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The Effect of Single File Systems on Apical Debris Extrusion During Retreatment: An In Vitro Study

Retreatment Sırasında Tek Eğe Sistemlerinin Apikal Debris Ekstrüzyonuna Etkisi: Bir İn Vitro Çalışma

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This study was presented as an oral presentation at The 20th Scientific Congress of Asian Pasific Endodontic Confederetion & The 14th International Congress of Turkish Endodontic Society, April 24-27, 2019, İstanbul, Türkiye.

ABSTRACT Objective: The aim of this study was to compare the amounts of debris extruded apically with the use of different single file systems during endodontic retreatment. **Material and Methods:** 36 mandibular premolar teeth were prepared with ProTaper Universal files up to F3. At every instrument change, the root canals were irrigated with 2 mL 5.25% NaOCl solution. After root canal preparation, final irrigation was performed using 5 mL 17% EDTA followed by 5 mL 5.25% NaOCl and 5 mL saline. The root canals were dried with paper point and filled with gutta percha and AH Plus sealer. The teeth were stored at 37 °C and 100% humidity for 1 week. Then the teeth were divided randomly into three groups (n=12) according to the single file system used: HyFlex EDM One File, Reciproc Blue File and One Curve. Debris extruded apically during the retreatment was collected into preweighed Eppendorf tubes. The initial weight was subtracted from final weight of the Eppendorf tubes to calculate the extruded debris for each group. Data were analyzed using one-way analysis of variance and post-hoc Tukey tests (p=0.05). **Results:** The Reciproc Blue extruded significantly more debris compared with HyFlex EDM and One Curve (p<0.05). When HyFlex EDM and One Curve files were compared, One Curve showed more extrusion of debris than HyFlex EDM, but this difference was not statistically significant (p>0.05). **Conclusion:** Under the conditions of this in vitro study, all instrumentation techniques resulted debris extrusion. The properties of the file systems may have an effect on the amount of apically extruded debris during endodontic retreatment.

Keywords: Endodontics; retreatment; root canal filling materials; root canal therapy

ÖZET Amaç: Bu çalışmanın amacı, tekrarlayan endodontik tedavi sırasında farklı tek eğe sistemlerinin kullanımının apikalden taşan debris miktarlarını karşılaştırmaktır. **Gereç ve Yöntemler:** Otuz altı adet mandibular premolar diş ProTaper Universal eğeler ile F3'e kadar genişletildi. Her eğe değişiminde kök kanalları 2 mL %5,25 NaOCl solüsyonu ile irrige edildi. Kök kanal preparasyonu sonrası 5 mL %17 EDTA ardından 5 mL %5,25 NaOCl ve 5 mL salin ile son irrigasyon yapıldı. Kök kanalları "paper point" ile kurutuldu ve gütaperka ve AH Plus kanal patı ile dolduruldu. Dişler 37 °C'de ve %100 nemli ortamda 1 hafta süreyle saklandı. Daha sonra dişler kullanılan tek eğe sistemine göre rastgele 3 gruba (n=12) ayrıldı: HyFlex EDM, Reciproc Blue ve One Curve. Tekrarlayan endodontik tedavi sırasında apikalden taşan debrisler, önceden ağırlıkları belirlenen Eppendorf tüplerinde toplandı. Her grup için apikalden taşan debris miktarını hesaplamak için Eppendorf tüplerinin başlangıç ağırlığı son ağırlığından çıkarıldı. Veriler, tek yönlü varyans analizi ve "post hoc" Tukey testleri (p=0,05) kullanılarak istatistiksel olarak analiz edildi. **Bulgular:** Reciproc Blue, HyFlex EDM ve One Curve ile karşılaştırıldığında önemli ölçüde (p<0,05) daha fazla debris taşmasına neden oldu. HyFlex EDM ve One Curve eğeleri karşılaştırıldığında, One Curve, HyFlex EDM'ye göre daha fazla debris ekstrüzyonu gösterdi ancak bu fark istatistiksel olarak anlamlı değildi (p>0,05). **Sonuç:** Bu in vitro çalışmanın sınırlamaları dâhilinde, tüm enstrümantasyon teknikleri debris ekstrüzyonuyla sonuçlandı. Eğe sistemlerinin özellikleri, tekrarlayan endodontik tedavi sırasında apikalden taşan debris miktarı üzerinde etkili olabilir.

Anahtar Kelimeler: Endodonti; yeniden tedavi; kök kanalı dolgu materyalleri; kök kanal tedavisi

During endodontic retreatment, root canal filling materials, irrigation solutions, microorganisms, and their by-products can extrude into the periapical area. These substances overflowing into the periapical area are known to cause flare-ups, periapical inflammation, post-operative pain, and hinder the healing of the periapical lesion.[1] Various techniques and instruments such as hand files, ultrasonics, lasers,

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chemical solvents, and rotational and reciprocal rotary Ni-Ti systems are used in the process of endodontic retreatment to remove filling materials.[2] However, all these systems are known to cause apical debris extrusion.[3,4]

Greater amounts of apical debris extrusion exacerbate the severity of inflammatory reactions in the periapical area during retreatment. Huang et al. reported that the ideal endodontic retreatment technique should minimize apical debris extrusion while providing complete removal of the filling materials from canal.[5] Endodontic retreatment is more complex and time-consuming compared to the primary root canal treatments. The use of Ni-Ti rotary instruments simplifies the root canal treatment process.[6] Studies report fewer apical debris extrusion with rotary instrumentation than with manual instrumentation.[7,8]

Reciproc Blue (VDW, Munich, Germany), is a single-file system designed for use with reciprocating motion. The file has a "S" shaped cross-section with double sharp edges and an inactive tip, and it is manufactured with M-Wire technology. It shows high flexibility and cyclic fatigue resistance.[9] Although the Reciproc Blue file is not specifically designed for endodontic retreatment, it has been reported that it is also used for initial treatment as well as for the removal of filling materials.[10]

HyFlex EDM (Coltene/Whaledent, Alstatten, Switzerland) is a single-file system that works with rotational motion. This file, manufactured with 'electrical discharge machining' technology, namely EDM, has varying diameters along the shaft. HyFlex EDM (25/.08) files show a constant 8% taper in the apical 4 mm portion, decreasing to 4% taper towards the coronal portion.[11]

One Curve (Micro-Mega, Besancon, France) is a single-file system and works with rotational motion. Having a controlled memory feature, One Curve provides easier access to root canals with its prebendable capability. One Curve also has varying cross-sections. While the tip of the instrument has a triangular-shaped cross-section, the shaft has an S-shaped cross-section. Varying cross-sectional shapes provide this file with a better cutting feature and center retention.[12]

Many available studies have investigated the effect of multi-file rotational systems and single-file reciprocating systems on apical debris extrusion during retreatment.[4,13-15] Although the results of these studies differ from each other, several studies report that reciprocal single-file systems result in greater debris extrusion than rotational multi-file systems.[4,13,15] In this regard, the search is still ongoing for alternative single-file systems that will cause less apical extrusion than single-file reciprocal systems. However, there are limited number of studies in the literature comparing the extrusion of debris carried by single-file instruments with different kinematic movements during endodontic retreatment.[16,17] Therefore, we aimed to compare the extrusion of debris during the removal of filling materials from single-file systems with different designs and working principles. The null hypothesis is that there is no significant difference in apically extruded debris between the 3 different single-file systems used.

MATERIAL AND METHODS

SPECIMEN SELECTION

For the study, approval was obtained from the Van Yüzüncü Yıl University Non-Interventional Clinical Research Ethics Committee with the decision numbered 2022/08-03 (date: August 19, 2022). This study was conducted in accordance with the principles of the Declaration of Helsinki. A total of 36 freshly extracted single-rooted mandibular premolar with single-canal were used. Inclusion criteria for the study comprised teeth with no calcified roots, a curvature of less than 10, no root resorption, and a root length of at least 12 mm. The coronal portions were removed using highspeed diamond burs with air-water spray coolant to obtain a uniform remaining root length of 12 mm.

ROOT CANAL PREPARATION

Access cavities were prepared and the working length was determined using a size 10 K file and 1 mm shorter than the length seen in the apical foramen. Root canal preparations were performed using ProTaper Universal instruments (Dentsply Sirona, Ballaigues, Switzerland) up to F3 (30/09v). After the use

of each instrument, the root canals were irrigated with a 2 mL volume of 5.25% NaOCl. Final irrigation was performed by using 5 mL, 17% EDTA, 5.25% NaOCl and saline solution.

ROOT CANAL OBTURATION

Root canals were dried with F3 paper point (Dentsply Sirona, Ballaigues, Switzerland) and then filled with a single cone technique using ProTaper Universal F3 Gutta Percha (Dentsply Sirona, Ballaigues, Switzerland) and AH Plus (Dentsply Sirona, Ballaigues, Switzerland) root canal sealer. After the teeth were closed with temporary filling material, they were stored for 1 week at 37°C and 100% humidity.

Debris Collection

The method developed by Myers and Montgomery was used to measure extruded debris.[18] The teeth were primarily attached to the Eppendorf tubes (Sigma-Aldrich, USA), then these tubes were fixed to the holes opened into the plastic stoppers of the 10 mL glass bottles and experimental set-up formed (Figure 1). A syringe needle was placed in each of the tubes to equalize the internal and external air pressure. In all experimental groups, the weight of the empty Eppendorf tubes was measured 3 times with an electronic precision scale (Denver Instrument, USA) with a precision of 10^{-4} g prior to the retreatment. The dry weight of the Eppendorf tubes was determined by taking the average of these 3 calculations.

Retreatment Procedure

All samples were randomly divided into 3 groups (n=12) according to the file system to be used in endodontic retreatment;

Group 1, Reciproc Blue: R25 (25.08) file was used in the "Reciproc ALL" program. The file was used with light apical pressure and brushing action.

Group 2, HyFlex EDM: Single file (25/~) was used in rotational mode at 500 rpm and 2.5 N/cm torque with a slight pecking motion towards the apex.

Group 3, One Curve: The One Curve file (25.06) was used with light apical pressure with rotational motion at 300 rpm and a torque of 2.5 N/cm.

FIGURE 1: The experimental setup.

Retreatment was considered complete when gutta-percha or canal sealer was not seen on the instrument surfaces and root canals when examined under the operating microscope (Leca M320, Leica Microsystems, Germany) and the canal walls were smooth. 20 mL of distilled water was used for each sample during the removal of filling material.[15,19] Endodontic retreatment procedures were performed by an experienced endodontist under an operation microscope (Leca M320, Leica Microsystems, Germany).

Debris Calculation

Following the removal of the filling material, the teeth were separated from the assembly. The apical parts of the samples were washed with 1 mL of distilled water to collect adhered debris into the Eppendorf tubes. Samples were incubated at 70°C for 5 days to measure the dry weight of debris. Followingly, the Eppendorf tubes were measured again 3 times in succession and the weight of the Eppendorf tubes containing debris was determined by taking the average. Then, the amount of apical debris extruded during the removal of filling material was calculated by subtracting the weight of the empty Eppendorf tubes from the Eppendorf tubes containing debris.

STATISTICAL ANALYSIS

SPSS (SPSS 20.0, IBM Corp., Armonk, NY, ABD) statistical package program was used for data analysis. It was determined that the data were normally distributed with the Shapiro-Wilk test. One-way analysis of variance and post hoc Tukey test were used to compare normally distributed data. The statistical significance level was accepted as $p<0.05$.

RESULTS

The mean, minimum, maximum, and standard deviation for apical debris extrusion are presented in Table 1 (Figure 2). A statistically significant difference was noted between the groups (p=0.000). The Reciproc Blue group yielded significantly higher apical debris extrusion than the HyFlex EDM (p=0.000) and One Curve (p=0.002) groups. Although there was more debris extrusion in the One Curve group compared to the HyFlex EDM group, no significant difference was found (p>0.05).

DISCUSSION

In endodontic retreatment, apical extrusion of debris during retreatment is one of the factors that cause failure of endodontic treatment.[20] Available studies report that even a very small amount of apical debris may cause inflammation in the periapical region and may be a factor in the failure of the treatment providing that it contains a large number of bacteria.[21]

Ni-Ti rotary instruments with both rotational and reciprocal motion are used in the process of endodontic retreatment.[4] Although the reciprocal motion was not originally designed for endodontic retreatment, it is hypothesized that it could be an effective approach to endodontic retreatment due to its high ability to advance toward the apex.[22] In their study, Zuolo et al. compared the efficiency of files with different kinematics in removing filling material and noted that the single-file reciprocal system is superior to the multi-file rotational systems, reporting less time required for

TABLE 1: Amount of apically extruded debris during retreatment of single file systems.

Group	n	$\bar{X}$±SD	Minimum	Maximum	p value
Reciproc Blue	12	0.0108±0.0019[a]	0.0082	0.0141	0.00*
One Curve	12	0.0085±0.0015[b]	0.0065	0.0113	
HyFlex EDM	12	0.0078±0.0012[b]	0.0061	0.0102	

a-b: There is no difference between groups with the same letter; *One-way analysis of variance; SD: Standart deviation.

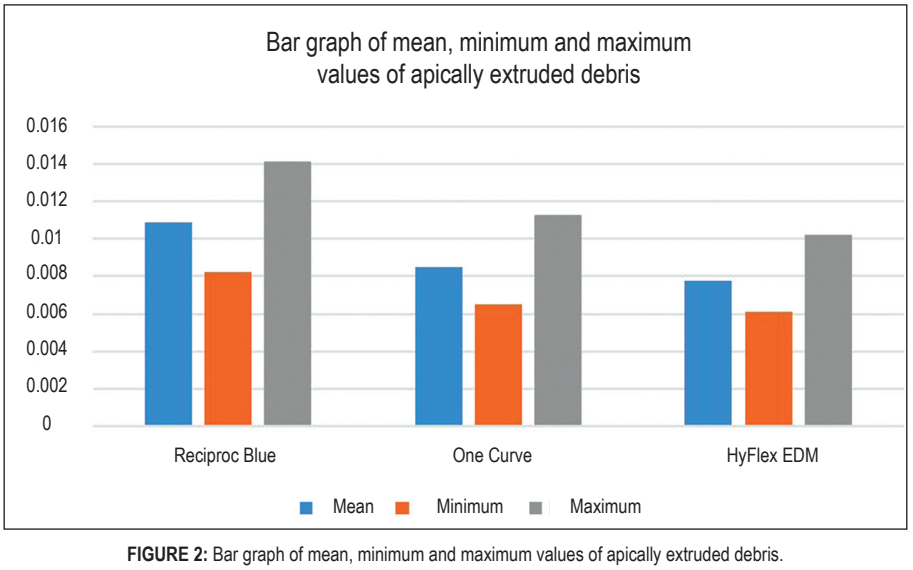

FIGURE 2: Bar graph of mean, minimum and maximum values of apically extruded debris.

reciprocal systems to remove obturation materials.[23] Again, Rios et al. reported that single-file reciprocal systems and multi-file rotary systems were equally effective in removing root canal filling materials.[24] Single file reciprocal systems are commonly used because they save physicians money and time due to benefits such as shorter preparation time, fewer procedural errors, and easier application.[23,24]

However, it has been reported that the use of reciprocating instruments during retreatment transports substances such as dentin residues, irrigation solutions, and microorganisms and their by-products to the periapical tissues at a greater rate than rotational instruments.[4,25] Therefore, in present study, we aimed to compare the effect of single file systems using rotational motion (HyFlex EDM, One Curve), which we think can be an alternative to reciprocal single file systems (Reciproc Blue), on debris extruded during retreatment. As shown by the results of the study, a greater debris extrusion was noted in the Reciproc Blue group than in the HyFlex EDM and One Curve groups. Therefore, the null hypothesis was rejected.

Bürklein and Schäfer reported that reciprocal files carried more debris than rotary files in a study in which they compared extruded debris with WaveOne (Dentsply Maillefer, Ballaigues, Switzerland), Reciproc, Mtwo, and ProTaper files during root canal filling removal.[4] Lu et al. reported more extrusion of debris in the Reciproc group than in the Mtwo group during retreatment.[26] In addition, the studies carried out by Çanakçi et al. and Keskin and Sarıyılmaz reported that reciprocal single-file systems yield greater debris extrusion than rotational multi-file systems.[13,19] The results are consistent with the results obtained in present study.

However, the study of Silva et al. compared extruded debris from the ProTaper Universal Retreatment (PTUR), Reciproc, and WaveOne files during root canal filling removal and reported that the PTUR carried more debris compared to files using reciprocating motion.[14] Dincer et al. compared extruded debris from the Reciproc, Mtwo, and PTUR files during root canal filling removal and reported statistically less debris extrusion in the Reciproc group compared to the rotary system files.[25] The results of both studies differ from the results of our study, which may be attributed to the number of files used. While Silva et al. reported using 6 different files for retreatment in the PTUR group, they used two files in the Reciproc and WaveOne groups.[14]

There are limited studies comparing single-file reciprocal systems and single-file rotational systems for extrusion of debris during retreatment.[16,17] AlOmari et al. reported that XP Endo Shaper (FKG Dentaire, La Chaux-de-Fonds, Switzerland) less debris extrusion than Reciproc Blue, but this difference was not statistically significant.[16] Azim et al. reported that WaveOne Gold, HyFlex EDM and XP Endo Shaper files did not cause a significant difference in debris extrusion during retreatment. Azim et al. used WaveOne Gold as the reciprocal system.[17] Also, in this study, Reciproc Blue was used as the reciprocal kinematics. Keskin and Sarıyılmaz reported that Reciproc Blue files cause greater debris extrusion than WaveOne Gold files.[13] Therefore, the results of their study may have shown differences from the study conducted by Azim et al.[17]

In our study, a statistically significantly higher debris extrusion was noted in the Reciproc Blue group than in the HyFlex EDM and One Curve groups. The difference in results can be explained by the difference in section design, cutting efficiency, speed, motion kinematics, and duration of the re-preparation.[16,17]

All Ni-Ti rotary instruments regardless of motion kinematics are known to cause apical debris extrusion during endodontic retreatment.[4] Consistently, apical extrusion of debris was detected in all groups in present study. Azim et al. reported that rotational motion exerted superior cutting efficiency compared to reciprocal motion in endodontic retreatment with single-file systems.[17] They also reported that the cutting efficiency of the files and the ability to remove the filling material from the root canal may affect the extrusion of debris during retreatment.

CONCLUSION

When removing root canal filling material, the reciprocal single file system extruded more debris compared to rotational single file systems.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Esin Özlek;* ***Design:*** *Esin Özlek;* ***Control/Supervision:*** *Esin Özlek;* ***Data Collection and/or Processing:*** *Esin Özlek, Hüseyin Gündüz;* ***Analysis and/or Interpretation:*** *Esin Özlek, Hüseyin Gündüz;* ***Literature Review:*** *Furkan Evrendilek, Pelinsu Şahin;* ***Writing the Article:*** *Hüseyin Gündüz, Furkan Evrendilek, Pelinsu Şahin;* ***Critical Review:*** *Esin Özlek, Hüseyin Gündüz;* ***References and Fundings:*** *Esin Özlek, Hüseyin Gündüz;* ***Materials:*** *Furkan Evrendilek, Pelinsu Şahin.*

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