even if root canal instrumentation (using Reciproc Blue) had correctly reached working length. These findings clearly showed that single-file reciprocation is a valid technique that in combination with proper irrigation and obturation procedures can provide excellent outcomes in nearly all cases.

On the other hand reciprocation offers significant advantages in terms of reducing time and costs of the procedures, and probably also reducing risk of errors by simplifying the procedure.

The present study followed the criteria provided by the recent S3 guidelines edited by the European Society of Endodontology, concerning the outcomes of the treatment of apical periodontitis (24), which highlighten the concept that the most critical outcome is tooth survival. However since outcomes are also a combination of patient and clinician reported outcomes measure other critical outcomes could be pain, tenderness, swelling, need for medication (analgesics, antibiotics), radiographic evidence of reduction of apical lesion size and radiographic evidence of normal periodontal ligament space. Guidelines also defined a minimum of 1year and a maximum of as long as possible for all outcome measures, except pain, tenderness, swelling, need for medication, which is a minimum of 7days and a maximum of 3 months, and for human clinical trials studies such as randomized control trials, comparative control trials, nonrandomized

longitudinal observational studies, a minimum number of 20 patients (10 in each arm) at the end of the study. In the present study a significant amount of patients reported some pain, swelling and moderate symptoms during the first days after treatment. This is consistent to some findings which showed a tendency of the reciprocating motion to push more debris towards / and eventually beyond) the apex, thus increasing periapical inflammatory responses (22,23). However all these symptoms were properly managed by analgesic drugs and they were no longer present at the 3-months and one-year recall, with the exception of one case. No flare-up was reported. There was a significant difference between the two groups in terms of post-operative symptoms which may be related to differences in dimensions between the two instruments. EOR's smaller dimensions are likely to reduce the risk of production and extrusion of debris beyond the apex. Hence we may conclude that single file reciprocation is a valid alternative to traditional rotary instrumentation and when combined to proper irrigation and obturation technique can provide excellent outcomes, while simplifying the procedure and minimizing operative time and costs.

References

- Bürklein S, Arias A. Effectiveness of root canal instrumentation for the treatment of apical periodontitis: A systematic re-view and meta-analysis. *Int Endod J.* 2023 Oct;56 Suppl 3:395-421. doi: 10.1111/iej.13782. Epub 2022 Jun 23. PMID: 35670625.
- Gambarini G, Miccoli G, Seracchiani M, Khrenova T, Donfrancesco O, D'Angelo M, Galli M, Di Nardo D, Testarelli L. Role of the Flat-Designed Surface in Improving the Cyclic Fatigue Resistance of Endodontic NiTi Rotary Instruments. *Materials (Basel).* 2019 Aug 8;12(16):2523. doi: 10.3390/ma12162523. PMID: 31398814; PMCID: PMC 6720207.
- Zanza, A.; D'Angelo, M.; Reda, R.; Gambarini, G.; Testarelli, L.; Di Nardo, D. An Update on Nickel-Titanium Rotary Instruments in Endodontics: Mechanical Characteristics, Testing and Future Perspective—An Overview. *Bioengineering* 2021, 8, 218. <https://doi.org/10.3390/bioengineering81202189>.
- Generalini L, Puddu P, Borghi A, Brancolini S, Lusvarghi L, Bolelli G, Consolo U, Pedullà E. Mechanical properties and metallurgical features of new and ex vivo used Reciproc Blue and Reciproc. *Int Endod J.* 2020 Feb;53(2):250-264. doi: 10.1111/iej.13214. Epub 2019 Sep 27. PMID: 31489641.
- De-Deus G, Silva EJ, Vieira VT, Belladonna FG, Elias CN, Plotino G, Grande NM. Blue Thermomechanical Treatment Optimizes Fatigue Resistance and Flexibility of the Reciproc Files. *J Endod.* 2017 Mar;43(3):462-466. doi: 10.1016/j.joen.2016.10.039. Epub 2017 Jan 25. PMID: 28131415.
- Plotino G, Grande NM, Testarelli L, Gambarini G, Castagnola R, Rossetti A, Özyürek T, Cordaro M, Fortunato L. Cyclic Fatigue of Reciproc and Reciproc Blue Nickel-titanium Reciprocating Files at Different Environmental Temperatures. *J Endod.* 2018 Oct;44(10):1549-1552. doi: 10.1016/j.joen.2018.06.006. Epub 2018 Aug 23. PMID: 305.
- Keskin C, Inan U, Demiral M, Keleş A. Cyclic Fatigue Resistance of Reciproc Blue, Reciproc, and WaveOne Gold Reciprocating Instruments. *J Endod.* 2017 Aug;43(8):1360-1363. doi: 10.1016/j.joen.2017.03.036. Epub 2017 Jun 27. PMID: 28662877.
- RECIPROC BLUE Available at: <https://www.VDW-dental.com>. Accessed January 5, 2024
- De-Deus G, Arruda TE, Souza EM, Neves A, Magalhães K, Thuanne E, Fidel RA. The ability of the Reciproc R25 instrument to reach the full root canal working length without a glide path. *Int Endod J.* 2013 Oct;46(10):993-8. doi: 10.1111/iej.12091. Epub 2013 Apr 6. PMID: 23560929
- Bartols A, Robra BP, Walther W. The ability of Reciproc instruments to reach full working length without glide path preparation: a clinical retrospective study. *PeerJ.* 2017 Jul 19;5:e3583. doi: 10.7717/peerj.3583. PMID: 28804693; PMCID: PMC5550015
- De-Deus G, Cardoso ML, Belladonna FG, Cavalcante DM, Simões-Carvalho M, Souza EM, Lopes RT, Silva EJNL. Performance of Reciproc Blue R25 Instruments in Shaping the Canal Space without Glide Path. *J Endod.* 2019 Feb;45(2):194-198. doi: 10.1016/j.joen.2018.10.011. PMID: 30711177.
- EDGE ONE R UTOPIA Available at: <https://www.Edgeendo.com>. Accessed December 21, 2023
- Altufayli MD, Salim B, Katbeh I, Merei R, Mamasaidova Z. Shaping Ability of Reciproc Blue Versus One Curve in Curved Canal: An In-Vitro Study. *Cureus.* 2022 Apr 22;14(4):e24387. doi: 10.7759/cureus.24387. PMID: 35619838; PMCID: PMC9126444.
- Feghali M, Al Atta AAD, Galli M. A comparative analysis of mechanical properties of different reciprocating Niti endodontic instruments. *Annali di Stomatologia I* 2023; 14(4): 9-13 ISSN 1971-1441 | DOI: 10.59987/ads/2023.4.9-13
- 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. <https://doi.org/10.1016/j.joen.2014.01.041>.
- Serefoglu B, Miçooğulları Kurt S, Kaval ME, Güneri P, Kandemir Demirci G, Çalışkan MK. Cyclic Fatigue Resistance of Multiused Reciproc Blue Instruments during Retreatment Procedure. *J Endod.* 2020 Feb;46(2):277-282. doi: 10.1016/j.joen.2019.10.024. Epub 2019 Dec 5. PMID: 31812359.
- Ajina M, Billis G, Chong BS. The Effect of Glide Path Preparation on Root Canal Shaping Procedures and Outcomes. *Eur Endod J.* 2022 Jun;7(2):92-105. doi: 10.14744/eej.2022.97659. PMID: 35786583; PMCID: PMC9285994.
- Plotino G, Grande NM, Mazza C, Petrovic R, Testarelli L, Gambarini G. Influence of size and taper of artificial canals on the trajectory of NiTi rotary instruments in cyclic fatigue studies. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2010 Jan;109(1):e60-6. doi: 10.1016/j.tripleo.2009.08.009. Epub 2009 Nov 17. PMID: 19926504
- Valenti-Obino F, Di Nardo D, Quero L, Miccoli G, Gambarini G, Testarelli L, Galli M. Symmetry of root and root canal morphology of mandibular incisors: A cone-beam computed tomography study in vivo. *J Clin Exp Dent.* 2019 Jun 1;11(6):e527-e533. doi: 10.4317/jced.55629. PMID: 31346372; PMCID: PMC6645266
- Zuolo ML, Carvalho MC, De-Deus G. Negotiability of Second Mesiobuccal Canals in Maxillary Molars Using a Reciprocating System. *J Endod.* 2015 Nov;41(11):1913-7. doi: 10.1016/j.joen.2015.08.004. Epub 2015 Oct 9. PMID: 26443438.
- Zanza A, Seracchiani M, Di Nardo D, Reda R, Gambarini G, Testarelli L. A Paradigm Shift for Torsional Stiffness of Nickel-Titanium Rotary Instruments: A Finite Element Analysis. *J Endod.* 2021 Jul;47(7):1149-1156. doi: 10.1016/j.joen.2021.07.007. PMID: 34444444
- Doğanay Yıldız E, Arslan H. The effect of blue thermal treatment on endodontic instruments and apical debris extrusion during retreatment procedures. *Int Endod J.* 2019 Nov;52(11):1629-1634. doi: 10.1111/iej.13161. Epub 2019 Jun 24. PMID: 31131904.

23. Vijayran VK, Khetarpal A, Vats A, Ahlawat M, Singhal N, Harshita. Comparison of the incidence of postoperative pain in single sitting root canal treatment after using two reciprocating systems and two continuous rotary systems: An in vi-vo study. *J Conserv Dent*. 2023 Jan-Feb;26(1):12-19. doi: 10.4103/jcd.jcd_331_22. Epub 2022 Dec 8. PMID: 36908735; PMCID: PMC10003282.
24. Duncan HF, Kirkevang LL, Peters OA, El-Karim I, Krastl G, Del Fabbro M, Chong BS, Galler KM, Segura-Egea JJ, Kebschull M; ESE Workshop Participants and Methodological Consultant. Treatment of pulpal and apical disease: The European Society of Endodontology (ESE) S3-level clinical practice guideline. *Int Endod J*. 2023 Oct;56 Suppl 3:238-295. doi: 10.1111/iej.13974. Epub 2023 Sep 29. PMID: 37772327.