ORIGINAL RESEARCH

Comparative Evaluation of Canal-shaping Ability between WaveOne and ProTaper Rotary Using Cone-beam Computed Tomography: A Systematic Review

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Abstract

Aim: To perform a systematic review comparing the canal-shaping ability of WaveOne and ProTaper rotary using cone-beam computed tomography (CBCT) and to evaluate the file that provides better performance clinically.

Materials and methods: The eligibility criteria selected for the study was based on the population intervention comparison outcome(s) study (PICOS). Using different search strategies from the keywords and their combinations, English language articles only between January 1, 2009, and October 31, 2019, from electronic biomedical journal databases were obtained. *In vitro* studies comparing the canal-shaping ability of ProTaper and WaveOne file systems using the CBCT method were included. Total 137 articles were reviewed out of which 61 articles were excluded during title screening as they did not meet the motive of our study. Total 76 articles were screened for duplicates and 63 articles were excluded. A total of 13 articles were selected for reviewing abstract and full text. Total 13 relevant articles were selected for final synthesis. The pilot Microsoft Excel sheet was filled with the relevant data that matched the study.

Review results: Total 13 relevant articles were selected for final review. The file systems were compared based on two main parameters such as the apical transportation caused and the ability of the file to remain centered within the canal. We found significant differences in these two parameters when the WaveOne reciprocating file system was compared with the ProTaper rotary file system. A definite conclusion could be drawn that the WaveOne reciprocating file system was better in shaping the canal.

Conclusion: Based on the results, the canal-shaping ability of the WaveOne reciprocating file system was better than the ProTaper rotary file system.

Clinical significance: Clinically, the canal-shaping ability determines the performance of a particular file system and CBCT is the most effective 3-D mode to determine the centering ratio and apical transportation caused. Thus, further comparative studies between these two file systems using CBCT with larger sample size and with elaborate search strategies are required for better result.

Keywords: Apical transportation, Canal-shaping ability, Centering ability, Cone-beam computed tomography, ProTaper, Root canal preparation, WaveOne.

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Introduction

Root canal preparation is an important step of root canal treatment. Preserving the actual anatomy of the canal is very important.[1] Canal shaping largely decides the results of the following stages of treatment such as irrigation and obturation of the canal.[2] Transportation is caused when endodontic instrument tends to straighten the root canal during the biomechanical preparation.[3,4] The overpreparation of the root canal leads to loss of dentin, thus making the tooth prone to fracture.[5]

Conventional stainless steel hand instruments were not able to meet these goals.[6,7]

Thus, the nickel–titanium (NiTi) alloys were introduced.[8,9] The super elastic property of the alloy helps the files to remain well centered and shapes the canals with less transportation.

Thus, improvement in the ability of canal shaping with less procedural damage was made. In the last few years, changes in the structure and manufacturing process of the instruments have been introduced to increase their reliability, effectiveness, and safety.[10,11]

The NiTi rotary instrument such as ProTaper (Dentsply Maillefer, Ballaigues, Switzerland) has an improved cross-sectional design that efficiently removes dentin, reducing the torsional stresses. But it leads to more amount of canal transportation when used aggressively.[12]

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Recently, WaveOne (Dentsply Maillefer, Ballaigues, Switzerland), a reciprocating file system, has been introduced. WaveOne files are featured from the M-wire, which is created by thermal treatment.[13] This increases the file tendency to bend, and cyclic fatigue induced in the file is reduced.[14] The system uses reciprocating motion.[15] The reciprocating nature of the file system prevents the file to get engaged with the root canal call during preparation, thus reducing the chances of fracture of instruments.[16]

The centering ability is characterized by the structure of the instrument and the root canal outline. The instrument undergoes less resistance and is more centered in straight root canals.

Cone-beam computed tomography (CBCT) has been widely used to produce three-dimensional details about the hard and soft tissues of the head and neck region with an effectively less amount of radiation dose when compared with conventional computed tomography. Advantages include less exposure time, high resolution with accurate image sharpness, and less distortion of images.[17]

The canal-shaping ability is an important factor governing the efficiency of any file system. And, nowadays, due to various advantages, CBCT is the best means of studying the detailed features on a particular file system.

Thus, this systematic review aimed to compare the canal-shaping ability of WaveOne and ProTaper rotary using CBCT and to evaluate the file that provides better performance clinically.

Materials and Methods

The study was conducted at Dr. DY Patil Dental College and Hospital, Pimpri, Pune. Formulation of a research question was done according to the population intervention comparison outcome(s) study (PICOS) format aiming at the apical transportation and centering ability of a particular file system.

"Which file system has the better canal-shaping ability?"

The eligibility criteria for the study were selected and were based on the PICOS. The PICOS guidelines that were selected were: P as Participants, freshly extracted human teeth were considered. I as the Intervention, WaveOne reciprocating file system was considered. C as comparison was considered as the ProTaper rotary file system. O as the outcome where canal-shaping ability of the file systems was assessed. S as the study designs, *in vitro* studies were included.

For the electronic search strategy, the following terms were used as keywords in several combinations: apical transportation, canal-shaping ability, centering ability, CBCT, ProTaper, root canal preparation, and WaveOne. These combinations were used to search the available articles from different electronic biomedical journal databases such as PubMed, Google Scholar, and ResearchGate.

Full-text English language articles only between January 1, 2009, and October 31, 2019, were selected. Only *in vitro* studies comparing the canal-shaping ability of WaveOne and ProTaper file systems using CBCT were included. Reviews, case reports, abstracts, letters to editors, editorials and animal studies, and *in vivo* studies were excluded.

Total 137 articles were identified through the database searching. After thorough reading of titles, 61 articles were excluded based on the parameters and inclusion criteria of our study. After searching for duplicates, 63 articles were excluded. These remaining 13 articles were further screened for abstract reading and no articles was excluded. Full texts for these 13 articles were obtained and were assessed for eligibility. All these 13 articles qualified and were selected. Number of investigators involved in this article reviewing process were five.

A pilot Microsoft Excel sheet was filled with only relevant data that matched the study.

The headings specifying author details, study design, sample size, and methodology were mentioned under which the data were tabulated. Population/products include freshly extracted human teeth. Intervention is the WaveOne reciprocating file system and comparison was done with the ProTaper rotary file system. The canal-shaping ability of both the file systems were mentioned according to the articles. Mean values and standard deviation (SD) were also mentioned for all the groups. Conclusion was mentioned according to the study's protocol.

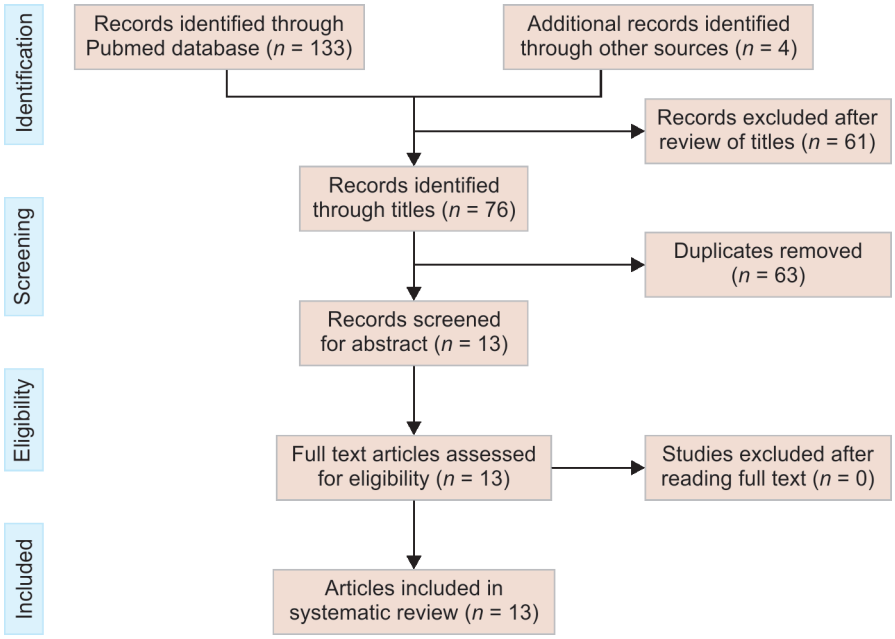
Results

Flowchart 1 shows the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA)-based articles selection process.

Total 13 relevant articles were selected for final review.

Studies differed in their sample number per group. Maximum studies (8 out of 13) had 10 and 20 samples per group. Four studies

Flowchart 1: PRISMA flowchart of search results and study selection



had 10 samples per group.[18–21] While other four studies had 20 samples per group.[22–25]

The analysis of the studies according to the region showed that India had the highest number of studies being selected.[19,20,22,23,26–28] Followed by Brazil having three studies.[25,29,30] And one each from Saudi Arabia,[18] Thailand,[21] and Turkey.[24]

The WaveOne reciprocating file system and the ProTaper rotary file system were compared based on two main parameters such as the apical transportation of the canal caused and the ability of the file to remain centered in the canal. Table 1 comprises the details of the studies considered for review.

A definite conclusion could be drawn that the WaveOne reciprocating file system was better in shaping the canal as 8 out of 13 studies supported it.[18–23,26,29] The ProTaper rotary file system was supported by two studies.[27,30] No significant differences between the file systems were shown by three studies.[24,25,28]

One of the study did not show any statistically significant differences in apical transportation values when the two file systems were compared.[29]

While comparing the centering ability values of both the files, no statistically significant difference was observed in one of the studies.[23]

Discussion

Biomechanical preparation of the canal system is regarded as the main part of root canal treatment. Disruption of the original canal anatomy leads to overinstrumentation, which causes removal of dentin wall excessively, making the canal outline straight with formation of ledges.[31] Thus, the significance of maintaining the original root canal space outline after biomechanical preparation is of utmost importance, which has been stressed upon in different studies.[32] Nonaggressive nature of NiTi instruments along with their flexibility and imparting less amount of force are their advantages.[33] Till date, different NiTi files systems have been introduced and studied in dentistry. The WaveOne file system has been introduced recently. Initially, the rotary file system was used. The ProTaper file system was regarded as a standard rotary file. Many studies have been performed based on its clinical performance. The flexibility and efficiency of cutting are the features of rotary ProTaper files, which prevent overinstrumentation by creating a conical shape, thus have less risk of transportation of the canal apically.[34] The WaveOne system is a single-file reciprocating system used to prepare the entire canal space in a single step. It is based on a reverse "balanced force" action. The M-wire technology is used to manufacture it to enhance strength and cyclic fatigue resistance.[35] The WaveOne file system lacks much of the supportive literature related to its canal-shaping performance. Assessment of data worldwide collectively to assess factors governing its efficacy is needed. Thus, in this present study, newly introduced, the WaveOne reciprocating file system is compared with the ProTaper rotary file system to assess whether the reciprocating motion of the file is better in shaping the canal than the rotary motion.

Cone-beam computed tomography is a commonly used technique having advantages, which include preservation of the sample. It helps in capturing different images, specifying appropriate features of the canal space prior, during, and after the root canal preparation.[36–38] Thus, CBCT is regarded as an accurate procedure in determination of the efficiency of techniques and was considered as an evaluation tool in this study.

The relevant articles were reviewed on the basis of canal-shaping ability including the apical transportation caused after biomechanical preparation and centering ability of the particularly two file systems: ProTaper rotary file system and WaveOne reciprocating file system.

On comparing one of the parameter of the study, apical transportation,

Mamede-Neto et al. found no statistically significant difference in-between the two file systems.[29] The reason behind this may be that the amount of preparation needed and the different levels along the root length considered for measurement were not standardized.[29] Apical transportation was not considered as a parameter by Dhingra et al. and Puri et al. in their studies to describe the canal-shaping ability of the files.[27,28] While comparing the centering ability values of both the file systems, Jain et al. showed no statistically significant difference in their study.[23] Possible reason for this finding is that the noncutting tips of all the instruments act upon less amount of apical pressure as a guide for easy entry into the canal.[28]

Based on the results in this present study, it can be concluded that the WaveOne reciprocating file system has better ability to shape the canal than the ProTaper rotary file system.[18–23,26,29] The rigidity of the ProTaper system with stiff tip and increasing taper of the instrument reduces the remaining dentin thickness creating a straight canal.[23] The flexibility of the instrument is greatly reduced by the convex structure of the core mass.[26] The reciprocating motion of the WaveOne file decreases the chance of engaging in the canal by reversing the direction of rotation continually. The contraclockwise motion helps the apical penetration of the file, whereas the clockwise action prevents the file from engaging in the root wall.[22] It has the presence of two different cross-sections in the active portion with variable pitch and helical angle, which decreases the diameter of the core, thus increasing the flexibility of the file.[26] According to studies done by Dhingra et al. and Mamede-Neto et al., ProTaper rotary files prepared the canals better.[27,30] The design of the tip and the brushing strokes favored the canal-shaping ability of ProTaper. The decrease in the torsional stresses increased the resistance to fracture within the canal.[27] ProTaper Gold differs from the other files from the ProTaper family as it is specialized with heat treatment, which reduced the apical transportation caused and kept the file centered in the canal. Studies done by Capar et al., Hoppe et al., and Puri et al. after comparing both the files showed neutral results with no statistically significant differences.[24,25,28] Though no significant differences are found between the two files, certain amount of deviation is observed with WaveOne. Coronal preflaring and a glide path would reduce the stresses created and prevent the file from binding in the canal.[25] Noncutting tips of the files only act as a guide for penetration into the canal with less amount of applied pressure.[28] Differences in the methodology, apical enlargement caused, and criteria for evaluation justified the differences in results found among the studies.[29] The efficiency of a single file system depends on the differences in their reciprocating angles and movement.[18] Jain et al. and Mamede-Neto et al. showed that original anatomy of the canal was well preserved by the WaveOne single reciprocating file.[23,29] Reciprocating files take less time to prepare the root canal efficiently compared to rotary files.[21,25] Various single-file systems are introduced lately in the market. Creation of a proper glide path reduces the chances of friction of the file against the root canal wall, thus maintaining the original anatomy of the root canal.[39,40] Studies conducted using single-file systems stated that the smaller-sized taper and flexibility of the instruments defines the root canal accurately.[41] The single-file system with reciprocating motioncaused less amount

Table 1: Canal-shaping ability of WaveOne reciprocating and ProTaper rotary file systems

S. no.	*Author name*	*Study design and sample*	*Methodology*	*Comparison of apical transportation*	*Comparison of centering ability*	*Outcome*
1	Al-Sudani et al.[18] Saudi Arabia 2014	*In vitro* 10 samples per group	Comparison between WaveOne reciprocating and ProTaper rotary file systems using ILUMA Vision software (3M IMTEC Corporation, OK, US) ILUMA Ultra Cone beam CT scanner (3M IMTEC Corporation, OK, US) on freshly extracted teeth	ProTaper: mean = 0.50 Standard deviation = 0.3 WaveOne: mean = 0.29 Standard deviation = 0.3	ProTaper: mean = 0.69 Standard deviation = 0.4 WaveOne: mean = 0.87 Standard deviation = 0.48	WaveOne, demonstrated the lowest mean value of root canal transportation. WaveOne yielded the highest mean centering ratio and ProTaper the lowest
2	Tambe et al.[19] Maharashtra, India 2014	*In vitro* 10 samples per group	Comparison between WaveOne reciprocating and ProTaper rotary file systems using CBCT imaging on freshly extracted teeth	ProTaper: mean = –0.076 Standard deviation = 0.11 WaveOne: mean = –0.014 Standard deviation = 0.087	ProTaper: mean = 0.543 Standard deviation = 0.42 WaveOne: mean = 0.37 Standard deviation = 0.34	Wave One files caused less transportation and remained better centered in the canal than rotary ProTaper files
3	Agarwal et al.[22] Indore, India 2015	*In vitro* 20 samples per group	Comparison between WaveOne reciprocating and ProTaper rotary file systems using CBCT system (CS 9000 3D, Carestream) on freshly extracted teeth	ProTaper: mean = 0.05600 Standard deviation = 0.03515 WaveOne: mean = 0.05750 Standard deviation = 0.03582	ProTaper: mean = 0.6310 Standard deviation = 0.1964 WaveOne: mean = 0.6445 Standard deviation = 0.2305	Single file systems demonstrated average canal transportation and centering ability comparable to full-sequence ProTaper system in curved root canal
4	Uppin et al.[20] Karnataka, India 2016	*In vitro* 10 samples per group	Comparison between WaveOne reciprocating and ProTaper rotary file systems using CBCT imaging on freshly extracted teeth	ProTaper: mean = 0.11 Standard deviation = 0.099443 WaveOne: mean = 0.02 Standard deviation = 0.042164	ProTaper: mean = 0.2833 Standard deviation = 0.416106 WaveOne: mean = 0.955 Standard deviation = 0.142302	The canal preparation with Wave One files results in less transportation and better centering ability than ProTaper rotary files in curved root canals

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S. no.	Author name	Study design and sample	Methodology	Comparison of apical transportation	Comparison of centering ability	Outcome
5	Jain, et al.[23] Chhattisgarh, India 2016	*In vitro* 20 samples per group	Comparison between WaveOne reciprocating and ProTaper rotary file systems using CBCT (Kodak 9000 DICOM Software CS 9000 3D) on freshly extracted teeth	ProTaper: mean = 0.05 Standard deviation = 0.09 WaveOne: mean = 0.02 Standard deviation = 0.07	ProTaper: no significant values WaveOne: no significant values	WaveOne single reciprocation file system is better than ProTaper
6	Thota et al.[26] Andhra Pradesh, India 2017	*In vitro* 15 samples per group	Comparison between WaveOne reciprocating and ProTaper rotary file systems using CS3D Imaging Software (Carestream Dental, Chicago, IL, USA) on freshly extracted teeth	ProTaper: mean = −0.1453 Standard deviation = 0.0398 WaveOne: mean = −0.0853 Standard deviation = 0.0331	ProTaper: mean = 0.6113 Standard deviation = 0.0789 WaveOne: mean = 0.7773 Standard deviation = 0.0724	WaveOne files showed slighter transportation and better centering ability than ProTaper
7	Jainaen et al.[21] Khon Kaen, Thailand 2018	*In vitro* 10 samples per group	Comparison between WaveOne reciprocating and ProTaper rotary file systems using White-Fox cone-beam CT scanner (Acteon, France) on freshly extracted teeth	ProTaper: mean = 0.17 Standard deviation = 0.07 WaveOne: mean = 0.14 Standard deviation = 0.07	ProTaper: mean = 0.46 Standard deviation = 0.08 WaveOne: mean = 0.39 Standard deviation = 0.08	Reciprocal files result in less transportation than the rotational files
8	Mamede-Neto et al.[29] Brazil 2018	*In vitro* 16 samples per group	Comparison between WaveOne reciprocating and ProTaper rotary file systems using Prexion 3D scanner (PreXion 3D Inc., San Mateo, CA). CT scanner software (Prexion 3D Viewer, TeraRecon Inc., Foster City, CA) on freshly prepared teeth	ProTaper: nil WaveOne: nil	ProTaper: mean = 0.563 WaveOne: mean = 0.386	WaveOne files were more efficient
9	Dhingra et al.[27] Modinagar, India 2014	*In vitro* 30 samples per group	Comparison between WaveOne reciprocating and ProTaper rotary file systems using CBCT CS 9300 (78kV, 2 mA, Planmeca, Helsinki, Finland) Software-CS 3D on freshly extracted teeth	ProTaper: nil WaveOne: nil	ProTaper: mean = 0.26478 Standard deviation = 0.23525 WaveOne: mean = −0.26478 Standard deviation = 0.23525	Under experimental conditions, ProTaper file system has better centric ability than WaveOne file system

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S. no.	*Author name*	*Study design and sample*	*Methodology*	*Comparison of apical transportation*	*Comparison of centering ability*	*Outcome*
10	Mamede-Neto et al.[30] Brazil 2017	*In vitro* 16 samples per group	Comparison between WaveOne reciprocating and ProTaper rotary file systems using software: PreXion 3D Viewer, TeraRecon Inc., Foster City, USA. PreXion 3D scanner (PreXion 3D Inc., San Mateo, USA) on freshly extracted teeth	ProTaper: mean = 0.002 Standard deviation = 0.068 WaveOne: mean = 0.039 Standard deviation = 0.072	ProTaper: mean = 0.779 Standard deviation = 0.184 WaveOne: mean = 0.671 Standard deviation = 0.177	ProTaper produced the lowest canal transportation values
11	Capar et al.[24] Turkey 2014	*In vitro* 20 samples per group	Comparison between WaveOne reciprocating and ProTaper rotary file systems using CBCT imaging Simplant pro 15 software on freshly extracted teeth	ProTaper: mean = 0.07 Standard deviation = 0.06 WaveOne: mean = 0.06 Standard deviation = 0.06	ProTaper: mean = 0.5 Standard deviation = 0.48 WaveOne: mean = 0.39 Standard deviation = 0.48	There were no significant differences in-between the two file systems in transportation and centering ratio after instrumentation
12	Hoppe et al.[25] Brazil 2016	*In vitro* 20 samples per group	Comparison between WaveOne reciprocating and ProTaper rotary file systems using i-CAT Cone-beam 3-D imaging on freshly extracted teeth	ProTaper: mean = −0.03 Standard deviation = 0.53 WaveOne: mean = −0.20 Standard deviation = 0.51	ProTaper: mean = 0.51 Standard deviation = 0.34 WaveOne: mean = 0.57 Standard deviation = 0.24	No significant differences for canal transportation and centering ability in the both the preparation techniques
13	Puri et al.[28] Greater Noida, India 2016	*In vitro* 25 samples per group	Comparison between WaveOne reciprocating and ProTaper rotary file systems using i-CAT CBCT and measurements were done using CS3D software on freshly extracted teeth	ProTaper: nil WaveOne: nil	ProTaper: mean = 0.022 Standard deviation = 0.01 WaveOne: mean = 0.032 Standard deviation = 0.01	Both the systems were efficient in shaping the canal without any deviation from the original path of the canal

of transportation apically and remained well centered in the root canal system.[42]

The limitation of this study was that research and publications related to this concerned topic are limited leading to restrictions in our systematic review. There were limited full-text articles to analyze and because of less access to search forums, this study did not give concrete conclusions due to inadequate search of the literature. Studies with larger sample size and with elaborate search strategies are required for better result.

Conclusion

Keeping in mind the limitations of this study, it can be concluded that canal-shaping ability of WaveOne reciprocating files was better than ProTaper rotary files. Clinically, the canal-shaping ability determines the performance of a particular file system and CBCT is the most effective 3-D mode to determine the centering ratio and apical transportation caused. Thus, further comparative studies between these two file systems using CBCT are to be conducted to give a concrete idea.

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