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http://dx.doi.org/10.17096/jiufd.97431 ORIGINAL RESEARCH

EFFICACY OF PROTAPER NEXT AND PROTAPER UNIVERSAL RETREATMENT SYSTEMS IN REMOVING GUTTA-PERCHA IN CURVED ROOT CANALS DURING ROOT CANAL RETREATMENT

Kök Kanal Tedavisi Yenilenmesi Sırasında ProTaper Next ve ProTaper Universal Retreatment Sistemlerinin Güta-Perka Uzaklaştırma Etkinliği

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ABSTRACT

Purpose: The aim of this study was to compare the cleanliness of root canal walls after retreatment using ProTaper Next (PTN), ProTaper Universal Retreatment (PTR) nickel-titanium (NiTi) systems and Hedström hand files in curved mesial canals of mandibular molar teeth and the time required for gutta-percha and sealer removal.
Materials and Methods: Ninety mandibular molar teeth with curved mesial roots were instrumented up to #35.04 with Mtwo NiTi rotary instruments and obturated using the continuous wave of condensation technique. Removal of gutta-percha and sealer was performed using one of the following: PTN and PTR NiTi systems and Hedström hand files. Samples were placed on the VistaScan phosphor plates in the mesio-distal direction and the radiographs were taken. The digital radiographs were analyzed using AutoCAD software. Also, the total time required for gutta-percha removal was calculated by a chronometer.
Results: The total retreatment time was significantly shorter in the PTN and PTR groups compared with the manual group ($p<0.05$). There was a significant difference between the groups according to the total residual gutta-percha and sealer ($p<0.05$). The PTN and PTR groups left significantly less gutta-percha and sealer remnant than the manual group ($p<0.001$).
Conclusion: Within the limitations of this study, the PTN and PTR groups showed less residual gutta-percha and sealer than the manual group. The NiTi rotary systems were significantly faster than the manual group in the time required for gutta-percha and sealer removal.

Keywords: ProTaper Next; ProTaper Universal; retreatment; curved Canals; endodontics

ÖZ

Amaç: Bu çalışmanın amacı ProTaper Next, ProTaper Universal Retreatment NiTi sistemleri ve Hedström el eğeleri ile kök kanal tedavisi yenilenmesi sonrasında mandibular molar dişlerin eğri mesial kök kanal duvarlarının temizliğinin değerlendirilmesi ve güta-perka ve sealer uzaklaştırmak için geçen sürenin hesaplanmasıdır.
Gereç ve Yöntem: Doksan adet eğri mesial köke sahip mandibular molar dişin apikali #35.04 olacak şekilde genişletilerek, devamlı ısı yöntemi ile dolduruldu. Kök kanal tedavisi yenilenmesi işlemi PTN ve PTR NiTi sistemleri ve Hedström el eğeleri ile yapıldı. Örnekler VistaScan fosfor plaklar üzerine yerleştirilerek mesio-distal yönde radyografileri alındı. Dijital radyografiler AutoCAD programı kullanılarak analiz edildi. Ayrıca kök kanal tedavisi yenilenmesi için gerek süre kronometre yardımıyla hesaplandı.
Bulgular: Kök kanal tedavisi yenilenmesi için gereken toplam süre PTR ve PTN gruplarında manuel gruba göre istatistiksel olarak kısaydı ($p<0.05$). Gruplar arasında arda kalan toplam güta-perka ve sealer açısından istatistiksel olarak anlamlı fark vardı ($p<0.05$). PTN ve PTR grupları istatistiksel olarak Hedström el eğesi grubundan daha az güta-perka ve sealer bırakmıştır ($p<0.001$).
Sonuç: Çalışmamızın sınırları dâhilinde PTN ve PTR grubunda el eğesi grubundan daha az gutta-perka ve sealera rastlanılmıştır. NiTi eğe gruplarının el eğesi grubuna göre gutta-perka ve sealer uzaklaştırılmasında daha hızlı olduğu tespit edilmiştir.

Anahtar kelimeler: ProTaper Next; ProTaper Universal; retreatment; eğri kanallar; endodonti

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Introduction

In root canal retreatment, removal of all filling materials from the root canals has a crucial importance in respect of three-dimensional cleaning, shaping and obturation of the root canal system (1). During retreatment, residual gutta-percha and sealer can remain in the root canal. Then the success of the retreatment can become questionable because of the remnant's potential microorganism load (2). In curved root canals, the removal of filling materials and further cleaning and shaping are more difficult than in straight canals and more likely to cause instrument distortion or breakage. Nowadays, in the endodontics practice, some nickel titanium (NiTi) rotary instrument systems introduced for the shaping of the root canals are also used in the removal of the root canal filling materials during retreatment. ProTaper Universal Retreatment (PTR; Dentsply, Maillefer, Ballaigues, Switzerland) is a rotary instrument system consisting of 3 NiTi files and developed for the removal of the filling materials from the root canals. Each file has a different length, diameter and taper. PTR D1 file is 16 mm long, has an apical diameter of 0.30 mm and a taper of 0.09. It is used for the initial penetration into the mass of gutta-percha within the canal. PTR D2 file, with its length of 18 mm, apical diameter of 0.25 mm and taper of 0.08, is used for the removal of the filling materials from the middle third. On the other hand, PTR D3 is 22 mm long, has an apical diameter of 0.20 mm and a taper of 0.07 and used for the removal of the filling material from the apical third. A recently introduced NiTi rotary instrument called the ProTaper Next (PTN; Dentsply, Maillefer, Ballaigues, Switzerland) features a rectangular crosssectional design and an asymmetric rotation that works on a continuous rotation motion and is manufactured from M-Wire alloy. According to the manufacturer, the rotation combined with unique offset design generates an enlarged space for debris removal (3). A literature review revealed that there are only a few previous studies comparing the cleanliness of root canal walls after retreatment using the PTN NiTi system (4, 5). Therefore, the aim of this study was to compare the cleanliness of root canal walls after retreatment using PTN and PTR NiTi systems and Hedström hand files in the mesial canals of curved mandibular molar teeth and the time required for gutta-percha and sealer removal. The null hypothesis was that there would be no significant difference between the cleanliness of root canal walls after retreatment using the two NiTi systems and Hedström files.

Materials and Methods

Selection of the samples

After the ethics committee approval (Ondokuz Mayıs University Clinical Research Ethics Committee no. B.30.2.ODM.0.20.08/1561), 90 mandibular molar teeth with curved mesial roots, which were extracted due to periodontal reasons, were chosen for the present study. The residues of soft and hard tissue around the teeth were removed mechanically. After the distal roots of the teeth were removed, occlusal abrasion was carried out until the tooth length reached 18 mm. Radiographic examination was carried out in mesio-distal and bucco-lingual directions. After the radiographic evaluation, teeth with calcification, previous canal treatment, internal and/or external resorption, fractured and immature roots were excluded from the study. The mesial roots with curvatures ranging between 20°-30° and curvature radii less than 12 mm were included in the study (6, 7). The chosen teeth were stored in distilled water with a temperature of 4°C before the experiment.

Root canal preparation

The working length (WL) of each canal was determined to be 1 mm short of the length of a size 10 K-file (Dentsply Maillefer) that was visible through the apical foramen. According to the manufacturer instruction, preparation of the root canal was carried out with the Mtwo rotary instrument system (VDW, Munich, Germany) using #10.04, #15.05, #20.06, #25.06, #30.05 and #35.04 files sequentially with a torque-controlled endodontic motor (X-Smart; Dentsply Maillefer, Ballaigues, Switzerland). After each file, the canals were irrigated with 2 ml 5.25% NaOCl. In order to remove the smear layer, 2 ml 17% EDTA for 2 min followed by 2 ml 5.25% NaOCl were used in the final irrigation of the roots.

Root canal obturation

The root canals were obturated with gutta-percha and the AH Plus (Dentsply DeTrey, Konstanz, Germany) root canal sealer using the Calamus 3D Obturation System (Dentsply Maillefer, Ballaigues, Switzerland) and the warm vertical compaction technique. The root canal filling quality was checked with radiographs taken from the mesio-distal and

bucco-lingual directions. Samples with insufficient and/or inhomogeneous root canal fillings were replaced. Following restoration with a temporary filling material (Cavit-G; 3M Espe, Seefeld, Germany), the samples were incubated in 37°C and fully saturated conditions for 14 days, in order to enable the complete setting of the sealer in the root canal.

Retreatment technique

During the retreatment procedure, no chemical solvent was used. Furthermore, no additional instrument was used for the removal of gutta-percha in the coronal region of the roots. Each set of file was used for the retreatment procedure of three samples. All retreatment procedures were carried out by one operator. The roots were randomly allocated into three groups consisting of 30 teeth and the following retreatment procedures were performed.

Group 1: ProTaper Next (PTN) **:** In this group, the retreatment procedure was carried out with the X3 (#30.07) and X2 (#25.06) files of the PTN rotary instrument system according to the crown-down technique. For gutta-percha removal, PTN X3 file was used in the coronal third of the root and PTN X2 file in the apical third with the torque-controlled endodontic motor operated at a speed of 300 rpm and a torque of 200 g cm^{-1}.

Group 2: ProTaper Universal Retreatment (PTR): In this group, the retreatment procedure was carried out with the D1 (#30.09), D2 (#25.08) and D3 (#20.07) files of the PTR rotary instrument system according to the crown-down technique. File PTR D1 was used in the coronal third, PTR D2 in the middle third and PTR D3 in the apical third for gutta-percha removal. In accordance with the manufacturer's instruction, on the torque-controlled endodontic motor, a speed of 550 rpm and a torque of 200 g cm^{-1} were selected for PTR D1 and D2 files. For the PTR D3 the selected speed and torque was 250 rpm and 150 g cm^{-1}.

Group 3: Hedström Files (Manual): In this group, retreatment procedure was carried out with H-type files #40, #35, #30, #25 and #20 according to the crown-down technique. Files were inserted through to the apical section with a rotation of one-quarter turn and the gutta-percha was removed with drawing the files back towards the coronal direction. The roots were irrigated with 2 ml 5.25% NaOCl after each file change. 5 ml 5.25% NaOCl and 5 ml 17% EDTA solutions were used for the final irrigation of the root canals. In all groups, the retreatment procedure was finalized after no debris of the filling material was visible on the files and/or no visible debris of the filling material was observed anymore during the retreatment procedure.

Evaluation of gutta-percha removal

Samples were placed on the VistaScan phosphor plates (Durr Dental, Bietigheim- Bissingen, Germany) in the mesio-distal direction. The distance between the X-ray source and film was set at a constant distance of 4 cm. Radiography was carried out with an irradiation time of 70 kVp/2 seconds. After the irradiation, the phosphor plates were immediately scanned in the VistaScan scanner with high resolution (40µm, 12,5lp/mm) and the images were recorded in 8-bit contrast depth with BMP file format. Two different observers identified the residual filling materials in the root canals. If the observers could not agree, the images were re-evaluated to enable a consensus. The obtained images were analyzed with AutoCAD (Autodesk, San Rafael, CA, USA) software and the areas of residual filling materials in the root canals were calculated in units of mm^2 (Figure 1).

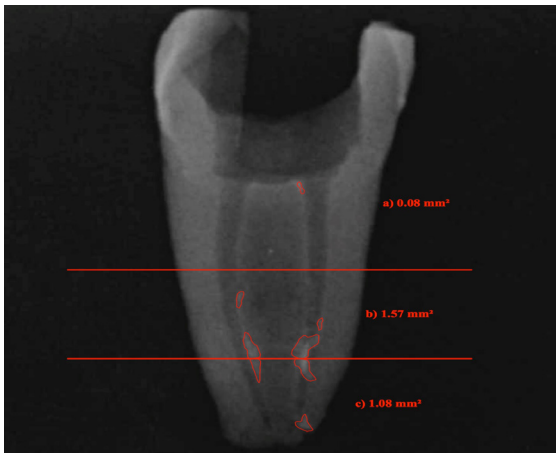

Figure 1. *Measurement of residual gutta-percha and sealer via AutoCAD software.*

Time required for gutta-percha removal

A chronometer was used for the calculation of the time required for the removal of gutta-percha. The total time was defined as the time between the start of the insertion of the first file into the root canal and the access to the working length. The chronometer was started with the insertion of the file into the canal and stopped with its removal from the canal.

Statistical analysis

Data was found to be normally distributed. Therefore, one-way analysis of variance (ANOVA) was used to analyze the differences between the groups. Statistical analysis for the area of the residual filling material was performed using two-way ANOVA and Duncan's test with a significance level of $p<0.05$.

Results

The results for total retreatment time and the mean area of residual gutta-percha and sealer are shown in Table 1. The total retreatment time was significantly shorter in the PTN (61.73 ± 15.81) and PTR (57.16 ± 14.28) groups compared to the Manual (101.98 ± 16.86) group ($p<0.001$). There was no statistically significant difference between PTN and PTR groups ($p>0.05$). There was a significant difference between the groups in the removal of the gutta-percha and sealer according to the total residual gutta-percha and sealer ($p<0.001$). The PTN (5.68 ± 1.15) and PTR (5.50 ± 1.16) groups left significantly less gutta-percha and sealer remnant than the Manual (7.10 ± 1.62) group ($p<0.001$). There was no statistically significant difference between PTN and PTR groups ($p>0.05$). When comparing the regions, the coronal third for all groups had significantly less residual gutta-percha and sealer when compared to the middle and apical thirds ($p<0.001$). There was also a significant difference between middle and apical thirds. In the apical thirds of all groups, there were more residual gutta-percha and sealer than the middle and coronal thirds. The difference was also statistically significant ($p<0.001$). There were no procedural errors in the PTR and Manual groups. However, 2 PTN X2 files fractured during retreatment procedures in the PTN group; these samples were replaced with new ones.

Table 1. *Mean and standard deviations of residual gutta-percha and sealer on canal walls (mm^2) and total time (sec) required for retreatment.*

Group	Apical	Middle	Coronal	P-value	Total	Time
ProTaper Next	6.79 ± 0.61^{ax}	5.75 ± 0.72^{bx}	4.50 ± 0.66^{cx}	< 0.001	5.68 ± 1.15^{x}	61.73 ± 15.81^{x}
ProTaper Universal	6.54 ± 0.95^{ax}	5.54 ± 0.70^{bx}	4.42 ± 0.66^{cx}	< 0.001	5.50 ± 1.16^{x}	57.16 ± 14.28^{x}
Manuel	8.55 ± 1.02^{ay}	7.43 ± 0.96^{by}	5.34 ± 0.76^{cy}	< 0.001	7.10 ± 1.62^{y}	101.98 ± 16.86^{y}
P-value	<0.001	<0.001	<0.001		<0.001	<0.001

**Different superscript letters indicate significant differences between groups (^{abc}; for rows and ^{xy}; for columns)*

Discussion

Gutta-percha is a filling material used commonly for the obturation of the root canals. Although it can be removed easily from canals of large and straight roots during retreatment, it is relatively difficult to remove it from the curved root canals. Regarding the literature, retreatment studies mostly focused on teeth with single and straight roots (8-10). There are only a few retreatment studies conducted with curved root canals (11-13). Therefore, the mesial roots of mandibular molar teeth with curved canals were used in the present study. In order to standardize the teeth, the roots were abraded up to 18 mm. In some studies, it was reported that vertical compaction provides a more homogeneous root canal filling compared with single cone and lateral compaction. Therefore, in the present study the vertical compaction technique was used for the obturation of the root canals (14, 15). Regarding the current literature, several methods such as micro-tomography (16), longitudinal sections (5) and radiography (17) were used for the evaluation of the root canal materials. In the present study, the residual gutta-percha and sealer were analyzed with the digital radiography similar to the method used in the study conducted by Gergi and Sabbagh (11). All samples were evaluated using the radiographic images obtained after retreatment using the AutoCAD software. Radiological method has the known restrictions like enabling only two-dimensional evaluation of a three-dimensional structure and limited detection of small volumes of the remnants. We believe that we minimized these disadvantages and obtained standardization through using the same technique for all samples and the evaluation of the residual materials in the radiographic images by two different observers. However, the results of the study might have been affected by the motion and loss of the gutta-percha and sealer during cutting if the longitudinal sectioning method was used (9, 16, 18).

In the present study, curved mesial root canals of mandibular molars were used thus the radiological method was preferred in order not to damage the samples. It is well known that the enlargement of the apical diameter during the retreatment procedure decreases the amount of the residual filling material (19). However, an additional enlargement of the root canals might decrease the resistance of the root canals due to the remaining dentin thickness and might cause vertical root fractures (20). Therefore, in our study, the apical diameters of the roots were not increased. In the present study, no solvents were used with the NiTi rotary instruments. Although, with the help of friction, the solvents enable easy access to the working length due to the softening of gutta-percha, the softened gutta-percha might slip off to the areas of the root canal, which are hard to access and clean (21). Abrasion, distortion and microcracks might occur on the surfaces of the NiTi files with repeated use. As a result of this, their cutting efficiency is diminished and they become more prone to break (13, 22). Therefore, in the present study during the retreatment procedures, every new file set was discharged after it was used for 3 samples (23). The results of the present study showed that PTR and PTN groups left significantly less gutta-percha and sealer on the root walls compared with the manual group ($p<0.001$). Therefore, the null hypothesis in the present study was rejected. There are other studies in the literature showing that NiTi rotary instruments clean the root canal walls better than the manual files (24-28). The comparison of the removal time of gutta-percha and sealer between the manual group and PTR and PTN groups displayed that the retreatment time in the manual group was significantly longer than the ones in the PTR and PTN groups. This result was in accordance with other studies in the literature (15, 24).

In the present study, none of the NiTi rotary instruments achieved a total cleaning of gutta-percha and sealer found in the root canals. This finding showed similarity with the results of the studies using different systems, instruments and methods (23, 29, 30). According to the results of our study, the manual group left significantly more gutta-percha and sealer compared with other groups (PTR and PTN). The easier adaptation of the NiTi files to the curved canals due to their flexibility, their larger taper and an easier removal of the softened gutta-percha due to their rotary motion principle might be considered as the reasons for this finding. In their study, Colaco and Pai (24) compared the manual files with the PTR and D-RaCe (FKG Dentaire, La Chaux-de-Fonds, Switzerland) NiTi rotary instrument systems and found out that manual group left significantly more remnants of gutta-percha, which confirms our results. Contrarily, Ünal *et al.* (17) reported that the manual group left significantly less remnants of gutta-percha than the PTR group in the teeth with curved roots. We believe that the reasons for this difference in the results are the usage of Gates-Glidden drills and gutta-percha solvent for the removal of the coronal gutta-percha. Giuliani *et al.* (26) compared the manual files, ProFile (Dentsply Maillefer, Ballaigues, Switzerland) and PTR NiTi files and reported that the PTR group left significantly less remnants of gutta-percha compared with other groups. In a confirming study conducted by Saad *et al.* (27), the retreatment efficacy of the ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland) NiTi rotary instrument system was evaluated. They reported that the ProTaper Universal group left significantly less remnants of gutta-percha compared with the manual group. However, Gergi and Sabbagh (11) reported that there was no statistical difference between the ProTaper Universal and manual groups regarding the remnants of filling material after retreatment. It is believed that the PTR group provides a better cleaning of the canal walls because of its large taper. In our study, the PTN group left significantly less remnants of gutta-percha than the manual group. The new offset design of the PTN and the more effective removal of the debris and/or gutta-percha from the root canals due to the M-Wire alloy (3) might be the reason for this result. Most of the debris of gutta-percha and sealer was detected in the apical third and the least of it in the coronal third in all groups, which confirms the previous studies (16, 17, 31). Contrarily Nevares *et al.* (4) compared the retreatment efficacy of PTN and Reciproc (VDW) in mesial canals of mandibular molar teeth via micro-CT. They found that in the apical third there were fewer remnants than the other thirds in both groups. This difference in the results might be due to the different obturation techniques used in the present study and the study of Nevares *et al.* Generally, the anatomic variations in the apical third make the cleaning of this region relatively difficult. Besides this, the curvatures in the root canals might prevent the direct access of the files and their effective functioning on all walls of the root canal (18). It is believed that the reason for the relatively fewer remnants of gutta-percha and sealer at the coronal third of the canal is the brushing movement used with the NiTi and manual files.

Conclusion

Within the limitations of this study, the PTN and the PTR groups showed less residual gutta-percha and sealer than the manual group. PTR was better than PTN in terms of cleaning ability as well as time taken, but the difference was not statistically significant. The NiTi rotary systems were significantly faster than the manual group in the time required for gutta-percha and sealer removal.

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Conflict of interest
None declared.

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