Effects of Various Retreatment Instrumentation Systems in Removing Root Canal Fillings from the Root Canals

Kök Kanallarından Dolgu Maddelerinin Uzaklaştırılmasında Çeşitli Retreatment Enstrümantasyon Sistemlerinin Etkileri

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ABSTRACT Objective: The aim of this study was to compare the efficacy of 3 retreatment rotary file systems and hand instrumentation in removing gutta-percha and sealer from root canals. **Material and Methods:** Forty freshly extracted human maxillary incisors, each with one straight canal were instrumented and filled with gutta-percha and sealer using cold lateral compaction technique. The teeth were then randomly divided into 4 groups (n=10). Group I was retreated using hand instrumentation. Groups II-III-IV was retreated using rotary systems R-Endo, ProTaper Universal Retreatment (PTUR), and D-RaCe respectively. For all specimens, the following data were recorded: residual filling material on the apical thirds of root canals, apically extruded debris, time for retreatment, and procedural errors. Data were statistically analyzed, and the level of significance was set as p=0.05. **Results:** There was statistically significant difference between the hand instrumentation and rotary systems regarding the amount of residual material in the apical third of the canal ($p<0.05$), but a significant difference was not found among the experimental groups. R-Endo, PTUR, and D-RaCe systems were significantly faster compared to the hand instrumentation ($p<0.05$). **Conclusion:** According to the results, all instrumentation techniques left residual filling material inside the root canals. There was no significant improvement in the removal of filling material using D-RaCe system when compared to with the other rotary file systems. Retreatment systems proved to be faster than hand instrumentation in removing root filling materials.

Key Words: Root canal therapy; retreatment; gutta-percha; canals sealer

ÖZET Amaç: Bu çalışmanın amacı, kök kanallarından guta-perka ve pat uzaklaştırılmasında 3 retreatment döner eğe sistemi ile elle preparasyon yöntemlerinin etkinliklerinin karşılaştırılmasıdır. **Gereç ve Yöntemler:** Her biri tek bir düz kanala sahip 40 adet yeni çekilmiş insan üst kesici dişleri enstrümante edildi ve lateral kondensasyon yöntemi kullanılarak guta-perka ve pat ile dolduruldu. Dişler daha sonra rastgele olarak 4 gruba ayrıldı (n=10). Grup I'de retreatment işlemi el eğeleri ile yapıldı. Grup II-III-IV'te ise retreatment işlemi, sırasıyla R-Endo, ProTaper Universal Retreatment (PTUR) ve D-RaCe döner eğe sistemleri kullanılarak yapıldı. Tüm örnekler için; apikal kök kanallarında kalan artık dolgu maddesi, apikalden taşan debris miktarı, retreatment işlem zamanı ve işlemsel hatalar ile ilgili veriler kaydedildi. Elde edilen veriler istatistiksel olarak p=0,05 önemlilik derecesinde incelendi. **Bulgular:** Kanal apikal üçlüsündeki rezidüel madde miktarı konusunda elle enstrümentasyon yöntemi ile döner eğe sistemleri arasında istatistiksel olarak anlamlı bir farklılık bulunmuştur ($p<0,05$), fakat döner eğe sistemleri arasında önemli bir farklılık bulunmamıştır. R-Endo, PTUR ve D-RaCe eğe sistemlerinin elle enstrümentasyona göre daha hızlı olduğu tespit edilmiştir ($p<0,05$). **Sonuç:** Elde edilen sonuçlara göre, kullanılan tüm enstrümentasyon yöntemleri kök kanallarında artık dolgu maddesi bırakmaktadır. D-RaCe eğe sistemi diğer döner eğe sistemleri ile karşılaştırıldığında önemli bir gelişme gösterememiştir. Kök kanal dolgularının uzaklaştırılmasında, elle enstrümentasyona göre döner eğe sistemleri daha hızlıdır.

Anahtar Kelimeler: Kök kanalı tedavisi; yeniden tedavi; gutaperka; kanal sealantı

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Cause of endodontic failure might occur in case of persistence of bacteria in the root canal system as a consequence of insufficient cleaning, inadequate filling, or when there is coronal leakage.[1] When root canal treatment is unsuccessful, treatment options include nonsurgical retreatment, periradicular surgery, or extraction. Nonsurgical retreatment option is preferred because it is the most conservative method to solve the failure.[2] The main objective of this treatment is remove all filling material from the root canal and to regain access to the apical foramen.[3] Gutta-percha, in combination with variety of sealers, is the most commonly used material for canal filling.[4] However gutta-percha cannot be removed completely from the root canals when retreatment is required.[5,6] For this purpose several attempts with hand files, engine driven rotary files, ultrasonic systems, heat carrying instruments, lasers and solvents were performed.[5,7-14]

Various nickel-titanium (NiTi) rotary file systems have been developed to remove the fillings from the canal walls. To improve safety preparation and to prepare intended shapes, new file designs with cutting tips, radial lands, varying tapers and rake angles, and changing pitch lengths have been developed.[10] Recently, a new file system has been introduced commercially: the D-RaCe (FKG Dentaire, La Chaux-de-Fonds, Switzerland) system. It consists of 2 instruments: DR1 with an active tip (size 30) and taper 0.10, DR2 with a non-active tip (size 25) and taper 0.04. The lengths are 15 mm for DR1 and 25 mm for DR2. These instruments are specially designed for the removal of root filling from the coronal third (with DR1), middle and apical thirds (with DR2) of the root canals. In addition, the DR1 working tip facilitates the initial penetration into the filling material.

PTUR files (Dentsply Maillefer, Ballaigues, Switzerland) are designed to facilitate the removal of filling material, with each file having different lengths, tapers, and apical tip diameters. The D1 instrument (size 30 and taper 0.09) is 16 mm long and has an active tip to facilitate initial penetration into the filling material. The D2 instrument (size 25 and 0.08) is 18 mm long and is used at the middle thirds. The D3 instrument (size 20 and 0.07) is 22 mm long and is used at the working length (WL).

The R-Endo retreatment files (Micromega, Becancon, France) comprise 3 files as R1 (15 mm, size 25, and taper 0.08), R2 (19 mm, size 25, and taper 0.06), and R3 (23 mm, size 25 and taper 0.04) and are used at coronal, middle, and apical thirds, respectively.

The purpose of this study was to compare the efficacy of three retreatment rotary files (D-RaCe, R-Endo, and PTUR) and hand instrumentation in removing gutta-percha and sealer from root canals.

MATERIAL AND METHODS

SPECIMEN SELECTION

Forty freshly extracted single-rooted maxillary incisors were selected from a random collection of extracted teeth stored in daily-changed saline solution. Inclusion criteria were absence of a root filling, presence of a single root canal, complete formation of the apex and no caries, fracture or resorption. Radiographs were taken of each root to confirm the canal anatomy. Soft tissues and calculus were mechanically removed from the root surfaces immediately after extraction with a scaler. The teeth were examined under a stereomicroscope (Carl Zeiss, Jena, Germany) to confirm the presence of a single apical foramen. Only root canals in which apical diameter was size 15 were selected. Standard access cavities into each pulp chamber were then prepared using high-speed diamonds under water cooling. The crowns were flattened to obtain a reference surface to determine the WL. A size 10 K-file was inserted into the canal until it was visible at the apical foramen, and the WL was determined to be 1 mm short of this position.

CANAL PREPARATION AND FILLING

The coronal portion of the canal was enlarged with gates glidden burs (Dentsply Maillefer, Ballaigues, Switzerland) sizes 2 and 3. Each canal was instrumented using ProFile series 0.04 NiTi rotary files (Dentsply Maillefer) with the passive step back technique. For the standardization, each canal was enlarged to a size 30 file. Each of the file was used in 5 canals. Patency of the canals was maintained throughout the procedure by passing a size 10 K-file approximately 1 mm through the apex. The

canal was irrigated with 2 ml freshly prepared 5% NaOCl (ADR Mediko Kimya, Istanbul, Turkey) with a 27-gauge needle after every file. A final rinse with 2 ml 17% EDTA (ADR Mediko Kimya) was given to remove the smear layer followed by rinsing with 2 ml 5% NaOCl. Each canal was then dried with paper points and filled with laterally compacted gutta-percha and sealer (Sealapex; Kerr, Scafati Solerno, Italy) that was mixed according to the manufacturer's instructions. A gutta cut (VDW, München, Deutschland) was used to cut the excess gutta-percha. Access cavity of the specimen was sealed with a temporary filing material (Cavit; 3M ESPE, Seefeld, Germany). Radiographs were taken to confirm the quality of the canal filling. All specimens were stored at 37 °C and 100 % relative humidity for 4 weeks.

RETREATMENT AND DEBRIS COLLECTION

Debris was collected as previously reported.[15] Before the retreatment procedures, the 40 Eppendorf tubes were weighed to 10^{-5} precision using a microbalance (Denver Instrument, Gottingen, Germany). Three measurements were taken for each tube, and the mean value was recorded. 2 ml 5% NaOCl was used after each instrument. R-Endo (Micro-Mega, Besançon, France), ProTaper Universal Retreatment (Dentsply Maillefer) (PTUR) and D-RaCe (FKG Dentaire, La Chaux-de-Fonds, Switzerland) rotary NiTi files were driven with a torque controlled motor (X- Smart; Dentsply Maillefer) according to the manufacturer's instructions. All teeth were numbered and randomly assigned to four groups of 10 samples each.

Group 1 (Hand instrumentation-Control Group): The gutta-percha was removed from the coronal and middle thirds with 2 and 3 gates glidden drills. The filling material was removed with K-files sizes 15-30 to the WL using a push-pull movement alternated with a rotary motion. Once the WL had been reached with a size 15 file, sizes 20, 25 and 30 were used at WL.

Group 2 (R-Endo Group): A size 25 Rm hand file was used with ¼ turn pressure directed towards the apex to dig the hard layer of the filling material and allow the alignment to the next file. A Re R-Endo file was used to remove the 3 mm coronal gutta percha without having to force the file. Then R1, R2, and R3 were used for removing filling material respectively from coronal, middle and apical thirds.

Group 3 [ProTaper Universal Retreatment (PTUR) Group]: The D1, D2, and D3 files were used to remove the filling material respectively from the coronal, middle and apical thirds of the root canal.

Group 4 (D-RaCe Group): DR1 file was used to remove the gutta-percha from the coronal third of the root canals. DR2 file was then used to remove the filling material from the middle and apical thirds.

Removal of filling materials was determined complete as the WL was reached, and no more gutta-percha could be seen on the last file used; the time in seconds was recorded. Each file was used for a maximum of 5 canals except RaCe DR2 which was used only for 1 canal (recommended by the manufacturer). Final irrigation was performed with 10 ml 5% NaOCl.

EVALUATION

Four types of data were recorded for all specimens:

Residual Filling on Apical Third: Teeth were split longitudinally in the buccopalatal plane. To facilitate fracture into two halves, all roots were longitudinally grooved on the external surfaces with diamond disk, avoiding penetration of the root canals. Then digital photographs of each half from the apical thirds were taken using a digital camera mounted on a stereoscopic microscope (Carl Zeiss) at X5 magnification. Digital images were imported into Adobe Photoshop (Adobe Systems, San Jose, CA, USA) (Figure 1). A pixel count of residual gutta-percha/sealer on the apical thirds of the specimens was recorded and the percentage of the overall surface was calculated with the following equation: area of residual filling material/area of canal wall×100=area % of residual filling material.

Apically Extruded Debris: The Eppendorf tubes were centrifuged (11 400 rpm) for 10 minutes (Sigma Laborzentrifugen, Harz, Germany) to collect the solid matter at the bottom. The fluid was evacuated using an automatic micropipette. The

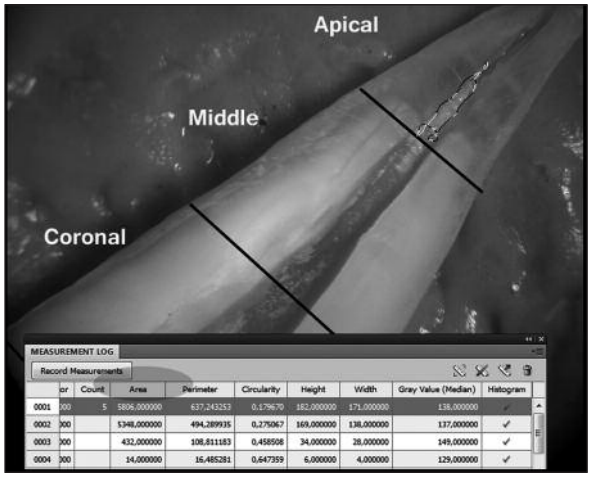

FIGURE 1: Image of residual filling material on the root canal wall and the calculation of the area of filling material using an image programme after photographed a sample.

caps of the tubes were left open to allow evaporation of the remaining fluid over the extruded material. The extruded debris was weighed with the tubes using microbalance. The net weight of the dry debris was determined by subtracting the original weight of the empty tube from the gross weight.

Time for Retreatment: The time required for removal gutta-percha and sealer was recorded.

Procedural Errors: Fractures and deformations of the instruments were also recorded.

STATISTICAL ANALYSIS

Kolmogorov-Smirnov test was performed to determine whether the data distribution is normal or not (p=0.991). According to the results of the test, the data was compared by using ANOVA and Tukey post-hoc tests at a significance level of $p<0.05$.

RESULTS

The following results were obtained from present in vitro study:

Residual Filling on Apical Third: There was statistically significant difference between the hand instrumentation and rotary systems regarding the amount of residual material in the apical third of the canal ($p<0.05$). But, there was no significant difference among the experimental groups (Table 1).

Apically Extruded Debris: No significant differences were found among the groups in terms of the apical extruded debris (p=0.077) (Table 1).

Retreatment Time: Regarding the mean retreatment time R-Endo, PTUR and D-RaCe required significantly less time when compared to hand instrumentation ($p<0.05$) (Table 1).

Procedural Errors: Three K-file was separated during retreatment. During instrumentation the specimens, in which instrument separation appeared in the root canal, were not counted in study. Also, visible deformations were seen in three K-files, four R-Endo files (one R1, one R2, and two R3), two PTUR files (D3) and two D-RaCe files (DR2).

DISCUSSION

The inability to remove all filling may result in necrotic tissue or bacteria being left behind, which may cause periapical inflammation.[7,15,16] Therefore, it is necessary to determine the optimal file system that will allow the fastest and most effective removal of fillings from the root canals.

As it has been demonstrated in the literature, it was difficult to remove all traces of filling material from the canals during any retreatment tech-

TABLE 1: Mean area of residual filling material on apical thirds of specimens, mean (SD) of apically extruded material and mean (SD) of the time necessary for retreatment recorded for different groups.

Groups	The mean area of residual filling on apical thirds of specimens (%)	Apically extruded material (× 10^{-3} g)	Mean time for retreatment (s)
Hand	27,18[a]±4,61	1.03±0.43	539.8±93.7
R-Endo	11,70[b]±9.44	2.41±1.94	375.5±85.4
PTUR	17,84[b]±6,64	1.97±1.07	381.3±86.9
D-RaCe	14,22[b]±6,43	1.15±0.53	411.2±74.6

SD: Standard deviation.

nique.[7,17-20] Similar to that studies, residual filling was observed in all groups of present study. Difference was found between the hand instrumentation and rotary systems (R-Endo, PTUR, and D-RaCe). But, there was no difference among the rotary systems in straight canals.

Debridement of the apical third of the canal is a big challenge to root canal treatment, especially because of the complexity of the root canal anatomy and the limitations of instrumentation. It has been reported that greater amount of filling material remained in the apical third than the others during the retreatment and there is difficulty of instrumentation.[6,21,22] Thus, to secure effective apical cleaning, the instruments should be in contact with every part of the canal wall. The present study revealed that rotary retreatment systems removed statistically significant amount of filling materials from apical third when compared with the hand instrumentation.

During the instrumentation dentine chips, pulp tissue fragments, necrotic tissue, microorganisms and intracanal irrigants may be extruded through the apical foramen. This is of concern as material extruded from the apical foramen may be related to undesirable pain and inflammation.[7,23-25] It has been proven that apical extrusion occurs in more instrumentation techniques, and therefore an attempt should be made to find a system that results in minimal extrusion of debris.[23-26] In this study, measurable apical extrusion was observed in all groups, yet there was no significant difference among the groups.

According to the previous studies, rotary systems required less time for gutta-percha removal than hand files.[9,16,27,28] By contrast, Unal et al. and Imura et al. reported a significant difference amongst the groups for the mean retreatment time, with the hand instrumentation requiring significantly less time than the rotary files.[21,27] They stated that this result was associated with the removal of larger pieces of gutta-percha with hand files and the number of rotary files.[21,27] In this study, all retreatment systems were significantly faster in removing fillings than hand files. It can be hypothesized that the active tip and the cutting blades of both rotary files used in this study positively influenced the time required for retreatment.[4,16,27] Also, some authors explained that the higher rotational speed plasticized the gutta-percha more rapidly.[5,16]

Several studies have reported a varying incidence of NiTi rotary file fractures.[5,6,16,27] In this study the rotary files were used according to the manufacturers' instructions and in combination with a torque-controlled engine. No rotary file fractures occurred. According to the results, use of rotary files, particularly designed for retreatment, seems to be free from problems during retreatment procedures.[4] Tactile sensitivity was increased by the low torque motor and reduced the risk of file separation as well as provided better control of rotary instrumentation, which might have contributed to the lack of rotary file fracture in the present study.[16]

The root canals were filled using the lateral compaction technique before retreatment. This technique has been used in many retreatment studies.[15,16,29] In previous studies, the removal of filling was performed after a period ranging from 7 days to 1 year.[6,7,30] In this study, the removal of filling material was accomplished after the one month. A protocol was based on methods developed by Takahashi et al. and Huang et al.[15,31]

The amount of remaining filling material was evaluated by longitudinal cleavage and quantitative analysis in this study. However in the quantitative analysis, the average score of one experimental group does not always reflect the original data. This technique minimizes subjectivity due to the use of a scoring system based on scales.[17,19]

CONCLUSION

Under the experimental conditions of this study, all instrumentation techniques left residual filling material in apical third of the root canals. There was no significant improvement in the removal of filling material using D-RaCe system when compared with the other rotary file systems. Retreatment systems proved to be faster than hand instrumentation in removing root filling materials. There was no significant difference among the groups in terms of the amount of apically extruded debris. Further studies are necessary to evaluate the effectiveness of this system in curved canals and in canals filled with different techniques.

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