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Comparative evaluation of shaping abilities of two different rotary files (an in vitro study).

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Abstract

Purpose: Successful endodontic therapy is based mainly upon effective mechanical instrumentation and disinfection of root canals. This study compares the antibacterial effect of Erbium, chromium: yttrium-scandium-gallium-garnet (Er, Cr:YSGG) laser 2780nm wavelength, diode laser 940nm wavelength and sodium hypochlorite (NaOCl) 5.25% solution on *Enterococcus faecalis* (*E. faecalis*) biofilm.

Materials and methods: A total of 50 extracted human permanent maxillary central incisor teeth were prepared to size X4 Protaper Next and contaminated with *E. Faecalis* for biofilm formation. After ten days of incubation and based on the method of disinfection of the root canals, the specimens were randomly grouped into; group A (n=15), which was irradiated by ER, Cr: YSGG laser 2780nm wavelength; group B (n=15), which was irradiated with a diode laser 940 nm wavelength; group C (n=15), which was rinsed with 5.25% NaOCl solution. Three teeth were used to confirm the biofilms formation by scanning electron microscope (SEM) and two teeth served as negative control. Intracanal bacteria sampling was performed under complete aseptic conditions before and after disinfection. The specimens were cultured to enumerate the colony forming units (CFUs) count.

Results: Although group C (5.25% NaOCl solution) showed a more disinfection than both laser systems, there was no significant difference between all groups (P> 0.05).

Conclusion: Both ER, Cr: YSGG laser 2780nm wavelength and diode laser 940nm wavelength have nearly similar antibacterial efficacy on *E. faecalis* compared with NaOCl 5.25% solution. The use of laser for root canal disinfection may be advantageous considering several unfavorable actions of NaOCl.

Key words: Laser, *Enterococcus faecalis*, Root canal, Sodium hypochlorite.

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Introduction

Cleaning and shaping of the root canal system is considered the most critical phase of the root canal treatment as cleaning involves the elimination of all organic materials that encourage bacterial growth, whereas shaping encompasses preparing the root canal into a continuously tapering form that allows effective irrigation and provide sufficient access for the obturation instruments and materials. Preserving the original canal's anatomy during cleaning and shaping phase, remains a major challenge as none of the rotary instruments used were able to produce a completely clean canal(1), with maintenance of the canal curvature. Conventionally, stainless steel instruments were used for cleaning and shaping of root canals. However, the use of such stiff instruments is associated with a higher incidence of procedural errors compared with Ni-Ti instruments(2).

The drawbacks encountered with the rigidity of stainless steel hand instruments, had led to the introduction of the more flexible Nickel-Titanium instruments, as they have many great advantages such as; their ability to overcome the rigidity issue, reduced treatment time with safety of instrumentation, and fewer procedural mishaps, due to their super-elasticity(3).

Despite all these advantages of the super elastic Ni-Ti rotary files, curved root canals are subjected to a high prevalence of preparation errors or canal aberrations like root canal transportation, which means asymmetrical root canal dentin removal during shaping, due to the tendency of the rotary file to straighten itself inside the canal. Also, rotary Ni-Ti instruments still suffer from the high risk of fracture. Hence, there have been considerable improvements in the file design, metallurgy, manufacturing methods of rotary Ni-Ti instruments. Heat treatment of Ni-Ti alloys producing M wire, CM wire, and R phase or incorporating new manufacturing processes such as surface treatments, and electrical discharge machining had improved mechanical properties, cutting efficiency and cyclic fatigue resistance of these instruments.

The iRaCe file system, which is made from conventional austenite Ni-Ti, with a uniform triangular cross section, alternating cutting edges, and a non-cutting tip design. It had undergone an electrochemical surface treatment, which significantly increased its cyclic fatigue resistance(4). Some studies reported that this system had good cleaning and shaping abilities, and recommended its use in shaping S-shaped canals, as it preserves and respects the original canal anatomy and the position of the apical foramen(5)(6)(7). The XP-Endo

Shaper file, which is made from Max-Wire (Martensite-Austenite-electropolish-fileX), is a recent type of alloy that is the first that combines both the super-elasticity and shape memory effect in a single system. This file showed better centering ability and less canal transportation[8] and has the ability to touch more canal walls[9]. These files are characterized by a significant increase in cyclic fatigue resistance[10]. However, they suffer from a decreased torsional resistance[11][12].

In this study the shaping ability of the recently introduced XP-Endo Shaper file, which made from the recent Ni-Ti alloy called "Max-Wire", was compared to iRaCe rotary file, which is made from the conventional super-elastic Ni-Ti alloy.

Materials and methods

a) Samples selection and preparation:

Thirty human permanent mandibular first and second molars, with mesiobuccal canal type III according to weine's classification, and canal curvature angle within 20º – 35º according to Schneider's method[13]. The occlusal surfaces were flattened, Access cavity and canal patency were done, then the working length was measured using K-file #10 until it is visible from the apex, then subtracting 1mm from tooth length.

b) Samples classification:

The thirty samples were divided into two equal groups, according to the type of rotary file used in canal instrumentation; **Group I** (XP-endo Shaper), and **Group II (**iRaCe).

c) Pre-instrumentation CBCT imaging:

Before CBCT scanning, two molds were made by using silaxil condensation silicones rubber base impression material putty consistency, each mold held up to 15 mandibular molars. The mesial roots were wrapped with teflon tape, whereas the distal roots were removed. Then each tooth was immersed vertically in the mold. A gutta percha cone was inserted vertically into the impression material, to enable the orientation of the canals during scanning and image analysis.

CBCT scanning was done using iCAT 17-19 CBCT scanner, with the following operation protocol: 120 kVp, 5 mAs, voxel size 0.125 mm, scanning time 7 sec, and field of view 8 x 4 cm. Image analysis was done by another clinician using Anatomage InVivoDental software version 5.3.1 to calculate pre-instrumentation measurements of: mesiobuccal root canal curvature using Schneider's method, and root dentin thickness measurements measured at three levels from root apex (3, 6 & 9mm), and the shortest distance from the canal walls to the external root surface was measured in two directions mesial (M1) and distal (D1), as the shortest distance between the mesial or the distal margin of the un-instrumented root canal to the external root surface respectively.

d) Root canal instrumentation:

For both groups, root canal instrumentation was done in a warm water bath, with temperature around 37°C, to simulate human body temperature. The irrigation protocol[14] was carried out using a total volume of 9 mL of 5.25% sodium hypochlorite solution delivered using a 30-G Navi Tip needle adapted to a disposable plastic syringe applied to a depth of 2mm short from the working length. After instrumentation was completed, 5 mL of 17% EDTA solution was used followed by 10 mL of distilled water as a final flush. Each file was operated according to manufacturer's recommendations, using gentle strokes until reaching down the working length.

e) Post-instrumentation CBCT imaging:

Post-instrumentation CBCT scanning was done to calculate post-instrumentation measurements.

f) Evaluation of Shaping Ability:

The superimposition tool of the software was applied to automatically superimpose pre- and post-instrumentation images, hence guaranteeing measuring dentin thickness at the same exact point and level of the root canal. So the Linear amount of dentin removed was calculated according to the following formula (M1-M2) & (D1-D2) from mesial and distal directions respectively.

Changes in mesiodistal canal curvature of the mesiobuccal canal were calculated in means of percentage of the change in canal curvature angle according to **Estrela et al.**[15]. The amount of transportation in mesiodistal direction was measured according to method developed by **Gambill et al.**[16], as the following equation (M1 – M2) – (D1 – D2). A result of zero means no transportation, a positive result means transportation is toward mesial, while a negative result means transportation is toward distal. Centering ratio was calculated mesiodistally by formula introduced by **Gambill et al.**[16], using the following formula (M1 – M2) / (D1 – D2). If these numbers are not equal, the lower figure is considered the numerator of the ratio. According to this formula, a result of 1 indicates perfect centering.

Statistical analysis

Numerical data were explored for normality by checking the data distribution, calculating the mean and median values and using Kolmogorov-Smirnov and Shapiro-Wilk tests. Data showed parametric distribution so; it was represented by mean and standard deviation (SD) values. Intergroup comparisons were done using independent t-test, while intragroup comparisons were done using one-way repeated measures ANOVA followed by bonferroni post hoc test. The significance level was set at $p \leq 0.05$ within all tests. Statistical analysis was performed with IBM SPSS Statistics Version 26 for Windows.

Results:

No statistically significant differences were observed between both files in, post instrumentation canal curvature, percentage of change of canal curvature, transportation, and centering ability (p>0.05). No statistically significant differences were observed between different canal levels within each group, regarding, transportation, and centering ability (p>0.05). **(Table 1)**

Table 1: mean and standard deviation values of canal curvature, transportation, and centering ratio of both groups (P-value; significant (p ≤ 0.05) ns; non-significant (p>0.05)).

		XP-Endo Shaper	**iRaCe**	**P-value**
PRE-INSTRUMENTATION CANAL CURVATURE		26.93±3.59	27.28±2.19	**0.785ns**
POST-INSTRUMENTATION CANAL CURVATURE		24.41±4.09	24.32±2.07	**0.948ns**
% OF CHANGE OF CANAL CURVATURE		9.79±1.73	10.80±1.57	**0.600ns**
CANAL TRANSPORTATION	Coronal	0.11±0.08	0.06±0.06	**0.072ns**
	Middle	-0.06±0.05	-0.06±0.07	**0.932ns**
	Apical	0.05±0.04	0.04±0.03	**0.190ns**
	P-value	**0.077ns**	**0.519ns**	
CENTERING RATIO	Coronal	0.60±0.24	0.70±0.22	**0.247ns**
	Middle	0.59±0.28	0.57±0.28	**0.896ns**
	Apical	0.49±0.27	0.44±0.34	**0.635ns**
	P-value	**0.490ns**	**0.079ns**	

Discussion

Recently introduced rotary files are claimed to be more superior over the previous files in canal preparation, with the continuous improvements in cross-sectional designs or file tip design, heat treatment of the alloys, surface treatments, or incorporating new manufacturing processes. So, it is essential to precisely evaluate canal geometry in three dimensions and to compare the pre-and post-instrumentation shapes to confirm or refute such claims.

Root canal transportation occurs result of asymmetrical root canal dentin removal during shaping, due to the tendency of the rotary file to straighten itself inside the canal, leading to an apical area of the root canal over prepared on the outer curve of the canal, whereas coronally over prepared toward the inner curve of the

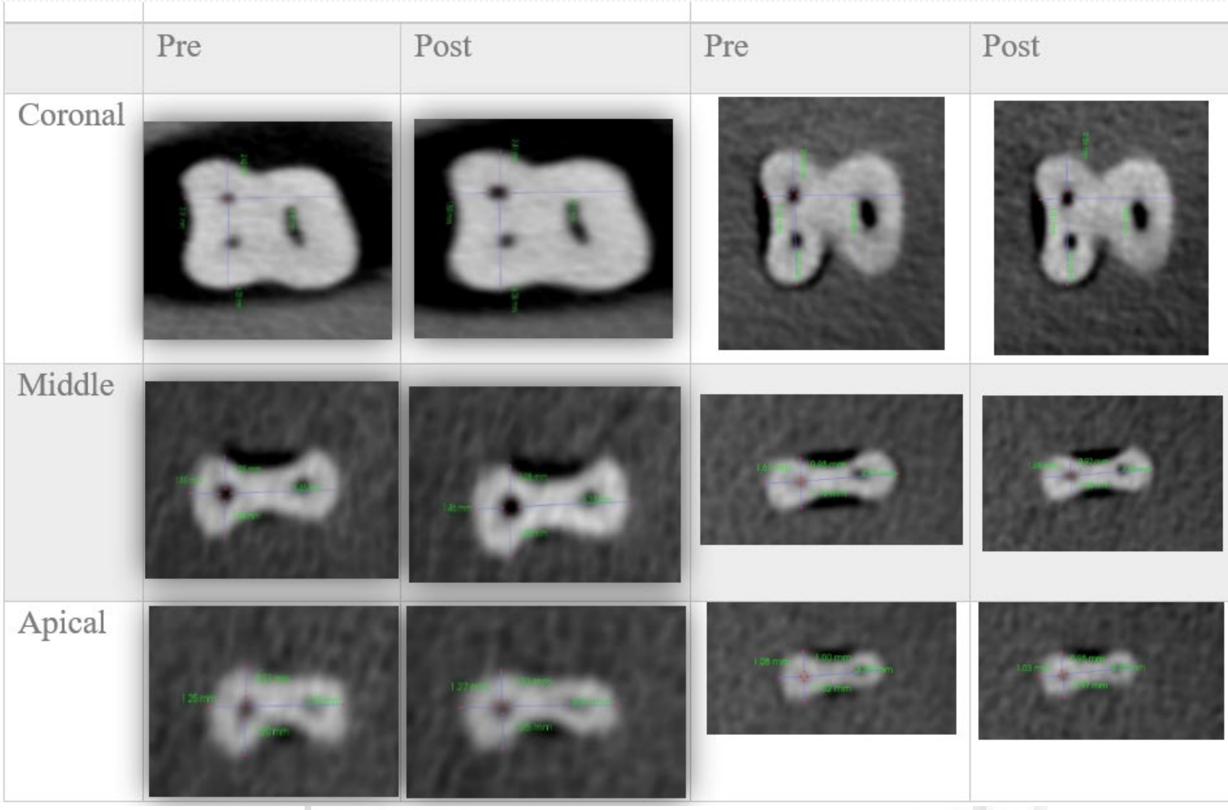

Plate 1 Pre-and post-instrumentation CBCT images of dentin thickness measurement at coronal, middle and apical levels

canal. As a consequence of root canal transportation, mishaps from ledge formation up to root canal perforation are possible to a varying degrees, so the higher the canal curvature degree and the lesser the radius of curvature, the higher the risk of canal transportation(17). An acceptable range for apical transportation is in the range of 5°-7.7° or not more than 300 µm, or it will adversely affect the seal of the obturation materials(18). Centering ability is the ability of the instrument to stay centered in the canal. The literature showed that shaping ability is influenced by; instrument design (cross-section, taper, and tip), type of alloy used, and kinematics(19). Both canal transportation and centering ability are used to assess the efficiency of rotary instruments in mechanical preparation of the root canals with the preservation of root canal anatomy(20).

Hence this study was to evaluate changes in canal curvature, transportation, centering ability, to assess the efficiency of the new generation of rotary files (XP-Endo Shaper), against a conventional uniform taper Ni-Ti rotary instrument (iRaCe rotary file system), which was chosen here as it can achieve final canal preparation of 30/.04, which is similar to XP-Endo Shaper final preparation size. In this study, extracted natural teeth were chosen over resin blocks, because of the major advantage of simulating the clinical, however the standardization of some variables is much more difficult than in resin blocks(21).

The mesiobuccal canals of extracted first and second mandibular molars were selected, as these canals are round, narrow, and usually have a curvature in at least the mesiodistal plane. Both pre-and post-operative determination of root canal curvature were measured using Schneider's method(23), as it is a reliable method used by many authors(24)(25). Comparison of the mean and standard deviation values of the pre-operative measurements of root canal curvature, was done to confirm that there was no statistically difference between both groups.

In order to mimic the clinical situation, the crowns were kept to preserve the cervical dentin projections, as they create interferences and tensions on the files during instrumentation(26)(27). Only flattening of the occlusal surfaces of the molars were done to achieve a standard working length and a reliable reference point during canal instrumentation. Also; all root canal instrumentation was done in a preheated water bath and the temperature was kept at 37° C, simulating the intracanal temperature, because heat-treated instruments like XP-Endo Shaper can change from martensite to austenite phase when heated affecting its expansion properties, and also for standardization purposes the iRaCe files were subjected to the same temperature, despite it has no effect on the file cleaning and shaping abilities(9).

CBCT was used in conjunction with the 3D software, for the evaluation of shaping ability, as it allows a noninvasive detailed 3D observation of the root canal anatomy with high-resolution images at the exact pre- and post-instrumentation root canal levels, for accurate measurement of changes in canal curvature and centering ability(21).

The instrumentation effects of both systems on shaping of the root canal, were examined at 3-, 6- and 9-mm levels from the apex. The first level was made at 3mm (apical) from the root apex, because various studies have found that root canal transportation often occurs within these few millimeters. The second and third levels were made at 6mm representing the mid-root and at 9mm representing coronal level, where there is a high risk for strip perforation during root canal instrumentation(17).

With regard to canal curvature results, the highest mean value of post-instrumentation measurements was recorded with the iRaCe files, followed by the XP-Endo Shaper file, without statistically difference between different them. On comparing percentage of change of canal curvatures, it was found that the highest mean value was recorded with the iRaCe files, followed by the XP-Endo Shaper file, with no statistically significant differences between the two groups. This may be attributed to their triangular cross section and small cross-sectional diameter, improving their flexibility. Both files did not cause more than 3° angle change which is below the acceptable range for apical transportation (5°-7.7°)[18].

Regarding the effect of instrument on mesiodistal canal transportation, it was found that the highest mean value of canal transportation was recorded with the XP-Endo Shaper, followed by the iRaCe files, at both the coronal and the apical levels, without statistically significant difference between them. Mesial transportation occurred with both files at the coronal and apical levels. While at the middle level, both files exhibited distal transportation, with similar mean values of transportation. These findings came into a partial agreement with that of **Hassan et al.**[25] in that, at the coronal level, the XP-Endo Shaper file showed mesial transportation, and did not agree with that, the XP-Endo Shaper files showed distal transportation apically, this might be related to the different methodology used in sample preparation and instrumentation, as decoronation was done and instrumentation was not done in preheated water bath. Also our findings did not agree **Xavier et al.**[28], who found that the XP-Endo Shaper exhibited distal transportation coronally and apically, this might be attributed to the usage of single rooted teeth in the evaluation of the XP-Endo Shaper file. Many other studies[29][30] reported that the apical part of the canal usually shows mesial transportation. These results might be attributed to the uniform taper and the small diameter of these files, as there is a higher tendency of canal transportation as the file diameter increases[25].The reason for the XP-Endo Shaper causing more mesial canal transportation coronally than the iRaCe files, might be attributed to its swaggering motion. According to **De Carvalho et al.**[29] and **Elnagy & Elsaka**[31], more than 0.3 mm of apical transportation can adversely affect the sealing ability of the obturation materials. Fortunately, in our study no rotary file produced more than 0.1 mm .

On comparing the effect of canal level on mesiodistal transportation, in XP-Endo Shaper group, the highest mean value of transportation was recorded coronally, followed by the middle level, and the least value was apically, without statistically significant difference between them. In iRaCe group, both the coronal and middle levels had similar and the highest values of transportation, followed by the apical canal level, without statistically significant difference between them. These results came into an agreement with many studies[25][28][32] in that, the coronal level had the highest mean value of transportation. These results might be attributed to the snake like motion and offset rotation center of the XP-Endo Shaper file, allowing it to engage and disengage the canal walls, reducing the stresses between the file and the canal and preserving the original canal pathway[25]. On the other hand, the alternating cutting edges of the iRaCe files, was claimed to prevent the screwing in effect thus reducing stresses exerted on the file, leading to only minimal canal transportation[6].

Comparing the effect of instrument on centering ratio, the iRaCe files recorded the highest mean value of centering ratio, only at the coronal level, followed by the XP-Endo Shaper file, without statistically significant difference between the two them. Whereas the XP-Endo Shaper recorded the highest mean value of centering ratio, at both the middle and apical levels, followed by the iRaCe files, without statistically significant difference between them. Although there was non-significant difference among both files at all levels, it is worth emphasizing that coronally, the iRaCe files had mean values closer to 1 than the XP-Endo Shaper. However, the XP-Endo Shaper had mean values closer to 1 at the middle and the apical levels of the canal than iRaCe file system. So, maintenance of canal curvature was seen to be slightly better for XP-Endo Shaper file than iRaCe, which might be explained by the flexibility of the new MAX-wire alloy of the XP-Endo Shaper file, adapting favorably to the original canal path .

Comparing the effect of canal level on centering ratio, we found that in both groups, the highest mean value was recorded coronally, followed by the middle level, and the least value was recorded apically, without statistically significant differences between them. These findings were found to be consistent with many studies[25][28], as the XP-Endo Shaper showed the least mean value of centering ratio apically and the highest value was coronally. Our findings did not agree with **Morales et al.**[32], as the highest mean value of centering ratio was recorded apically and the least was recorded coronally, which might be attributed to the selection of premolars with root curvatures angle between 10 – 20 degrees.

Conclusion

Within the limitations of this study, it can be concluded that both files were equally effective in shaping the root canal system, maintaining the original canal anatomy.

References

1. Bidar M, Moradi S, Forghani M, Bidad S, Azghadi M, Rezvani S, et al. Microscopic evaluation of cleaning efficiency of three different nickel-titanium rotary instruments. Iran Endod J [Internet]. 2010;5(4):174–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23130047%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC3471575
2. Cheung GSP, Liu CSY. A Retrospective

Study of Endodontic Treatment Outcome between Nickel-Titanium Rotary and Stainless Steel Hand Filing Techniques. J Endod [Internet]. 2009;35(7):938–43. Available from: http://dx.doi.org/10.1016/j.joen.2009.04.016
3. Walia H, Brantley WA, Gerstein H. An initial investigation of the bending and torsional properties of nitinol root canal files. J Endod. 1988;14(7):346–51.
4. Lopes HP, Elias CN, Vieira VTL, Moreira EJL, Marques RVL, MacHado De Oliveira JC, et al. Effects of electropolishing surface treatment on the cyclic fatigue resistance of biorace nickel-titanium rotary instruments. J Endod. 2010;36(10):1653–7.
5. 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.
6. Saber SED, Nagy MM, Schäfer 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.
7. Sh Al-Gharrawi HA, Ali Fadhil M. 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 [Internet]. 2016;12(10):103–15. Available from: http://www.jofamericanscience.orgonline
8. Arıcan Öztürk B, Atav Ateş A, Fişekçioğlu E. Cone-Beam Computed Tomographic Analysis of Shaping Ability of XP-endo Shaper and ProTaper Next in Large Root Canals. J Endod. 2020;46(3):437–43.
9. Azim AA, Piasecki L, da Silva Neto UX, Cruz ATG, Azim KA. XP Shaper, A Novel Adaptive Core Rotary Instrument: Micro–computed Tomographic Analysis of Its Shaping Abilities. J Endod [Internet]. 2017;43(9):1532–8. Available from: http://dx.doi.org/10.1016/j.joen.2017.04.022
10. Elnaghy A, Elsaka S. Cyclic fatigue resistance of XP-endo Shaper compared with different nickel-titanium alloy instruments. Clin Oral Investig. 2018;22(3):1433–7.
11. Silva EJNL, Vieira VTL, Belladonna FG, Zuolo A de S, Antunes H dos S, Cavalcante DM, et al. Cyclic and Torsional Fatigue Resistance of XP-endo Shaper and TRUShape Instruments. J Endod. 2018;44(1):168–72.
12. Elnaghy AM, Elsaka SE. Torsional resistance of XP-endo Shaper at body temperature compared with several nickel-titanium rotary instruments. Int Endod J. 2018;51(5):572–6.
13. Balani P, Niazi F, Rashid H. A brief review of the methods used to determine the curvature of root canals. J Restor Dent. 2015;3(3):57.
14. Yamada RS, Armas A, Goldman M, Lin PS. A scanning electron microscopic comparison of a high volume final flush with several irrigating solutions: Part 3. J Endod. 1983;9(4):137–42.
15. Estrela C, Bueno MR, Sousa-Neto MD, Pécora JD. Method for determination of root curvature radius using cone-beam computed tomography images. Braz Dent J. 2008;19(2):114–8.
16. Gambill JM, Alder M, Carlos E. del Rio. Comparison of nickel-titanium and stainless steel hand-file instrumentation using computed tomography. J Endod. 1996;22(7):369–75.
17. SCHÄFER E, DAMMASCHKE T. Development and sequelae of canal transportation. Endod Top. 2006;15(1):75–90.
18. Wu MK, Fan B, Wesselink PR. Leakage along apical root fillings in curved root canals. Part I: Effects of apical transportation on seal of root fillings. J Endod. 2000;26(4):210–6.
19. Deivanayagam Kandaswamy NV, Porkodi I, Pradeep G. Canal-centering ability: An endodontic challenge. J Conserv Dent. 2009;12:3–9.
20. de Sousa-Neto MD, Silva-Sousa YC, Mazzi-Chaves JF, Carvalho KKT, Barbosa AFS, Versiani MA, et al. Root canal preparation using micro-computed tomography analysis: A literature review. Braz Oral Res. 2018;32:20–43.
21. Hulsmann M, Peters OA, Dummer PMH. Mechanical preparation of root canals: shaping goals, techniques and means. Endod Top. 2005;10(1):30–76.
22. Aminsobhani M, Razmi H, Nozari S. Ex Vivo Comparison of Mtwo and RaCe Rotary File Systems in Root Canal Deviation: One File Only versus the Conventional Method. J Dent Tehran Univ Med Sci. 2015;12(7):469–77.
23. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surgery, Oral Med Oral Pathol. 1971;32(2):271–5.
24. El Batouty KM, Elmallah WE. Comparison of canal transportation and changes in canal curvature of two nickel-titanium rotary instruments. J Endod [Internet]. 2011;37(9):1290–2. Available from:

http://dx.doi.org/10.1016/j.joen.2011.05.024

25. Hassan R, Roshdy N, Issa N. Comparison of Canal Transportation and Centering Ability of Xp Shaper, Waveone and Oneshape: a Cone Beam Computed Tomography Study of Curved Root Canals. Egypt Dent J. 2018;64(2):1845–53.
26. Hartmann MSM, 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.
27. Hashem AAR, Ghoneim AG, Lutfy RA, Foda MY, Omar GAF. Geometric analysis of root canals prepared by four rotary NiTi shaping systems. J Endod [Internet]. 2012;38(7):996–1000. Available from: http://dx.doi.org/10.1016/j.joen.2012.03.018
28. Xavier SR, de Lima CO, Marceliano-Alves MFV, Lacerda MFLS, Lopes RT, Campos CN. Shaping ability of two root canal instrumentation systems in oval-shaped canals: A microcomputed tomography study. Aust Endod J. 2020;(3):1–8.
29. De Carvalho GM, Sponchiado Junior EC, Garrido ADB, Lia RCC, Roberti Garcia LDF, Franco Marques AA. Apical Transportation, Centering Ability, and Cleaning Effectiveness of Reciprocating Single-file System Associated with Different Glide Path Techniques. J Endod. 2015;41(12):2045–9.
30. Alfadley A, Alrajhi A, Alissa H, Alzeghaibi F, Hamadah L, Alfouzan K, et al. Shaping Ability of XP Endo Shaper File in Curved Root Canal Models. Int J Dent. 2020;2020.
31. Elnaghy AM, Elsaka SE. Shaping ability of ProTaper Gold and ProTaper Universal files by using cone-beam computed tomography. Indian J Dent Res. 2017;27(1):37-41.
32. Perez Morales M de las N, González Sánchez JA, Olivieri Fernández JG, Laperre K, Abella Sans F, Jaramillo DE. TRUShape Versus XP-endo Shaper: A Micro–computed Tomographic Assessment and Comparative Study of the Shaping Ability—An In Vitro Study. J Endod. 2020;46(2):271–6.