Research article

ISSN 2234-7658 (print) / ISSN 2234-7666 (online)
http://dx.doi.org/10.5395/rde.2016.41.3.176

RDE Restorative Dentistry & Endodontics

# Preference of undergraduate students after first experience on nickel-titanium endodontic instruments

**Sang Won Kwak[1], Gary Shun-Pan Cheung[2], Jung-Hong Ha[3], Sung Kyo Kim[3], Hyojin Lee[4], Hyeon-Cheol Kim[1]***

[1]Department of Conservative Dentistry, School of Dentistry, Pusan National University, Dental Research Institute, Yangsan, Korea
[2]Area of Endodontics, Faculty of Dentistry, the University of Hong Kong, Hong Kong SAR, China
[3]Department of Conservative Dentistry, School of Dentistry, Kyungpook National University, Daegu, Korea
[4]Climate Research Department, APEC Climate Center, Busan, Korea

***Objectives:*** This study aimed to compare two nickel-titanium systems (rotary *vs*. reciprocating) for their acceptance by undergraduate students who experienced nickel-titanium (NiTi) instruments for the first time. ***Materials and Methods:*** Eighty-one sophomore dental students were first taught on manual root canal preparation with stainless-steel files. After that, they were instructed on the use of ProTaper Universal system (PTU, Dentsply Maillefer), then the WaveOne (WO, Dentsply Maillefer). They practiced with each system on 2 extracted molars, before using those files to shape the buccal or mesial canals of additional first molars. A questionnaire was completed after using each file system, seeking students' perception about 'Ease of use', 'Flexibility', 'Cutting-efficiency', 'Screwing-effect', 'Feeling-safety', and 'Instrumentation-time' of the NiTi files, relative to stainless-steel instrumentation, on a 5-point Likert-type scale. They were also requested to indicate their preference between the two systems. Data was compared between groups using *t*-test, and with Chi-square test for correlation of each perception value with the preferred choice ($p = 0.05$). ***Results:*** Among the 81 students, 55 indicated their preferred file system as WO and 22 as PTU. All scores were greater than 4 (better) for both systems, compared with stainless-steel files, except for 'Screwing-effect' for PTU. The scores for WO in the categories of 'Flexibility', 'Screwing-effect', and 'Feeling-safety' were significantly higher scores than those of PTU. A significant association between the 'Screwing-effect' and students' preference for WO was observed. ***Conclusions:*** Novice operators preferred nickel-titanium instruments to stainless-steel, and majority of them opted for reciprocating file instead of continuous rotating system. (*Restor Dent Endod* 2016;41(3):176-181)

**Key words:** Nickel-titanium file; Reciprocating; Rotary; Preference; Undergraduate student

Received March 8, 2016;
Accepted May 12, 2016

Kwak SW, Cheung GS, Ha JH, Kim SK, Lee H, Kim HC

***Correspondence to**
Hyeon-Cheol Kim, DDS, MS, PhD.
Professor, Department of Conservative Dentistry, School of Dentistry, Pusan National University, 20 Geumo-ro, Mulgeum-eup, Yangsan, Korea 50612
TEL, +82-55-360-5222; FAX, +82-55-360-5214; E-mail, golddent@pusan.ac.kr

## Introduction

The purpose of root canal treatment is to remove all the pulp tissues, bacteria and their products, as well as to attain proper sealing of the root canal system.[1,2] To achieve this goal, effective cleaning and shaping is important. Conventional stainless-steel (SS) hand instruments have some limitations, especially for their rigidity, which can result in procedural errors such as transportation, ledges and/or perforations. Since the first report introducing the nickel-titanium (NiTi) alloy for endodontics in 1988 by Walia *et al.*,[3] NiTi rotary instruments have been marketed to overcome the disadvantage of SS files. The benefit and advantages of shaping with NiTi rotary files have been

widely reported.[4-7] With the super-elasticity and low elastic modulus of NiTi rotary instruments, there is a low risk of transforming the original canal shape. In addition, the increased efficiency allows clinicians to shape the canal more predictably and expeditiously. NiTi files are likely to result in less debris extrusion and reduced chance of postoperative sensitivity. Rotary instrumentation has also been shown to produce a higher rate of clinical success than a hand filing technique.[4]

Few years ago, reciprocating systems such as Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) were introduced, both of which adopt an asymmetric back-and-forth rotational movement, a motion similar to the balanced force technique.[8] The manufacturers claim that only one file is needed, selected according to the uninstrumented canal's size, to shape the canal with the reciprocating motion.[9] By reducing the steps/changes of instruments in conventional NiTi rotary systems, the root canal shaping may be achieved in a shorter time.[10,11] Therefore, it is plausible that novices may be able to master the reciprocating system more readily than the conventional rotary instrumentation that often involves the use of multiple files.

There is a growing trend that NiTi rotary techniques are taught at the undergraduate level in dental schools, with reports of the clinical performance of NiTi instruments operated by undergraduate students appearing nowadays.[12,13] Sonntag *et al.*[14] observed that undergraduate dental students could achieve better canal preparations with NiTi, compared to SS files, although they noted more fractures with NiTi files. File separations may well be the main concern why beginners avoid using NiTi rotary systems. Yet, there is little information on perception of novices or, even, undergraduate students for their first experience with engine-driven NiTi instruments. Data related to reciprocating systems is lacking. Such information would be helpful to identify the 'most accepted' system that beginners or students may be most comfortable (or confident) with. Therefore, the purpose of this study was to compare two NiTi systems (rotary *vs*. reciprocating system) for their acceptance by undergraduate students who experienced NiTi instruments for the first time.

## Materials and Methods

The protocol of this study was approved by the Pusan National University Dental Hospital Institutional Review Board (PNUDH-2015-029). The Institutional Review Board approved to obtain the consent in a verbal form. This study was conducted in full accordance with the World Medical Association Declaration of Helsinki.

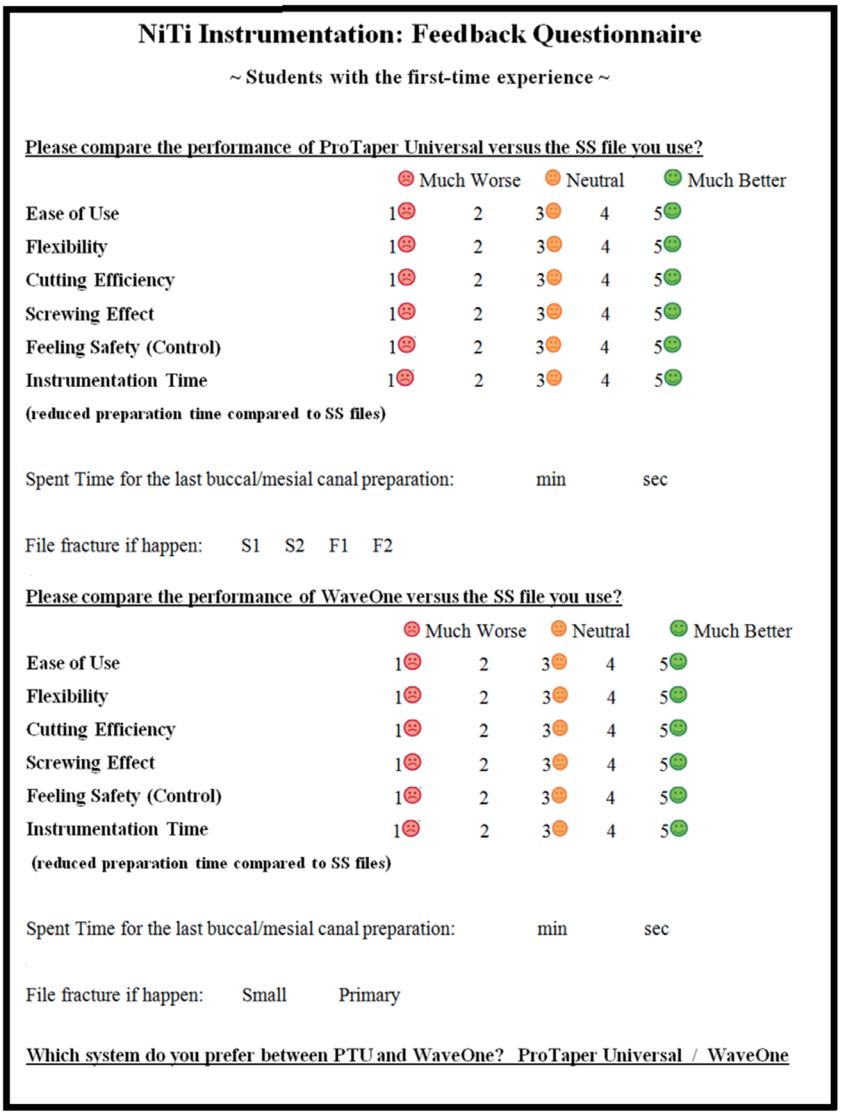
Eighty-one sophomore undergraduate students of a university's School of Dentistry were asked to complete a questionnaire after using a rotary (ProTaper Universal [PTU], Dentsply Maillefer) and after a reciprocating system (WaveOne [WO], Dentsply Maillefer). These students did not have any prior experience of NiTi instrumentation. They were first introduced to the basic procedures of root canal therapy and practiced on 4 artificial teeth (1 incisor, 1 premolar, and 2 molars) with artificial root canals inside (B22X Series, Nissin, Kyoto, Japan), followed by 4 extracted teeth (1 incisor, 1 premolar, and 2 molars) with manual instrumentation using SS files for 10 to 12 hours. The extracted teeth were selected by the supervisors so that the teeth do not have moderate to severe root canal curvature or sclerotic canals. After that and in another session, the students were given an approximately 1 hour instruction on the manufacturer's recommended technique for using the rotary PTU instrument (see brief description of procedure below), before practicing with the system on 2 molars under supervision. Then they were asked to work on their own to prepare the buccal canals of another maxillary first or the mesial canals of a mandibular first molar. When using the NiTi files, working length was first determined and a glide path prepared to a size 15 SS K-file. The canals were shaped in the order of S1, S2, F1, and F2 with the PTU system. The irrigation procedure and patency filing were done as recommended. For the WO system, working length and glide path were similarly obtained before the use of the WO Primary file (notice that for very fine canals the WO Small file was used, according to the manufacturer's recommendation).

After completing the canal preparation, all students were asked to fill in a questionnaire for their experience when using the SS instruments and the NiTi rotary systems (Figure 1). The same questionnaire was completed to compare SS instruments and the NiTi reciprocating system for the last session. The questions concerned students' perception on the 'Ease of use', 'Flexibility', 'Cutting efficiency', 'Screwing effect', 'Feeling safety', and 'Instrumentation time' of the respective instrument, compared with SS files, on a 5-point Likert-type scale (Score 1, Much Worse; 2, Worse; 3, Neutral; 4, Better; 5, Much Better). The questionnaire also recorded the time taken for the shaping the last canal (that students did on their own) and for any file fracture. Lastly, students were requested to select one preferred NiTi system between PTU and WO.

The scores of each perception category between two NiTi systems were compared using *t*-test. Then, Pearson Chi-square test was used to examine any correlation, or association between the preferred choice of system and each perception categories. The significance level was set at $p = 0.05$.

## Results

All the questionnaires were returned. Excluding those that



**NiTi Instrumentation: Feedback Questionnaire**

~ Students with the first-time experience ~

Please compare the performance of ProTaper Universal versus the SS file you use?

| | Much Worse | | Neutral | | Much Better |
|---|---|---|---|---|---|
| Ease of Use | 1 | 2 | 3 | 4 | 5 |
| Flexibility | 1 | 2 | 3 | 4 | 5 |
| Cutting Efficiency | 1 | 2 | 3 | 4 | 5 |
| Screwing Effect | 1 | 2 | 3 | 4 | 5 |
| Feeling Safety (Control) | 1 | 2 | 3 | 4 | 5 |
| Instrumentation Time (reduced preparation time compared to SS files) | 1 | 2 | 3 | 4 | 5 |

Spent Time for the last buccal/mesial canal preparation: min sec

File fracture if happen: S1 S2 F1 F2

Please compare the performance of WaveOne versus the SS file you use?

| | Much Worse | | Neutral | | Much Better |
|---|---|---|---|---|---|
| Ease of Use | 1 | 2 | 3 | 4 | 5 |
| Flexibility | 1 | 2 | 3 | 4 | 5 |
| Cutting Efficiency | 1 | 2 | 3 | 4 | 5 |
| Screwing Effect | 1 | 2 | 3 | 4 | 5 |
| Feeling Safety (Control) | 1 | 2 | 3 | 4 | 5 |
| Instrumentation Time (reduced preparation time compared to SS files) | 1 | 2 | 3 | 4 | 5 |

Spent Time for the last buccal/mesial canal preparation: min sec

File fracture if happen: Small Primary

Which system do you prefer between PTU and WaveOne? ProTaper Universal / WaveOne

Figure 1. The questionnaire form used in this study. SS, Stainless-Steel file; NiTi, Nickel-Titanium; PTU, ProTaper Universal.

were not completed in full, there were 79 for PTU and 81 for WO system available for analysis; the response rate was 97.5% and 100%, respectively. The distribution of scores for each evaluation category was expressed graphically for the two systems (Figure 2). Of all who responded, 77 indicated their preference, with the single file WO system being more often preferred than PTU ($n$ = 55 *vs.* 22). Fractures were noted for 2 PTU (each for S1 and F1) and 2 WO instruments (each for the Small and Primary file).

Comparing with SS hand instrumentation a value of greater than 4 (*i.e.* subjectively better) was accorded to the 2 NiTi instruments in the great majority of questions, except for PTU in the category of 'Screwing effect' (Table 1). When comparing the two NiTi systems, PTU gave a significantly higher score in flexibility ($p < 0.05$) and safety feeling ($p < 0.05$), while WO scored better in 'Screwing effect' ($p < 0.05$). A significant association between the 'Screwing effect' and students' preference for WO was observed ($p < 0.05$).

The mean time taken for instrumenting the canal by the students on their own was 285 ± 114 seconds for PTU and 135 ± 95 seconds for WO, for which the difference was statistically significant ($p < 0.05$).



http://dx.doi.org/10.5395/rde.2016.41.3.176

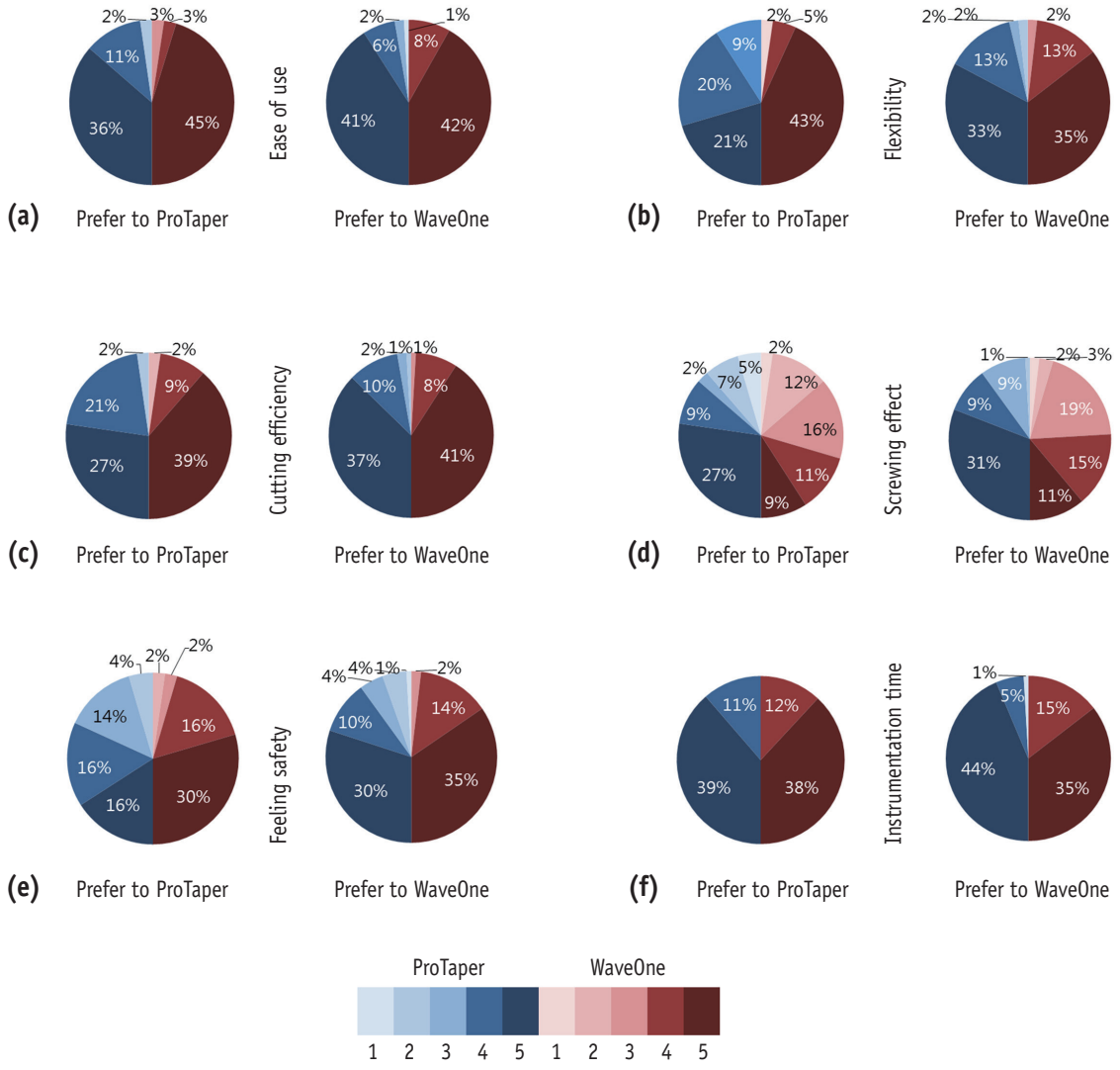



Figure 2. Comparison of score distribution for the categories based on the preferences to ProTaper Universal (ProTaper) or WaveOne. Score 1, Much Worse; 2, Worse; 3, Neutral; 4, Better; 5, Much Better.

Table 1. The scores (mean ± standard deviation) from the categories of questionnaires

| | ProTaper Universal | WaveOne | *t*-test* (*p* value) | Pearson value** (*p* value) |
|---|---|---|---|---|
| Ease Use | 4.83 ± 0.41 | 4.70 ± 0.72 | 1.368 (0.175) | 0.034 (0.765) |
| Flexibility | 4.68 ± 0.67 | 4.46 ± 0.74 | 2.108 (0.038) | 0.098 (0.385) |
| Cutting efficiency | 4.74 ± 0.57 | 4.59 ± 0.69 | 1.563 (0.122) | 0.079 (0.484) |
| Screwing effect | 3.51 ± 1.06 | 4.24 ± 1.11 | -5.263 (0.000) | 0.350 (0.002) |
| Feeling safety | 4.59 ± 0.63 | 4.12 ± 1.08 | 3.534 (0.001) | 0.094 (0.405) |
| Instrumentation time | 4.68 ± 0.52 | 4.80 ± 0.56 | -1.485 (0.141) | 0.035 (0.761) |

*t-test compared the scores from the evaluated categories between the two nickel-titanium system.
**Pearson values indicate the correlation significance between the preferred choice of nickel-titanium system and evaluation category

## Discussion

This questionnaire survey was during the semester time of the undergraduate curriculum and, hence, a high response rate was obtained (as expected). Instead of artificial canals in resin blocks, extracted teeth were used for practice by students. Although simulated resin block can offer standardized canal shape, size, and curvature for all canals, the resin material is no substitute for the dental hard tissues. Furthermore, the extracted tooth is a much better representation of real clinical situation. PTU and WO were used as examples of a multi-sequence system with continuous rotary motion and a single-file reciprocating system, respectively. All students had never experienced NiTi instruments before, so the present results would reflect the perception of novices or new users who first attempt the use of engine-driven NiTi files. This perception may well be the experience of general practitioners who begin with these instruments.

The great majority of students felt that the two NiTi systems provided a better clinical result than manual SS files. The greatly reduced operation time, the easiness of use (much less tiring to the operator) and well-looking final canal shape would contribute to this perception. Various studies comparing NiTi rotary and SS files gave similar conclusions.[14,15] Others also reported that NiTi instruments produced more predictable canal shapes and were able to maintain the original canal configuration with little chance of procedural errors.[16-18] A clinical cohort study comparing manual SS instrumentation and a NiTi rotary technique performed by dental students has concluded that teeth prepared with SS files showed a higher incidence of procedural errors and a lower success rate.[4] They further observed that the increased success rate was dependent on operator experience, with the treatment outcome and clinical success achieved by undergraduate students (*i.e.* novices) being significantly improved when NiTi files were used. A similar quantum improvement in treatment outcome was not observed for endodontic postgraduate students.[4] Hence, engine-driven NiTi instruments should benefit the general practitioners and the patients at large.

File separation has been a worrying consideration for many practitioners who may want to incorporate NiTi instruments into their practice. It is undeniable that instruments will break if used beyond their physical strength or due to accumulation of fatigue damages. Wolcott *et al.*[19] reported that the incidence of breakage of ProTaper (first-time use) was 17.7%, with the F3 file showing the greatest amount of separation.[19] In contrast, only 4 files in total had separated, giving an incidence of 1.0% for all files used in the present study. Careless usage of the NiTi files and inherent or induced defects in the instrument would be the main reason of fracture here. While one may think that experienced users may be able to limit the amount of instrument breakage, Generali *et al.*[20] reported that there was no significant difference in the amount of separation for WO Primary file between experienced practitioners and beginners; one reason might be related to the amount of stresses caused to the instrument for such single-file system.

In this study, 71% students preferred the WO after using the two NiTi systems for the first time. The reciprocating motion was associated with a significant reduction in the amount of 'screw-in' sensation experienced by the students. The reduced tendency of reciprocating files to 'screw in' to the canal was due to the periodic change in rotation direction. The fatigue resistance of the instrument operated in this motion is also enhanced, compared with the continuous rotation mode.[21,22] Despite being the preferred system, WO was inferior to PTU in the score for 'Feeling of Safety'. The multi-step, serial enlargement of the canal might have imparted a feeling of being safer and under control, than the use of one single file to complete the canal enlargement. The subjective feeling of PTU being more flexible than WO (see result in Table 1) might have also contributed to the 'feeling of safety' with the use of PTU instrument. Considering PTU is made of conventional NiTi alloy and WO made of M-wire (Dentsply Maillefer) with slightly different cross sectional configuration, there should be little difference in flexibility or, arguably, more flexible for WO.[23] The reciprocating movement of WO files might have masked the tactile sensation of beginner users. The S1 and S2 files of PTU system have a smaller diameter and apical taper than WO Primary file, which could have given the students such a perception that PTU system is more flexible than WO.

One would expect that preparation using one single file should be quicker than the multi-step rotary instrumentation with multiple files. This is one selling point for reciprocating files. The trend was indeed observed from the times recorded by students in this present study. Interestingly, however, there was little difference in the subjective perception of reduction in 'Instrumentation Time', compared with SS files, for the two systems examined. Considering the experience being the students' first encounter with NiTi engine-files, the reliability of their judgments and of the understanding of criteria may be low and, hence, more data would be preferable. Nonetheless, the present results indicated a significantly higher preference for reciprocating files by beginners and novice operators.

Orcid number
Hyeon-Cheol Kim, 0000-0001-8032-1194

Conflict of Interest: No potential conflict of interest relevant to this article was reported.



http://dx.doi.org/10.5395/rde.2016.41.3.176

## References


1. Siqueira JF Jr, Rôças IN, Alves FR, Silva MG. Bacteria in the apical root canal of teeth with primary apical periodontitis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009;107:721-726.
2. Sakamoto M, Siqueira JF Jr, Rôças IN, Benno Y. Molecular analysis of the root canal microbiota associated with endodontic treatment failures. *Oral Microbiol Immunol* 2008;23:275-281.
3. Walia HM, Brantley WA, Gerstein H. An initial investigation of the bending and torsional properties of Nitinol root canal files. *J Endod* 1988;14:346-351.
4. Cheung GS, Liu CS. A retrospective study of endodontic treatment outcome between nickel-titanium rotary and stainless steel hand filing techniques. *J Endod* 2009;35: 938-943.
5. Schäfer E, Schulz-Bongert U, Tulus G. Comparison of hand stainless steel and nickel titanium rotary instrumentation: a clinical study. *J Endod* 2004;30:432-435.
6. Setzer FC, Kwon TK, Karabucak B. Comparison of apical transportation between two rotary file systems and two hybrid rotary instrumentation sequences. *J Endod* 2010; 36:1226-1229.
7. 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; 36:904-907.
8. Yared G. Canal preparation using only one Ni-Ti rotary instrument: preliminary observations. *Int Endod J* 2008; 41:339-344.
9. Ruddle CJ. Canal preparation: single-file shaping technique. *Dent Today* 2012;31:124, 126-129.
10. Park SK, Kim YJ, Shon WJ, You SY, Moon YM, Kim HC, Lee W. Clinical efficiency and reusability of the reciprocating nickel-titanium instruments according to the root canal anatomy. *Scanning* 2014;36:246-251.
11. Jin SY, Lee W, Kang MK, Hur B, Kim HC. Single file reciprocating technique using conventional nickel-titanium rotary endodontic files. *Scanning* 2013;35:349-354.
12. Martins RC, Seijo MO, Ferreira EF, Paiva SM, Ribeiro Sobrinho AP. Dental students' perceptions about the endodontic treatments performed using NiTi rotary instruments and hand stainless steel files. *Braz Dent J* 2012;23:729-736.
13. Arbab-Chirani R, Vulcain JM. Undergraduate teaching and clinical use of rotary nickel-titanium endodontic instruments: a survey of French dental schools. *Int Endod J* 2004;37:320-324.
14. Sonntag D, Guntermann A, Kim SK, Stachniss V. Root canal shaping with manual stainless steel files and rotary Ni-Ti files performed by students. *Int Endod J* 2003;36:246-255.
15. Peru M, Peru C, Mannocci F, Sherriff M, Buchanan LS, Pitt Ford TR. Hand and nickel-titanium root canal instrumentation performed by dental students: a micro-computed tomographic study. *Eur J Dent Educ* 2006;10: 52-59.
16. 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;38:743-752.
17. Schäfer E, Florek H. Efficiency of rotary nickel-titanium K3 instruments compared with stainless steel hand K-Flexofile. part 1. shaping ability in simulated curved canals. *Int Endod J* 2003;36:199-207.
18. Hata G, Uemura M, Kato AS, Imura N, Novo NF, Toda T. A comparison of shaping ability using ProFile, GT file, and Flex-R endodontic instruments in simulated canals. *J Endod* 2002;28:316-321.
19. Wolcott S, Wolcott J, Ishley D, Kennedy W, Johnson S, Minnich S, Meyers J. Separation incidence of protaper rotary instruments: a large cohort clinical evaluation. *J Endod* 2006;32:1139-1141.
20. 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;102:217-222.
21. Kim HC, Kwak SW, Cheung GS, Ko DH, Chung SM, Lee W. Cyclic fatigue and torsional resistance of two new nickel-titanium instruments used in reciprocation motion: Reciproc versus WaveOne. *J Endod* 2012;38: 541-544.
22. 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;37:1296-1300.
23. Bonessio N, Pereira ES, Lomiento G, Arias A, Bahia MG, Buono VT, Peters OA. Validated finite element analyses of WaveOne endodontic instruments: a comparison between M-Wire and NiTi alloys. *Int Endod J* 2015;48:441-450.