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Comparison of transportation and centering ability using RECIPROC and iRace: A cone-beam computed tomography study

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Original Article

Abstract

BACKGROUND AND AIM: Root canal treatment, especially in curved and constricted root canals, can be very difficult and time consuming. Several investigations have compared the reciprocating and full sequence motions in terms of shaping ability. The purpose of the present study was to compare the root canal transportation and centering ability of RECIPROC and iRace using cone-beam computed tomography (CBCT).

METHODS: Thirty-two mesiobuccal (MB) root canals of maxillary first molars with curvature ranged 25-40 degrees were selected. Pre-instrumentation CBCT images were captured at 2, 4 and 6 mm distances from the root apex. Thirty samples were randomly divided into two groups (n = 15). After root canal preparation using either iRace or RECIPROC #25, post-instrumentation CBCT images were obtained at the same levels. Two specimens served as control group. Pre- and post-CBCT images were evaluated to measure root canal transportation and centering ability. Mann-Whitney and Friedman tests were used for statistical analysis.

RESULTS: There was no significant difference between the groups ($P > 0.05$).

CONCLUSION: iRace and RECIPROC maintained original root canal geometry and may be safe to be used in curved root canals.

KEYWORDS: Cone-Beam Computed Tomography; Root Canal Preparation; Transportation

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Root canal treatment, especially in curved and constricted root canals of molar teeth, can be very difficult and time consuming.[1] Since stainless-steel instruments have a tendency to restore their original linear shape, they may result in canal transportation.[2] Introduction of Ni-Ti rotary instruments to endodontic therapy has resulted in more flexible files with the ability to maintain original root canal shape.[3] Race files (FKG, La Chaux-de-Fonds, Switzerland) consist of full rotary instruments with a triangular cross-section and alternating cutting edges.[4] Several investigations have confirmed the ability of this system to properly clean and shape the curved root canals.[5-7] iRace is a recently introduced sequence with similar design features as Race consisting R1 (15.06), R2 (25.04) and R3 (30.04) and the manufacturer claimed that this sequence can be quick, safe and effective for preparation of curved root canals.[8]

Nowadays, reducing the number of instruments for root canal preparation has attracted more attention.[9-15]

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RECIPROC instruments (R25, R40 and R50; VDW GmbH, Munich, Germany) are made of M-wire, with regressive taper. They have S-shaped cross-section design and two effective cutting edges. The rational of reciprocating movement is based on balanced-force technique.[16] The R25 is used at 10 cycles of reciprocating motion per second for preparation of small, curved canals.[17] So far, no investigation has been performed to compare the centering ability of iRace and RECIPROC. Therefore, the aim of the present study was to compare root canal transportation and centering ability of iRace and RECIPROC in mesiobuccal (MB) canals of maxillary first molars by CBCT.

Methods

In this experimental study, thirty-two maxillary first molar teeth extracted for periodontal reasons were used. The inclusion criteria were: intact pulp chamber, fully formed MB roots, and MB root canal curvature ranging between 25-40 degrees according to the Schneider technique (1971). Exclusion criteria were sign of either presence of internal or external resorption and root canal calcification.

A #10 K-file (Maillefer/Dentsply, Ballaigues, Switzerland) was inserted in the MB canal until the tip was observed at the apical foramen and working length was established at 0.5 mm short of the measured length. The teeth with apical constriction wider than #15 K-file (as glide path), shorter than 21 mm and longer than 23 mm were excluded. Each tooth with the buccal root facing up was embedded in high-precision rubber-based impression material (Speedex, Coltene/Whaledent, Switzerland) for providing a mold. A #30 gutta-percha cone (Dia Dent, Korea) was placed along the MB root length as an indicator. Teeth with their impressions were mounted on some fiber platforms. Initial CBCT (NewTom VG, QR srl, Verona, Italy) images were conducted with the following settings: 0.3 mm voxel resolution at 110 kV and 10 mA, 12 s of exposure time, matrix of 512 × 512 pixels, axial pitch 0.3 mm and axial thickness 0.4 mm. Axial cross sections with 0.16 mm thickness were obtained at 2, 4 and 6 mm far from the apex. The images were stored, analyzed and converted in to JPEG format with the software NNT (NewTom VG, QR srl, Verona, Italy) provided for the CBCT machine.

The specimens were randomly divided into two groups (n = 15) with similar mean root canal curvature and two samples were used as control.

Canal preparation

Group A: The canals in this group were prepared by iRace (FKG, La Chaux-de-Fonds, Switzerland) sequence for curved canals using VDW Silver RECIPROC motor (Sirona, Bensheim, Germany) set at full rotation, torque equal to 1.5 N/cm and speed set at 600 rpm. A #15.06 file was carried to the working length followed by #25.04.

Group B: The canals of this group were prepared with R25 RECIPROC file with a taper of 0.08 over the first 3mm. The file was gradually inserted to the working length according to the manufacturer instructions by a torque-controlled motor VDW, Silver RECIPROC motor (Sirona, Bensheim, Germany) set at reciprocating mode.

In both groups, the root canals were irrigated with 2 ml 5.25% NaOCl after each file using a 28-gauge needle (Dentsply Tulsa Dental, Tulsa, OK). After root canal preparation, rinsing was done with 2 ml 17% EDTA (Meta Biomed Co., Ltd., Mandaluyong, Korea) followed by normal saline and 5.25% NaOCl (each 2 ml), respectively then 5 ml normal saline served as final irrigation. An Endodontist (B.D) prepared all the canals and each file was discarded after using in three canals.

The specimens were then returned to their initial jigs and post-instrumentation CBCT images were captured in the same manner as pre-instrumentation images. No preparation was done for the two control samples. They served as controls for the accuracy of the imaging set up. The images were exported to

the Adobe Photoshop software (version 7.0, Adobe system Inc., San Joes, CA, USA). The Magic tool was selected. The initial canal image was colored dark red and the post-instrument one was colored pink. The outer borders of the MB root in pre- and post-images were superimposed, so that the outer borders coincided (Figure 1). Zoom was increased to 1200.[2,18,19]

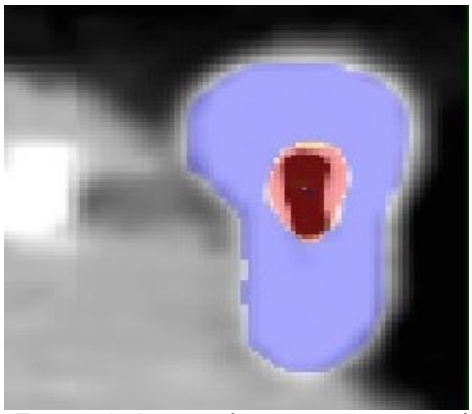

Figure 1. Pre- and post-superimposed images at level of 6 mm from the apex in a RECIPROC sample

The shortest distance from the outer border of the root to the outer border of the root canal was measured on mesial and distal aspect of each pre-and post-instrumentation images at each level (2, 4 and 6 mm far from the apex) three times and the mean scores was recorded by a graduated dental student (Figure 2).

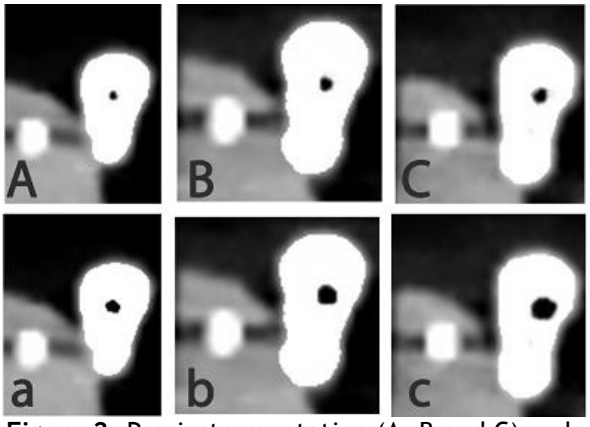

Figure 2. Pre-instrumentation (A, B and C) and post-instrumentation (a, b and c) images at 2, 4 and 6 mm distances from the apex, respectively in an iRace sample

Canal transportation was calculated according to the following formula:[3]

$$|(M_1 - M_2) - (D_1 - D_2)|$$

M_1 was the shortest distance from the mesial border of the root to the mesial border of the root canal before instrumentation. M_2 was the same distance measured on the image of instrumented canal. D_1 and D_2 served for the same measurements on the distal aspect of the root canal. According to this formula the result equal to 0 indicated no transportation, otherwise indicated root canal transportation. The centering ability of the preparation systems was calculated based on the following formula:[3]

$$\frac{(M_1 - M_2)}{(D_1 - D_2)}$$

Perfect centering was gained when the ratio = 1, otherwise transportation was recorded. Since the distribution of dependent variable was not normal, to compare the differences between the two groups and between the groups, Mann-Whitney U and Friedman tests were used, respectively and the level of significance was set at $P \leq 0.05$. The findings were evaluated using SPSS software (version 22, IBM Corporation, Armonk, NY, USA).

Results

The two control specimens showed exact superimposition of the root borders and canal border with no transportation.

iRace showed a lower transportation and a higher root canal centering ability compared to RECIPROC with no significant difference ($P \geq 0.05$) (Tables 1 and 2).

Table 1. Root canal transportation regarding to the root canal level and rotary system

Level	iRace (mean ± SD)	RECIPROC (mean ± SD)	P
2 mm	0.03 ± 0.01	0.04 ± 0.03	0.653
4 mm	0.04 ± 0.03	0.06 ± 0.04	0.187
6 mm	0.04 ± 0.02	0.05 ± 0.03	0.217

Mann-Whitney U was used for pairwise comparisons
SD: Standard deviation

Also there were no significant differences in transportation among different levels (i.e. 2 mm, 4 mm, 6 mm from the apex) ($P \geq 0.05$).

Table 2. Centering ability regarding to the root canal level and rotary system

Level	iRace (mean ± SD)	RECIPROC (mean ± SD)	P
2 mm	0.52 ± 0.29	0.41 ± 0.35	0.325
4 mm	0.53 ± 0.25	0.49 ± 0.33	0.806
6 mm	0.49 ± 0.29	0.45 ± 0.26	0.775

Mann-Whitney U was used for pairwise comparisons
SD: Standard deviation

Discussion

The results of this study showed no significant difference between RECIPROC and iRace regarding either centering ability or transportation following root canal preparation. Several methods such as double exposure of conventional or digital periapical radiographs, CBCT or micro CT have been used to evaluate the centering ability and transportation of either different rotary instruments or root canal preparation techniques on original root canal curvature. CBCT is a useful device and has been extensively used for various aspects in endodontics such as diagnosis of root fractures[2] and the efficacy of different instrumentation systems on root canal centering ability and transportation.[21-24]

In the present study, for evaluating the centering ability and transportation of MB root canal of maxillary first molars using RECIPROC and iRace rotary files, CBCT method was used for providing the 3D images of pre- and post-instrumentation of the root canal without destroying the specimens.[2,20,25-27] In order to assess the effect of new endodontic preparation techniques and instruments, it is reasonable to use mature teeth, especially those with more complicated anatomy. The most MB root canals of maxillary molar teeth are curved and delicate, and most of the time their preparation is so challenging. Some previous investigations on centering ability and root canal transportation have also used curved root canals.[2,3,5,7,28] It has been shown that the operator's level of experience had no influence on fracture or blockage of WaveOne reciprocating file,[13,15] however, in this study for improving internal reliability of the data, an endodontist (B.D) prepared all root canals.

In this study for apical matching of initial diameter of the samples and also for evaluation of the MB root canal curvature, a #15 K-file was introduced to the moderate to severe curved root canals as glide path. The manufacturer of RECIPROC has recommended creating a glide path with or without initial hand filing.[29] Nevertheless, it has been shown that glide path could help to reduce canal modification during reciprocating motion.[30] The usage of R25 RECIPROC instrument without a glide path for preparation of straight to moderate curved canals was recommended.[31]

Previous studies have attributed the ability of Race instruments on maintaining the original root canal morphology to the design of the active part of these files, with alternating cutting edges preventing the screw effect.[5,7] While, the ability of RECIPROC R25 to maintain the original root canal shape in this study might be the result of reciprocal motion that relieves stress on the instrument and prevents the screw effect as well.[11] Nevertheless, in this study, iRace showed a lower transportation and a higher root canal centering ability compared to RECIPROC with no significant difference. As Al-Gharrawi and Fadhil[8] have mentioned, it might be attributed to the greater taper of RECIPROC (0.08) compared to iRace (0.04) and smaller cross-sectional area and the resultant flexibility. On the other hand, the alternating cutting edges in iRace resulted in less screwing effect which had positive impact on shaping ability.[32] Also Hiran-us et al.[33] reported that the apical transportation was the least by iRace system.

In spite of different methods of evaluating centering ability and root canal transportation, the results of the present study regarding the RECIPROC was in

agreement with the findings of Burklein et al. who found no significant difference between RECIPROC, WaveOne, Mtwo and ProTaper.[11] Jain et al.[34] have stated that reciprocating movement can minimize torsional and flexural stresses, which results in less taper lock and minimum canal transportation.

Conclusion

Based on the results of this study, iRace with the sequence of #15.06 and #25.04 and R25 RECIPROC, in spite of many design variables and taper differences, have similar centering ability and maintain root canal curvature. Both systems seem to be safe for preparation of curved root canals.

Conflict of Interests

Authors have no conflict of interest.

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References

1. Yoshimine Y, Ono M, Akamine A. The shaping effects of three nickel-titanium rotary instruments in simulated S-shaped canals. J Endod 2005; 31(5): 373-5.
2. Ozer SY. Comparison of root canal transportation induced by three rotary systems with noncutting tips using computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011; 111(2): 244-50.
3. Gergi R, Rjeily JA, Sader J, Naaman A. Comparison of canal transportation and centering ability of twisted files, Pathfile-ProTaper system, and stainless steel hand K-files by using computed tomography. J Endod 2010; 36(5): 904-7.
4. Nabavizadeh M, Abbaszadegan A, Khojastepour L, Amirhosseini M, Kiani E. A Comparison of apical transportation in severely curved canals induced by Reciproc and BioRaCe systems. Iran Endod J 2014; 9(2): 117-22.
5. Schafer E, Vlassis M. Comparative investigation of two rotary nickel-titanium instruments: ProTaper versus RaCe. Part 2. Cleaning effectiveness and shaping ability in severely curved root canals of extracted teeth. Int Endod J 2004; 37(4): 239-48.
6. Guelzow A, Stamm O, Martus P, Kielbassa AM. Comparative study of six rotary nickel-titanium systems and hand instrumentation for root canal preparation. Int Endod J 2005; 38(10): 743-52.
7. Pasternak-Júnior B, Sousa-Neto MD, Silva RG. Canal transportation and centring ability of RaCe rotary instruments. Int Endod J 2009; 42(6): 499-506.
8. Al-Gharrawi H, Fadhil MA. A comparative study to evaluate canal transportation and centering ratio at different levels of simulated curved canals prepared by iRaCe, ProTaper NEXT and ProTaper universal files. J Am Sci 2016; 12(10): 103-15.
9. You SY, Kim HC, Bae KS, Baek SH, Kum KY, Lee W. Shaping ability of reciprocating motion in curved root canals: a comparative study with micro-computed tomography. J Endod 2011; 37(9): 1296-300.
10. Yoo YS, Cho YB. A comparison of the shaping ability of reciprocating NiTi instruments in simulated curved canals. Restor Dent Endod 2012; 37(4): 220-7.
11. Burklein S, Hinschitza K, Dammaschke T, Schafer E. Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals of extracted teeth: Reciproc and WaveOne versus Mtwo and ProTaper. Int Endod J 2012; 45(5): 449-61.
12. 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(4): 505-9.
13. Goldberg M, Dahan S, Machtou P. Centering ability and influence of experience when using WaveOne Single-File technique in simulated canals. Int J Dent 2012; 2012: 206321.
14. Lim YJ, Park SJ, Kim HC, Min KS. Comparison of the centering ability of Wave.One and Reciproc nickel-titanium instruments in simulated curved canals. Restor Dent Endod 2013; 38(1): 21-5.
15. Generali L, Righi E, Todesca MV, Consolo U. Canal shaping with WaveOne reciprocating files: influence of operator experience on instrument breakage and canal preparation time. Odontology 2014; 102(2): 217-22.
16. Burklein S, Benten S, Schafer E. Shaping ability of different single-file systems in severely curved root canals of extracted teeth. Int Endod J 2013; 46(6): 590-7.
17. Munoz E, Forner L, Llena C. Influence of operator's experience on root canal shaping ability with a rotary nickel-titanium single-file reciprocating motion system. J Endod 2014; 40(4): 547-50.
18. Hartmann MS, Barletta FB, Camargo Fontanella VR, Vanni JR. Canal transportation after root canal instrumentation: a comparative study with computed tomography. J Endod 2007; 33(8): 962-5.
19. Hartmann MS, Fontanella VR, Vanni JR, Fornari VJ, Barletta FB. CT evaluation of apical canal transportation

associated with stainless steel hand files, oscillatory technique and pro taper rotary system. Braz Dent J 2011; 22(4): 288-93.
20. Wenzel A, Haiter-Neto F, Frydenberg M, Kirkevang LL. Variable-resolution cone-beam computerized tomography with enhancement filtration compared with intraoral photostimulable phosphor radiography in detection of transverse root fractures in an in vitro model. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009; 108(6): 939-45.
21. Moazzami F, Khojastepour L, Nabavizadeh M, Seied HM. Cone-Beam computed tomography assessment of root canal transportation by Neoniti and Reciproc Single-File systems. Iran Endod J 2016; 11(2): 96-100.
22. Prabhakar AR, Yavagal C, Dixit K, Naik SV. Reciprocating vs rotary instrumentation in pediatric endodontics: Cone beam computed tomographic analysis of deciduous root canals using two single-file systems. Int J Clin Pediatr Dent 2016; 9(1): 45-9.
23. Navos BV, Hoppe CB, Mestieri LB, Bottcher DE, So MV, Grecca FS. Centering and transportation: in vitro evaluation of continuous and reciprocating systems in curved root canals. J Conserv Dent 2016; 19(5): 478-81.
24. Prasanthi NN, Rambabu T, Sajjan GS, Varma KM, Satish RK, Padmaja M. A comparative evaluation of the increase in root canal surface area and canal transportation in curved root canals by three rotary systems: A cone-beam computed tomographic study. J Conserv Dent 2016; 19(5): 434-9.
25. Siqueira JF, Jr., Alves FR, Versiani MA, Rocas IN, Almeida BM, Neves MA, et al. Correlative bacteriologic and micro-computed tomographic analysis of mandibular molar mesial canals prepared by self-adjusting file, reciproc, and twisted file systems. J Endod 2013; 39(8): 1044-50.
26. Versiani MA, Leoni GB, Steier L, De-Deus G, Tassani S, Pecora JD, et al. Micro-computed tomography study of oval-shaped canals prepared with the self-adjusting file, Reciproc, WaveOne, and ProTaper universal systems. J Endod 2013; 39(8): 1060-6.
27. Robinson JP, Lumley PJ, Cooper PR, Grover LM, Walmsley AD. Reciprocating root canal technique induces greater debris accumulation than a continuous rotary technique as assessed by 3-dimensional micro-computed tomography. J Endod 2013; 39(8): 1067-70.
28. Saber SE, Nagy MM, Schafer E. Comparative evaluation of the shaping ability of ProTaper Next, iRaCe and Hyflex CM rotary NiTi files in severely curved root canals. Int Endod J 2015; 48(2): 131-6.
29. Yared G. Canal preparation with only one reciprocating instrument without prior hand filing: A new concept [Online]. [cited 2011]; Available from: URl: http://endodonticcourses.com/cmsAdmin/uploads/RECIPROC-OL-Article.pdf
30. Berutti E, Paolino 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(1): 101-4.
31. Yared G. Canal preparation of the MB2 canal with the R25 RECIPROC® instrument without prior hand filing or glide path [Online]. [cited 2013]; Available from: URL: http://endodonticcourses.com/cmsAdmin/uploads/MB2_en_26-3-13.pdf
32. Deka A, Bhuyan AC, Bhuyan D. A comparative evaluation of root canal area increase using three different nickel-titanium rotary systems: An ex vivo cone-beam computed tomographic analysis. Contemp Clin Dent 2015; 6(1): 79-83.
33. Hiran-us S, Pimkhaokham S, Sawasdichai J, Ebihara A, Suda H. Shaping ability of ProTaper NEXT, ProTaper Universal and iRace files in simulated S-shaped canals. Aust Endod J 2016; 42(1): 32-6.
34. Jain A, Asrani H, Singhal AC, Bhatia TK, Sharma V, Jaiswal P. Comparative evaluation of canal transportation, centering ability, and remaining dentin thickness between WaveOne and ProTaper rotary by using cone beam computed tomography: An in vitro study. J Conserv Dent 2016; 19(5): 440-4.