Al-Rafidain Dental Journal

rden.mosuljournals.com

Cone Beam Computed Tomography Evaluation of Transportation of Three Endodontic Single File Systems.

Ali M. Mahmood [1], Manal A. Sultanb [2]

[1] Ministry of Health/ Nineveh Health Directorate

[2] Department of Conservative Dentistry, College of Dentistry, University of Mosul

Article information

Received: September 7, 2021
Accepted: August 22, 2021
Available online: March 20, 2023

Keywords
Transportation
Edge one fire
Wave one gold

***Correspondence:**
E-mail:
allawi12312@gmail.com

Abstract

Aims: The present study aims to compare and evaluate transportation of three different single endodontic files (EdgeOne Fire, One curve file and Wave One Gold file) by using CBCT. **Materials and Methods**: Thirty freshly extracted human mandibular first molars with mature apices and intact mesial root randomly distributed into three groups (n=10) only Mesiobuccal canals (MB) with curvatures of 25–35 were prepared by using Edge One Fire (group A), MicroMega One curve file (group B) and Wave One Gold file (group C) and 3-dimensional, high-resolution CBCT images were obtained using CS8100 3D equipment (Carestream Health, Rochester, NY) at three cross-section levels that corresponded to 3-mm, 5-mm, and 7-mm distance from the apical end of the root before and after root canal preparation with 87 KV, 2.00 mA and 150 µm voxel size to determine the degree of canal transportation of the three file systems. **Results**: the highest degree of root canal transportation appeared with One Curve file while Edge One Fire showed the lowest degree of root canal transportation and there was a statistically significant difference between all three files. **Conclusions**: Within the limitations in this study, it can be concluded tha all tested Ni-Ti file systems resulted in root canal transportation, and Edge One Fire file is safer during preparation of curved canals than One Curve file.

الخلاصة

الأهداف: تهدف الدراسة الى لقارنة وتقييم قابلية نقل القناة اللبية اثناء التحضير لثلاثة مبارد لبية باستخدام التصوير المخروطي المقطعي المحوسب (EdgeOne Fire, One curve file and Wave One Gold file system). **المواد وطرائق العمل**: تمت الدراسة باستخدام ثلاثون ضرسًا سفليا بشريًا تم قلعها حديثا ذات جذور أنسية سليمة ونهايات قمية ناضجة تم توزيع العينات على ثلاث مجاميع كل مجموعة تحتوي على عشر عينات و تم تحضير القنوات الانسية الدهليزية ذات درجة انحناء 25-35 درجة باستخدام الثلاث مبارد اللبية المختلفة ثم تصوير العينات باستخدام جهاز (Carestream CS 8100) والحصول على صوردقيقة ثلاثية الابعاد على ثلاثة مستويات مقطعية عرضية تقابل مسافة 3 مم و 5 مم و 7 مم من الطرف القمي للجذر قبل و بعد تحضير قناة الجذر بقوة 87 كيلوفولت و 2.00 مللي أمبير و حجم فوكسل 150 ميكرومتر لتحديد درجة نقل القنوات لأنظمة الملفات الثلاثة. **النتائج**: اظهرت النتائج اعلى درجة لنقل القناة باستخدام مبرد (One Curve) بينما اظهر مبرد (Edge One Fire) اقل قابلية لنقل القناة الجذرية ووجد اختلاف معنوي في قابلية نقل القناة بين المبارد اللبية الثلاثة. **الاستنتاجات**: جميع المبارد اللبية الثلاثة اظهرت قابلية لنقل القناة الجذرية وان استخدام مبرد (Edge One Fire) امن اثناء تحضير القناة اللبية لقابليته المنخفضة لنقل القناة

DOI: 10.33899/RDENJ.2021.130745.1116

INTRODUCTION

Root canal treatment aims to eliminate any pathologies of the pulp and peri-radicular tissues, this is accomplished through meticulous disinfection and shaping by both mechanical preparations using various types of endodontic instruments and chemical disinfection by using chemical irrigation solution to accomplish the final goal of root canal treatment [(1)].

Various complications may occur during endodontic treatment, such as canal transportation in curved roots which may be caused by the high rigidity of the file or iatrogenic errors, such as forcing files inside the root canal or incorrect file sequencing and lack of sufficient irrigation; therefore, endodontic treatment of severely curved canals requires special preparation techniques to avoid such complications, preserve canal anatomy and morphology (curvature) and decrease the amount of canal straightening [(2,3)].

Great advancement have been achieved in endodontic files manufacturing and enhancement in the properties of endodontic files such as improved flexibility , better resistance to cyclic fatigue and improved fracture resistance of endodontic files due to introduction of Nickel-Titanium alloy which characterized by its super-elasticity and can improve canal shaping and reduce the degree of canal straightening (transportation) compared to stiffer stainless steel files [(4)].

Highly flexible and efficient Ni-Ti instruments and torque-adjusted devices have been introduced to overcome the problems associated with high rigidity, endodontic treatment of severely curved roots remains a challenge and root canals may be subjected to iatrogenic errors and endodontic mishaps such as transportation and/or other procedural errors [(5)].

It has been proven that Ni-Ti instruments remain much more centered within the root canal and display less canal transportation than instruments made with stainless steel alloy, which is critical for providing a proper expansion without excessive weakening of the root structure[(6,7)].

Different approaches have been used to examine the quality of root canal preparation of various Ni-Ti file systems, including histological sections, simulated root canals made with plastic models, sequential teeth sectioning and radiographic evaluation, silicone imprints of prepared canals, and cone-beam computed tomography (CBCT) has also been utilized to evaluate root canal preparation and by utilizing CBCT, and it is possible to acquire pre and post-instrumentation images without the necessity of cutting the tooth structure before, during or after the process of instrumentation[(8)].

The aim of the current study was to evaluate and compare the degree of transportation of three Ni-Ti single-file systems (Edge One Fire, One Curve and

Wave One Gold file) using cone beam computed tomography.

MATERIALS AND METHODS

Ethical Statement:

The present study was approved by Research Ethics Committee board(University of Mosul, College of Dentistry, REC reference No. UoM.Dent/DM.H.L.52/21).

Prepared Samples:

Thirty freshly extracted human mandibular first molars with mature apices and intact mesial root were collected for this study, the inclusion criteria for selected teeth which must be included: mandibular molar teeth with completely developed mesial root and mature apices and no calcified canal, no internal or external root resorption and absence of root caries. The samples were cleaned and stored in normal saline solution until use. The degree of the curvature of root canals were calculated according to the method introduced by Schneider, only Mesiobuccal canals (MB) with a degree of curvature of 25–35 degrees will be involved in this study [9].\

For Schneider's method, two lines was drawn on the mesial root canals, the first line was drawn and aligned to the long axis of the mesial root canal and the second line was extended from the apical foramen of mesial root to intersect the point at the first line where the canal deviated from long axis. The resultant angle (Figure 1) was measured to detect the degree of curvature [10].

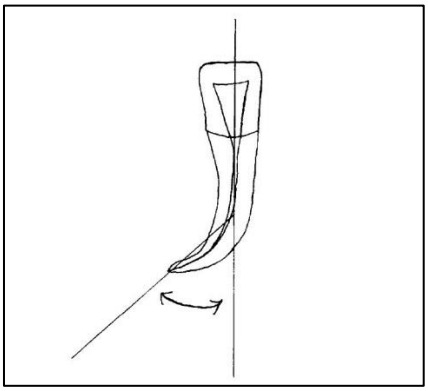

Figure (1): Example of how degree of root curvature was determined [10].

The occlusal surfaces of selected specimens were flattened to achieve a reproducible reference point and for the purpose of standardization, the working lengths of all specimens were adjusted at 18 mm and checked with x-ray [11].

Patency was established in mesiobuccal (MB) canal of all the samples using No. 10 K-file and the working length (WL) was adjusted to be 0.5 mm short of the apex and checked by x-ray and only canals that permit the passage of NO.10 K-file to the adjusted WL were chosen.

The samples were fixed on a blocks made by self cured acrylic resin material with the dimensions of (3*3*6 cm),

customised rectangular-shaped mould was filled with self-cure acrylic resin and the block was marked buccal, lingual, mesial and distal. Each mould contain six specimens were inserted in a way that their mesial and buccal aspects were facing the same side.

Samples Grouping:

Three groups was assigned each group contain 10 samples with the samples being randomly distributed as follows :

Group A: MB canals of samples in this group will be instrumented using Edge One Fire primary (EdgeEndo, USA) with tip size of 0.25/0.06.

Group B: MB canals of samples in this group will be instrumented using One curve file 25/0.06 (MicroMega, Besancon, France) .

Group C: MB canals of samples in this group will be instrumented using Wave One Gold file 25/0.07 (Dentsply maillefer, Switzerland).

Pre-instrumentation Cone Beam Computed Tomography Imaging:

Three dimensional (3D), high-resolution CBCT images were obtained using CS8100 3D equipment (Carestream Health, Rochester, NY) at three different cross-section levels that represent 3-mm, 5-mm, and 7-mm length from the apical end of the root (Figure 2) with 87 KV, 2.00 mA and 150 µm voxel size.

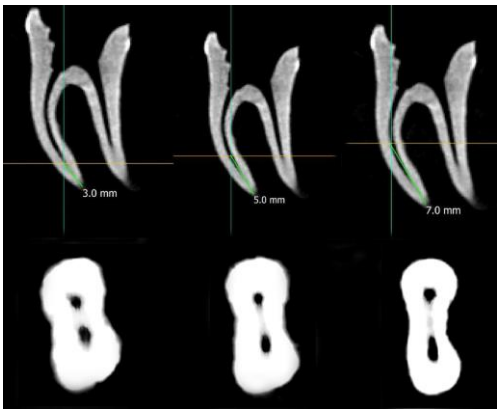

Figure (2): three cross-section levels that corresponded to 3-mm, 5-mm, and 7- mm distance from the apex of the root.

Root Canal Instrumentation:

Canals were prepared according to the manufacturers' instructions for each file system, all the files used in a gentle and slow in and out pecking motion with a magnitude of about 3 mm. The flutes of the files are cleaned after three in and out motions.

As recommended by the manufacturer, single-file systems are used for a single patient, thereby, each instrument will prepare only four canals.

The canals were irrigated with 2.5% sodium hypochlorite (NaOCl) 2ml/min[9] for each canal during instrumentation followed by irrigation with normal saline as

a final rinse and E-connect endo motor (Eighteeth, China) was used for preparation of root canals.

Samples of group A were prepared by EdgeOne fire system. The file was used with reciprocal motion operated at 350 rpm speed as recommended by the manufacturer with a reciprocating movement in 170° counterclockwise and 50° clockwise direction and completes 360° in 3 cycles.

Before insertion of EdgeOne Fire file the canals were expanded to at least 0.15 mm using ISO K-15 hand files, then the canals were expanded using EdgeOne Fire files in a gentle inward pressure with irrigation , recapitulation and re-irrigation with 2.5% Sodium Hypochlorite between each pass of the file.

Samples of group B were prepared by using MicroMega One curve file (25/0.06) which was used with a continuous rotation at 300-450 rpm and maximum torque of 2.5 N.cm with irrigation , recapitulation and re-irrigation with 2.5% Sodium Hypochlorite between each pass of the file. as recommended by the manufacturer.

The MB canal of the samples of group C were prepared with Wave One Gold primary file (25/0.07) with short 3 mm amplitude strokes in a gentle inward motion to passively advance the file to adjusted W.L. operated at 350 rpm speed as recommended by the manufacturer with a reciprocating movement in 170° counterclockwise and 50° clockwise direction and completes 360° in 3 cycles.

Post-instrumentation Cone Beam Computed Tomography imaging:

After completion of the instrumentation for all groups, all the specimens were scanned using CBCT with the same manner (Figure 3) and measured at the same levels (7mm, 5mm and 3mm from the apex) with the exact same parameters used for pre-instrumentation scans and saved in DICOM format (Digital Image Communication of Medicine).

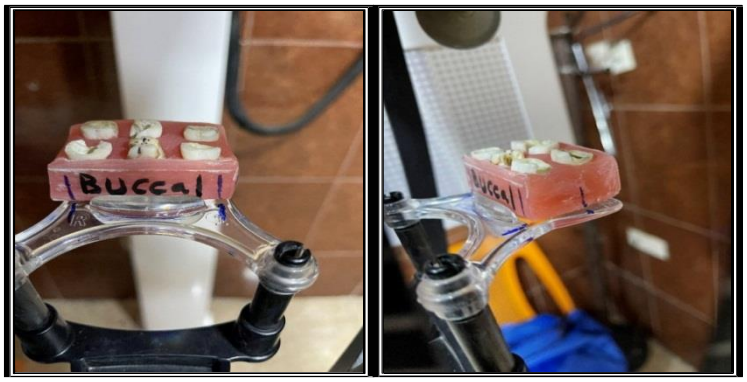

Figure (3): Marking the block with the CBCT bite plane to ensure that before and after imagaes are obtained with the samples are in the exact same position.

Cone Beam Computed Tomography Measurements and Image Analysis:

Analysis of pre-instrumentation and post-instrumentation stored images and measurements of MB canals was performed by using CS 3D imaging software (Carestream Health, Rochester, NY). The degree of root canal transportation will be determined according to the method introduced by Gambill [24], this method calculate the amount of transportation through the following formula:

Degree of transportation = (M1-M2) – (D1-D2)

Where M1 is the smallest distance between the border of an un-instrumented canal and the root's mesial perimeter.

M2 is the smallest distance between the border of instrumented canal and the root's mesial perimeter.

D1 is the smallest distance between the border of an un-instrumented canal and the root's distal perimeter.

D2 is the smallest distance between the border of instrumented canal and the root's distal perimeter (Figure 4).

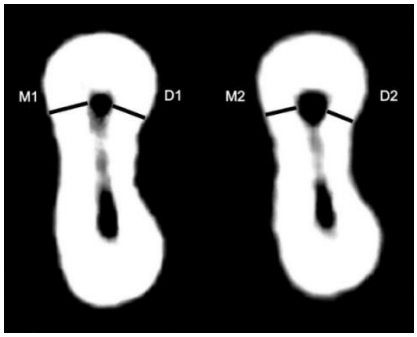

Figure (4): before and after preparation CBCT images showing measurement marks.

After insertion of the values in the formula, if the resultant value is zero, there is no canal transportation. Any value other than zero indicated canal transportation.

While positive and negative outcomes would mean mesial and distal transportations, respectively.

Statistical analysis:

Data was analyzed by using SPSS (statistical package of social science) software version 26.0 Statistics **:**

1. Normality of data distribution: by using Kolmogorov-Smirnov and Shapiro-Wilk tests , to detect data distribution and apply the proper statistical test.

2. mean, standard deviation (SD), minimum and maximum degree of canal transportation (descriptive statistics)

3.The difference among groups was examined by Kruskal-Wallis test and multiple comparison with Bonferroni correction with the level of significant that was used ($0.05 \geq P$).

RESULTS

The mean values and standard deviation for the degree of canal

transportation of the three files are shown in Table (1)

Table (1): Mean and Standard Deviation of Transportation (mm), and Kruskal Wallis test .

Level	Edge One Fire	One Curve	Wave One Gold	*P-value*
3 mm	0.15 ± 0.07	-0.37 ± 0.067	-0.21 ± 0.073	0.000*
5 mm	0.24 ± 0.05	0.27 ± 0.048	-0.22 ± 0.063	0.000*
7 mm	-0.18 ± 0.078	-0.49 ± 0.12	-0.38 ± 0.078	0.000*

*$P \leq 0.01$ mean highly significant variation exist.

At the coronal level One Curve file showed the highest transportation value (-0.49 mm) while the lowest transportation value was found in Edge One Fire which was (-0.18 mm). The values with negative numbers indicate that the preparation of root canal has been deviated toward the distal side (distal transportation).

At the middle level the highest transportation value (0.27 mm) was found in One Curve File while the lowest value (-0.22 mm) was found in Wave One Gold file.

At the apical level it was found that the lowest transportation value (0.15 mm) in EdgeOne Fire and the highest value (-0.37 mm) in One Curve File as showed in Table (1).

In apical level, there was no statistically significant difference between One Curve and Wave One Gold in mean value of canal transportation and in the middle level, there was no significant difference between Edge One Fire and One Curve files while in the coronal level, there was no statistically significant difference between One Curve and Wave One Gold as seen in Table (2).

Table (2): Multiple comparison of the three groups across three levels with Bonferroni correction.

Levels	*P-value*		
	Group A-B	Group A-C	Group C-B
3 mm	0.000**	0.019*	0.700
5 mm	1.000	0.010**	0.000**
7 mm	0.000**	0.008**	0.396

*$P \leq 0.05$ mean significant variation exist , ** $P \leq 0.01$ Highly Significant

DISCUSSION

One of the most important determinative factors of proper root canal preparation ability of an endodontic file is its capacity to remain closely centered inside the root canal and hindering any iatrogenic mishaps [12].

Various methods are available to evaluate the degree of root canal transportation and various endodontic file systems, and in the current study root canal transportation was evaluated using extracted human mandibular molar teeth instead of plastic models with simulated root canals. The main drawback of plastic models is that they possess mechanical properties that are different from dentin, so they do not reflect the true clinical situation; another drawback is the possibility of heat generated during canal instrumentation, which results in softening and sticking of the plastic with the cutting blades of the instrument[13,14], cone beam computed tomography (CBCT) is utilized as a non-invasive evaluation of the ability of three endodontic single file systems (EdgeOne Fire , One Curve and Wave One Gold) for shaping curved canals [15].

Analysis of the data in this study indicated that there is no file system that can establish an ideal preparation and reproduction of the original shape of the root canal anatomy and all three systems evaluated in this study showed some degree of root canal transportation (straightening), although all the file systems that were studied had a non-cutting end or tip; which only guides the files inside the canal with minimal pressure.

Furthermore, the current study supports the results of Saritha et al. (2017) and Yoo and Cho (2012) where reciprocating systems (edge one fire and wave one gold) maintain original canal contour better than files with continuous rotation (one curve), which tend to transport the outer canal wall of the curve in the apical part of the canal [16,17].

Despite that the manufacturer of one curve file claims that the file manufactured with special heat treated Ni-Ti alloy (c-wire) and the triple helix cross-section on the first 4 mm of the file increases the centering ability of the file and reduce transportation tendency specially in the apical zone, however our results showed that one curve file tend to great a higher amount of root canal transportation which is similar to the report of Berutti *et al*. (2012) which stated that reciprocating movement allows a more centralized chemo-mechanical preparation when compared to continuous rotary motion, especially in the apical third [18] .

In the current study, the EdgeOne Fire single file system (Edge Endo, USA) showed a lower average root canal transportation followed by the Wave One Gold single file system (Dentsply Maillefer, Switzerland), and the highest amounts of canal transportation were observed in the One Curve single file system (MicroMega, France) across all categories of levels, which is in agreement with the results of Christina *et al*. (2020) and Hasheminia *et al*. (2018) [19,20].

The lower transportation values achieved with edge one fire may be attributed to the following:

The file was manufactured from a proprietary thermal "Fire-wire" treatment, and it has been suggested that heat treatment decreases cyclic fatigue and greatly improves the flexibility which is a key for maintaining the original canal shape [21,22].

Second, EdgeOne Fire has a variable taper design and operates in a reverse reciprocal motion which is associated with a higher centering ability as well as lower transportation and taper lock [23].

The lower transportation ratio may also be attributed to the design of the file with a taper of 6% with a special cross section that has a hyperbolic design according to the manufacturer.

CONCLUSIONS

Within the limitations in this study, it can be concluded that all tested Ni-Ti file systems resulted in root canal transportation, and Edge One Fire files are safer during preparation of curved root canals.

REFERENCES

1. Tabassum, S., & Khan, F. R. Failure of endodontic treatment: The usual suspects. *European journal of dentistry*, 2016; *10*(1), 144–147.
2. Schafer, E. and Dammaschke, T. Development and sequelae of canal transportation. *Endodontic Topics.* 2006; 15: 75-90.
3. Bürklein, S. and Schäfer, E. Critical evaluation of root canal transportation by instrumentation. *Endod Topics*, 2013; 29: 110-124.
4. Ya Shen, Hui-min Zhou, Yu-feng Zheng, Bin Peng and Markus Haapasalo Current Challenges and Concepts of the Thermomechanical Treatment of Nickel-Titanium Instruments. *Journal of Endodontics*, 2013; 39(2):163-172.
5. Sebastian C. and Edgar S. Critical evaluation of root canal transportation by instrumentation. *Endod Topics*, 2013; 29(1):110-124.
6. Kyu-Sang S., Soram O., KeeYeon K., Yu-Chan K., Kwang-Koo J. and Seok-Woo C. Mechanical and Metallurgical Properties of Various Nickel-Titanium Rotary Instruments. Biomed Res Int. 2017 ;2017:4528601.
7. Kandaswamy, D., Venkateshbabu, N., Porkodi, I., & Pradeep, G. Canal-centering ability: An endodontic challenge. *Journal of conservative dentistry: JCD*, 2009; 12(1), 3–9.
8. Hashem A., Ghoneim AG. and Lutfy RA. Geometric analysis of root canals prepared by four rotary NiTi shaping systems. *J Endod*. 2012; 38:996–1000.
9. Elnaghy, A. M., & Elsaka, S. E. Evaluation of root canal transportation, centering ratio, and remaining dentin thickness associated with ProTaper Next instruments with and without glide path. *Journal of endodontics*, 2014;40(12), 2053– 2056.
10. Schneider SW. A comparison of canal preparations in straight and curved root canals. *Oral Surg Oral Med Oral Pathol*. 1971; 32:271–275.

11. Adel, M., Leheta, N., & Zaazou, A. Evaluation of canal transportation and centring ability of nickel-titanium versus stainless steel rotary systems: an in-vitro study. *Endodontic Practice*, 2018; 12, 267–274.
12. Shen, Y. and Cheung, G.S. Methods and models to study nickel–titanium instruments. *Endod Topics*, 2013; 29: 18-41.
13. Silva, E. J., Muniz, B. L., Pires, F., Belladonna, F. G., Neves, A. A., Souza, E. M., & De-Deus, G. Comparison of canal transportation in simulated curved canals prepared with ProTaper Universal and ProTaper Gold systems. *Restorative dentistry & endodontics*, 2016; 41(1), 1–5.
14. Zhang L, Luo HX, Zhou XD, Tan H, Huang DM. The shaping effect of the combination of two rotary nickel-titanium instruments in simulated S-shaped canals. *J Endod*. 2008; 34:456–458.
15. Mittal, A., Dadu, S., Singh, N. S., Singh, S., Gupta, B., Abraham, A., Yendrembam, B., & Kumari, S. Comparative Assessment of Canal Transportation and Centering Ability of Reciproc and One Shape File Systems Using CBCT-An In Vitro Study. *Journal of clinical and diagnostic research : JCDR*, 2017; 11(4), ZC31–ZC34.
16. Vallabhaneni S, Fatima K, Kumar TH. Cone-beam computed tomography assessment of root canal transportation using WaveOne Gold and Neoniti single-file systems. *J Conserv Dent*. 2017;20(6):434-438.
17. Yoo YS, Cho YB. A comparison of the shaping ability of reciprocating NiTi instruments in simulated curved canals. *Restor Dent Endod.* 2012;37:220–7.
18. 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;38:101–4.
19. Christina R., Zacharopoulos A, Anestis D, Mikrogeorgis G, Zacharakis G, Lyroudia K. Micro-Computed Tomographic Evaluation of Canal Transportation and Centering Ability of 4 Heat-Treated Nickel-Titanium Systems. *J Endod.* 2020; 46(5):675-681.
20. Hasheminia, S. M., Farhad, A., Sheikhi, M., Soltani, P., Hendi, S. S., & Ahmadi, M. Cone-beam Computed Tomographic Analysis of Canal Transportation and Centering Ability of Single-file Systems. *Journal of endodontics*, 2018; 44(12), 1788–1791.
21. Topçuoğlu HS, Topçuoğlu G, Kafdağ Ö, Arslan H. Cyclic fatigue resistance of new reciprocating glide path files in 45- and 60-degree curved canals. *Int Endod J*. 2018; 51(9):1053-1058.
22. Plotino G, Grande NM, Cotti E, Testarelli L, Gambarini G. Blue treatment enhances cyclic fatigue resistance of vortex nickel-titanium rotary files. *J Endod*. 2014; 40(9):1451-3.
23. Coelho MS, Fontana CE, Kato 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(1):33-7.

24. Gambill JM, Alder M, del Rio CE. Comparison of nickel titanium and stainless steel hand-file instrumentation using computed tomography. *J Endod*. 1996; 22(7):369-375.