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Several Shaping Characteristics of OneCurve Continuously Rotating System versus Three Different Kinematic Systems: ProTaper Universal, Twisted File Adaptive and WaveOne Gold

Üç Farklı Kinematik Sisteme Karşı OneCurve Sürekli Rotasyon Sisteminin Şekillendirme Özellikleri: ProTaper Universal, Twisted File Adaptive ve WaveOne Gold

Ali Türkyılmaz[1], Volkan Arıkan[2]

[1]Kırıkkale University Faculty of Dentistry, Department of Endodontics, Kırıkkale, Turkey
[2]Kırıkkale University Faculty of Dentistry, Department of Pedodontics, Kırıkkale, Turkey

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Address for Correspondence/Yazışma Adresi:
Ali Türkyılmaz Ph.D.,
Kırıkkale University Faculty of Dentistry, Department of Endodontics, Kırıkkale, Turkey
Phone : +90 532 248 20 51
E-mail : turkyilmaz_a@hotmail.com
ORCID ID: orcid.org/0000-0003-0641-0062

Abstract

Objective: This study aimed to compare the curvature change, preparation time, resin removal amount and working length reduction properties of the OneCurve (0.25/0.06), ProTaper Universal F2 (0.25/0.06), Twisted File Adaptive SM2 (0.25/0.06) and WaveOne Gold Primary (0.25/0.07) using simulated root canal models.

Materials and Methods: A total of 67 plastic models were used. Three models were used to verify the initial curvature angle, the weight of the unprepared resin block and the initial root canal length. The remaining 64 models were divided into four groups of 16 samples. After preparation, the changes in parameters were measured again. Statistical analysis was done with SPSS 22.0 using one-way ANOVA and post hoc Tukey's tests and Kruskal–Wallis with Bonferroni corrections. Pearson and Spearmen correlation coefficients were also used. A p-value <0.05 was significant.

Results: Significant differences were observed between OneCurve, ProTaper Universal F2, Twisted File Adaptive SM2 and WaveOne Gold Primary file systems in terms of resin removal amount, root canal curvature change and preparation time ($p<0.05$). The correlations were statistically significant ($p<0.05$).

Conclusions: Twisted File Adaptive SM2 performed significantly less resin removal and curvature change. Furthermore, the Twisted File Adaptive and WaveOne Gold Primary instruments required less preparation time compared with OneCurve and ProTaper Universal F2.

Öz

Amaç: Bu çalışmanın amacı simüle edilmiş kök kanal modelleri kullanılarak OneCurve (0,25/0,06), ProTaper Universal F2 (0,25/0,06), Twisted File Adaptive SM2 (0,25/0,06) ve WaveOne Gold Primer (0,25/0,07) eğelerinin kurvatür değişimi, preparasyon süresi, rezin uzaklaştırma miktarı ve çalışma boyu kaybı özelliklerini karşılaştırmaktır.

Gereç ve Yöntemler: Toplam 67 plastik model kullanıldı. İlk eğrilik açısını, hazırlıksız reçine bloğunun ağırlığını ve ilk kök kanal uzunluğunu doğrulamak için üç model kullanıldı. Kalan 64 model, 16 örnekten oluşan dört gruba ayrıldı. Hazırlandıktan sonra parametrelerdeki değişiklikler tekrar ölçüldü. İstatistiksel analiz SPSS 22.0

ile tek yönlü ANOVA ve post hoc Tukey testleri ve Kruskal-Wallis ile Bonferroni düzeltmesi kullanılarak yapıldı. Ayrıca, Pearson ve Spearmen korelasyon katsayıları kullanıldı. P değeri <0,05 istatistiksel olarak anlamlı olarak kabul edildi.
Bulgular: Rezin uzaklaştırma miktarı, kök kanal eğiminde değişim ve preparasyon süresi açısından OneCurve, ProTaper Universal F2, Twisted File Adaptive SM2 ve WaveOne Gold Primary eğe sistemleri arasında önemli farklılıklar gözlendi (p<0,05). Korelasyonlar istatistiksel olarak anlamlıydı (p<0,05).
Sonuç: Twisted File Adaptive SM2 önemli ölçüde daha az miktarda rezin uzaklaştırdı ve eğim değişikliği gösterdi. Ayrıca, Twisted File Adaptive ve WaveOne Gold Primary enstrümanları, OneCurve ve ProTaper Universal F2 ile karşılaştırıldığında daha az preparasyon süresi gerektirdi.

Introduction

The ideal preparation preserves the original anatomy of the root canal with the smallest possible apical diameter and the largest possible root canal orifice diameter. In this manner, the mechanical preparation of curved canals needs more attention since several complications may arise during the preparation of these canals, such as thinning of the root canal walls or straightening of curved canal paths. Thus, an adequate entrance and optimal preparation of the root canal at the coronal third should be maintained to avoid over-instrumentation and outright perforation (1).

In recent years, advances in rotary instruments made of nickel-titanium (NiTi) have improved the effectiveness of root canal treatment notably, especially in curved canals. Their properties of superelasticity, resistance and shape memory are the main advantages of their use (2). Another benefit of NiTi files is in reducing the preparation time for root canal instrumentation, and facilitation of debris removal (3). On the other hand, the curvature of the canal is a potential problem for cyclic fatigue failure due to cyclic stresses on instruments by bending (4), and NiTi instruments have a risk of fracture due to the different curvature shapes of root canals in clinical application.

The OneCurve (OC; MicroMega, Besancon, France) is a recently produced NiTi endodontic file with a patent-protected heat treatment, known as C-Wire alloy technology (5). It is a continuously rotating rotary file that preparing of the entire root canal length with a single instrument; it has a pre-bendable property and a shape memory. The OC file has a similar tip size and taper (0.25/0.06) to its predecessors [One Shape (MicroMega) and Two Shape (MicroMega)] but has a new shape design (5). A triangular cross-sectional instrument ProTaper Universal F2 (PTU; Dentsply Maillefer, Ballaigues, Switzerland) has a gradual taper. The file system has registered metallurgy that enhance the resistance and flexibility to cyclic fatigue (6). The Twisted File Adaptive SM2 (TF Adaptive, Axis/SybronEndo Orange, CA, USA) is a NiTi instrumentation system that combines the continuous rotation motion and reciprocating motion. The instrument works in continuous rotation if there is little or no stress loading on the instrument. WaveOne Gold (WOG) Primary reciprocal files are the advanced version of WaveOne (WO) files (Dentsply Sirona, Ballaigues, Switzerland), with metallurgical properties modified from M-Wire to Gold-Wire to improve the fracture resistance (7).

Currently, the information on the shaping ability of the OC is limited, and studies comparing OC shaping characteristics with different kinematics in curved canals are insufficient. This study aimed to compare the OC with three different kinematic rotary systems; the continuous rotating PTU, the adaptive motion TF Adaptive and the reciprocating WOG on four different shaping characteristic properties of files curvature change, working length (WL) reduction, resin removal amount and preparation time and to provide an analysis of the correlations between interrelated shaping properties.

Materials and Methods

Ethical approval was not required since no human or animal subjects were involved. The study was planned to be conducted with four groups and the sample calculation was performed considering an alpha-type error of 0.05, a beta power of 0.80 and with 0.40 as the effect size using G* Power v.3.1 software (Heinrich Heine University, Dusseldorf, Germany). A minimum sample size of 16 for each group was determined.

Similar to previous studies (8-10), for standardization and simulation of the curved root canals of natural human teeth, plastic models (curved endo-training resin blocks; Dentsply Maillefer, Ballaigues, Switzerland) with an approximately

mean curvature of 33°, ISO 15 apical enlargement, and 16-mm, 0.02 taper canal space were used. Four groups were formed each containing 16 samples. An electronic balance (Mettler Toledo, Switzerland) with an accuracy of 0.0001 g was used to weight the unprepared plastic models before instrumentation, and weights were recorded. An experienced endodontist (A.T.) performed all procedures. An ISO size 15 stainless steel K-file (Dentsply Maillefer, Ballaigues, Switzerland) was set when the tip of the file was visible at the edge of the canal at 2.5x magnification under a dental microscope (OPMIpico version 8.0, Carl Zeiss Meditac AG, Germany), and initial WL was obtained by subtracting 0.5 mm from the length. All canals were prepared according to this initial WL up to size 25 enlargement.

Group 1: OneCurve (0.25/0.06). The models were prepared with the X-Smart Plus endodontic motor at 300 rpm and 2.5 N.cm torque with continuous rotation. The One Flare (0.25/0.09) (Micro Mega), ISO K-file (0.10/0.02), One G (0.14/0.03), ISO K-file (0.15/0.02) and OneCurve files were used. The Glide Path One G (Micro Mega, France) (250-400 rpm max 1.2 N.cm torque) was used with 300 rpm and 1.0 N.cm torque.

Group 2: ProTaper Universal F2 (0.25/0.06). The models were prepared with the X Smart Plus (Dentsply, Switzerland) endodontic motor in the ProTaper Universal program with continuous rotating motion at 300 rpm and at various torque values in accordance with the files used. The SX, ISO 015 K-File, S1, S2, F1 and F2 files were used.

Group 3: Twisted File Adaptive SM2 (0.25/0.06). The models were prepared with the Elements Motor (SybronEndo, Glendora, CA, USA) in the TF Adaptive program with adaptive motion. The ISO K-file (0.08/0.02 and 0.15/0.02), SM1 (0.20/0.04) and SM2 files were used.

Group 4: WaveOne Gold Primary (0.25/0.07). The models were prepared with the X-Smart Plus endodontic motor in the WOG program with reciprocating motion including own rpm and N.cm values. The One G and a primary file were used.

The models were instrumented with TF Adaptive using an 8:1 reduction handpiece for TF Adaptive and a 6:1 reduction handpiece for the other files. All instruments were inserted with light pressure, and an in-and-out pecking motion not exceeding 3 mm was applied to engage the resin canal surfaces. After three pecks, resin canal was flushed with 2 mL distilled water. The instrument was cleaned regularly using a moist sponge to remove resin particles from the flutes. Following the use of each file, a 15 K-sized file was placed up to the WL to unclog debris blockage. The preparation was continued until the file reached the WL established previously. Each instrument was discarded after preparation of two resin canals. The WL was established again after instrumentation to the nearest 0.25 mm.

Evaluation of Canal Curvature and WL Change

Pre- and post-instrumentation images were taken at 1.6x magnification (Carl Zeiss). As previously described by Schneider (11), a parallel line was drawn to the axis of the canal on the digital photo images. Another line was scribed from the apical foramen to the previous line at the point that the simulated root canal began to leave the long axis of the tooth. The angle created by two lines was accepted as a curvature parameter. The same procedure was done for the postoperative images. The change in curvature was measured by subtracting the postoperative angle from the pre-operative one.

The initial WL was verified with an ISO 15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) until the file was just visible at the apical edge of the resin canal at 2.5x magnification under a dental microscope (Carl Zeiss Meditac AG, Germany), and 0.5 mm was subtracted to determine the WL. After instrumentation was completed, the WL was measured with a similar method and the difference between the initial and last value was recorded as the change in WL.

Evaluation of Resin Removal and Preparation Time

The removal amount of resin was determined by subtracting the weight of the prepared model from the weight of the unprepared model. The time elapsed during preparation including the operation period, instrument changes and irrigation application was recorded using a chronometer.

Statistical Analysis

All parameters were analyzed with SPSS 22.0 software (IBM, Armonk, NY). Normality was verified by using the Shapiro-Wilks test. The one-way analysis of variance and post hoc Tukey's tests were used for curvature change and WL change as there were normally distributed data. The resin amount

and preparation time data were not distributed normally, so the Kruskal-Wallis test with Bonferroni correction was used for these comparisons. P<0.05 was considered significant. In correlation analyses, Spearman's t-test (for non-parametric variables) was used for the association between resin removal amount and preparation time, and Pearson's t-test (for parametric variables) was used for the association between WL reduction and curvature change.

Results

Comparative investigation of the shaping ability properties of the files is presented in Table 1. The mean change of canal curvature presents a significant difference between the four groups (p=0.004). The PTU demonstrated a significantly curvature reduction when compared with the TF Adaptive and WOG. Preparation of the canals resulted in a mean loss in WL for all file systems, but statistically significant differences were not found in WL reduction between file systems (p=0.295).

A significant difference was found in the resin removal amount between the files (p=0.012). The TF Adaptive removed significantly less resin from the canals when compared to the PTU and WOG. There was a significant difference between groups in preparation time (p<0.001). The shortest mean preparation time was recorded with the WOG. The post-hoc test showed that the WOG file carried out preparation significantly faster than the OC or PTU.

A significant correlation between the shaping properties was found. The Pearson correlation coefficient (rs) between curvature change and WL change was equal to 0.381 (between 0.3 and 0.7) (p=0.003), showing a positive moderate correlation between these two variables. The Spearman correlation coefficient (rs) between resin removal and preparation time was equal to 0.390 (between 0.3 and 0.7) (p=0.002), showing a positive moderate correlation between these two variables.

Discussion

The NiTi alloys were developed with thermal treatment technology, namely, M-wire (Dentsply Tulsa Dental Specialities, Tulsa, OK), controlled memory wire (CM wire, DS Dental, Johnson City, TN) or R-phase wire (SybronEndo, Orange, CA). Thermomechanical processing is an optimized technique to control the transformation and microstructure properties of NiTi alloys for enhanced mechanical properties (12). The OC is a single-file system that uses rotating motion, manufactured with C-wire thermo-mechanical technology. The file has a variable-cross-section design. The manufacturer claims that the instrument is developed to maintain effective preparation while protecting original root canal anatomy (13).

Meanwhile, the PTU is a much researched NiTi file system that uses M-wire thermo-mechanical properties. In TF Adaptive technology, R-phase heat treatment, forming of the mental core and designing of the special surface increase the strength, fatigue resistance and flexibility of the file (14). The WOG is a single-file system with similar kinematics to the WO, though the metallurgic property is changed to Gold-wire, which provides greater fracture resistance to the file and increases its flexibility when compared with NiTi and the M-wire alloy (15). The WOG size 25 with a 0.07 taper is suggested by the manufacturer to come at the ideal size for most root canals (16). The

Table 1. Differences in the degree of canal curvature change (°), WL reduction (mm), resin removal amount (mg) and preparation time (s) with OneCurve, Protaper Universal F2, Twisted File Adaptive SM2 and WaveOne Gold Primary

	Curvature change (°)	WL change (mm)	Resin removal amount (mg)		Preparation time (s)	
File type	Mean ± SD	Mean ± SD	Min-max	Mean rank	Min-max	Mean rank
OneCurve	6.75±2.75^{a,b}	0.28±0.19^{a}	2.40-4.60	32.97^{a,b}	191-345	35.13^{a,b}
ProTaper Universal	8.06±3.11^{a}	0.35±0.16^{a}	1.20-9.80	34.87^{b}	248-567	51.60^{a}
TF Adaptive	4.83±201^{b}	0.23±0.15^{a}	0.90-4.10	17.90^{a}	122-233	19.60^{b,c}
WaveOne Gold	5.11±2.44^{b}	0.25±0.21^{a}	2.70-9.70	37.07^{b}	106-231	15.67^{c}
p-value	p=0.004	p=0.295	-	p=0.012	-	p<0.001

*In each column the values followed by the same superscript letter do not differ (p<0.05), TF: Twisted file, Min-max: Minimum-maximum, WL: Working length

cross-section of the file is designed with two cutting edges on an off-centered parallelogram.

The continuous rotating motion was the first kinematic movement used in endodontic motors. This technique aimed to decrease the preparation time and cost and increase the shaping quality and safety (3). Another rotation technique is adaptive motion, which works with its own motor (Elements Motor, Sybron Endo) including a special mode that combines of continuous and reciprocating rotation.

The present study investigated the shaping ability of four NiTi instruments working with three different kinematic motions in simulated moderate curvature canals. The four main findings obtained from four shaping ability features were that: (i) less flexible instruments caused more canal straightening even if the instruments compared have similar tapers; (ii) similar to previous reports (9,17,18), WL reduction occurred with all instruments regardless of the taper, flexibility or alloy technology; (iii) although the files used in the study have similar taper angles, the equilateral triangular cross-sectioned (two sharp cutting edges) TF Adaptive removed less resin than the One Curve (S-shaped near the shaft and triangular-shaped at the tip), ProTaper (convex triangular cross-section) or WOG (parallelogram-shaped cross-section); (iv) using a single-file system with reciprocating motion resulted in faster preparation than the others.

Reduction in WL in curved canals is one of the main concerns for the preparation of the curved root canals has been emphasized by numerous studies (19,20). This unpredictable change may lead to overpreparation and overfilling, which may result in foreign-body reaction, delayed periapical healing (9) or postoperative pain (21). In the present study, root canal curvature and root canal length were correlated with WL reduction. The straightening of a severe curvature influenced WL modification. On the contrary, it has been reported that straight canals do not cause a significant WL decrease after instrumentation (22). Essentially, minimal reduction in WL for canals with curvatures is predictable since NiTi file systems prepare root canals with the crown-down method, and in curved canals, the preparation of the coronal section of the canal facilitates the placement of the file in the apical section by straightening the curvature at the coronal part. A study described a mean WL reduction of 0.22 mm after canal preparation with NiTi files (23). Similar to this result, the present study found the average reduction in WL to be 0.28±0.18 mm in curved canals regardless of the file type. Also, the positive correlation between WL change and canal curvature corroborates the results of previous studies (19,20). In line with the present study, it was previously reported that different kinematic and metallurgic properties could not protect the original anatomy of root canals and caused a modification in WL (9,18,20). Although the WOG has a more tapered structure (0.07) than the other files, it caused a similar curvature change when compared to the TF Adaptive and OC instruments. Its flexibility may have contributed to the control of curvature change.

The preparation time is calculated by measuring the total preparation time, which includes active instrumentation, instrument changes and irrigation application (24), or the active instrumentation time only (18). In this study, to obtain more realistic results that could reflect clinical conditions, using a chronometer, the total duration of preparation was recorded.

The findings revealed that the use of WOG instruments showed a significantly faster preparation than the use of PTU or OC instruments, but that difference was not statistically significant against the TF Adaptive. The shortest mean preparation time was recorded for the WOG against the other files used. The WOG is a single-file system that works in a reciprocating motion. The files that run with a continuous rotating motion use a series of files, while reciprocating system have only one main file used to enlarge the root canal generally. This presents an advantage in terms of preparation time for practitioners. When acrylic blocks were used, the weight of the removed acrylic resin gives a measurement with which to understand the enlargement capacity of the file. In the present study, TF Adaptive caused less significant resin removal when compared to the PTU or WOG. Different parameters mentioned above could be effective in this complex interrelationship, warranting further investigation. The positive correlation between resin removal and preparation time reveals that the systems with shorter preparation times cause greater dentin removal from the canals. This is presumably the result of more aggressive preparation. While a shorter preparation time is an important feature of

rotary systems, a balance between a quick and safe preparation would be more desirable for clinicians.

In the present study, the taper angles of the files in different groups were not standardized, which can be considered as one of the limitations of the study, as this may have prevented higher correlation values from being obtained. Another limitation is the resin blocks used. These blocks provide a standard condition that cannot perfectly mimic the anatomic irregularities and variabilities in root canal systems, thus; the results may not definitively reflect *in vivo* conditions (3).

Conclusion

Considering the experimental conditions of the present study, OC did not show a superior shaping performance versus the other files used. To obtain more specific information about the shaping ability of the OC, further examinations comparing with different-generation instruments on simulated canals and/or extracted teeth are needed.

Ethics

Ethics Committee Approval: Ethical approval was not required since no human or animal subjects were involved.

Informed Consent: Informed consent was not required since no human subjects were involved.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: A.T., Concept: A.T., V.A., Design: V.A., Data Collection or Processing: A.T., Analysis or Interpretation: A.T., Literature Search: A.T., V.A., Writing: A.T., V.A.

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