

COMPARATIVE EVALUATION OF THE EFFICIENCY OF DIFFERENT FILES IN REMOVING GUTTA-PERCHA FROM CURVED ROOT CANALS DURING ROOT CANAL RETREATMENT

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ABSTRACT

Present study aimed to compare the cleanliness of root canal walls after using ProTaper Universal Retreatment, NRT GPR nickel-titanium systems and Hedstrom hand files in curved root canals during root canal retreatment.

Thirty simulated canals with a 30-degree curvature in resin blocks were instrumented up to #30.04 with ProTaper Next nickel-titanium rotary instruments and obturated using gutta percha and AH plus root canal sealer. The specimens were randomly divided into three groups (n=10 each). Removal of gutta-percha was performed with the following devices and techniques: Group 1 (H-files), Group 2 (ProTaper Universal Retreatment), and Group 3 (NRT GPR). The retreatment time was recorded for each specimen using a stopwatch. After radiographing in buccolingual and mesiodistal directions, the amount of remaining gutta-percha in the roots was quantified using Image J 2X software. Apically extruded debris was weighted using analytical balances. Statistical analysis was performed with one-way ANOVA test.

The volume of remaining filling material was significantly less in H-files and NRT GPR groups than in ProTaper Universal Retreatment group ($p<0.05$). The total retreatment time was significantly shorter in the ProTaper Universal Retreatment and NRT GPR groups compared with the manual group ($p<0.05$). NRT GPR files were associated with significantly less extruded debris than with the ProTaper Universal Retreatment ($p<0.05$).

Neither of the studied instruments completely removed the root filling material. NRT GPR files left less gutta-percha and sealer than ProTaper Universal Retreatment and H-files. The nickel-titanium rotary systems were significantly faster than the manual group in the time required for gutta-percha removal.

KEYWORDS: curved canals, gutta-percha removal, NiTi, NRT GPR, ProTaper Universal retreatment.

INTRODUCTION

One of the goals of endodontic treatment is that adequate filling of the root canal is achieved after its preparation. In cases where endodontic treatment failure necessitates retreatment, the success of treatment largely depends upon efficient removal of root filling material, minimal apical debris extrusion and use of effective armamentarium.

As the most effective treatment method of endodontic and periapical periodontal disease, the reported success rates of root canal therapy vary from 53%~95% [Feng J et al., 2004]. Long term success of root canal therapy depends on complete debridement and compact filling of the entire root canal system. The root canal pathogens persist if the primary treatment is ineffective and eventually lead to endodontic failure [Joseph M et al., 2016]. Root canal retreatment or apical surgery is then performed subsequently in order to retain the teeth. The goal of the root canal retreatment is to re-establish healthy periapical tissues after inefficient pre-treatment or re-infection of the filled root ca-

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nals because of coronal or apical leakage [Akpınar K et al., 2012]. Complete removal of the filling material from the root canals is a crucial step to the cleaning and disinfection of the root canal system in the retreatment process [Saad A et al., 2007].

Schäfer E. and co-authors studied the bending of total 1163 root canals of 700 teeth in vitro other than the third molars. The results showed that 84% of all the teeth analyzed possessed curved root canals [Schäfer E et al., 2002]. In curved root canals, the removal of filling material and further cleaning are more difficult than in straight canals and more likely to cause instrument deformation and fracture.

Removal of filling material in the root canal is a time-consuming process, but it is considered that the most efficient way to achieve this is to employ NiTi rotary instruments in root canal retreatment. Nowadays, hand instruments, NiTi rotary instrument systems, ultrasonic instruments and etc. can all be used in root canal retreatment [Friedman S et al., 1990; Farge P et al., 1998].

ProTaper Universal Retreatment (Dentsply Maillefer, Switzerland) is a rotary instrument system developed for the removal of the filling material from the root canals. The files in this system have a convex triangular cross section and progressively increasing tapers. The ProTaper Universal Retreatment system consists of three instruments (D1, D2, and D3). D1 (size 30, 16 mm length, 0.09 taper) is used for the removal of the filling material from the coronal, third which has an active tip for penetration in the gutta-percha. D2 (size 25, 18 mm length, 0.08 taper) is used for the removal of the filling material from the middle third. D3 (size 20, 22 mm length, 0.07 taper) is used for the removal of the filling material from the apical third.

A recently introduced new rotary file system called the NRT GPR (Mani Inc., Japan) is specially designed for gutta-percha removal from the root canals. The working section is provided with a deep spiral groove and the crest of the blade gradually becomes wider and deeper, which increases the discharge of the gutta-percha. It has four instruments: 1S, 2S, 3N and 4N. 1S (size 70, 16 mm length, 0.04 taper) and 2S (size 50, 18 mm length, 0.04 taper) are stainless steel files, which are used

for gutta-percha removal from the coronal and middle third of the canal. The 3N (size 40, 21 mm length, 0.04 taper) and 4N (size 30, 21 mm length, 0.04 taper) are NiTi files which are used for the apical third of the canal.

The aim of this study was to compare the efficacy of ProTaper Universal Retreatment system, NRT GPR file system and H-files in gutta-percha removal from the curved canals during root canal retreatment.

MATERIALS AND METHODS

Specimen preparation and filling: A total of 30 simulated canals with a 30-degree curvature in resin blocks (Musen, Xuzhou, China; canal length = 17mm) were used in this study. Working length was set at 16.5 mm and the canals were instrumented with ProTaper NEXT (Dentsply Maillefer, Ballaigues, Switzerland) to a size 30/.06 taper according to the instructions. The instruments were driven using a torque-controlled motor (Dentsply Maillefer, Ballaigues, Switzerland) set to 250 rpm using a gentle in-and-out motion.

The canals were irrigated with 2 ml of distilled water during the shaping and cleaning intervals. After preparation, canals were finally rinsed with 5 ml distilled water and dried with absorbent paper points. The canals were then obturated with gutta-percha and the AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) using the warm vertical compaction technique. Subsequently the access cavities were sealed with temporary filling material (Cavition; GC Corporation, Tokyo, Japan). The specimens were stored at 37°C in 100% humidity for seven days to allow complete setting of the sealer.

Retreatment technique: The specimens were randomly divided into three groups of 10 specimens each. After the temporary filling material was removed from the access cavity using a Gates-Glidden bur (size 2), 0.1 ml of desocclusol was placed for 2 minutes into the access cavity to soften the gutta-percha. Each canal was operated in a blinded manner, masked with a rubber barrier and placed over the petri dish to collect the apically extruded debris.

Group 1 (H-files): #30, #25 and #20 size of H-

files (Dentsply Maillefer, Ballaigues, Switzerland) were used in a crown down manner using circumferential quarter-turn push-pull filing motion to remove gutta-percha and sealer from the canals till the working length.

Group 2 (ProTaper Universal Retreatment): All the three ProTaper Universal Retreatment files were used in crown down technique, until the working length was reached using a brushing action against the canal walls. The D1 ProTaper file was used to remove the filling material from the coronal third of the canal. The D2 ProTaper file was used in the middle third and D3 was used in the apical third until the working length was reached. The three retreatment files were used at a speed of 500 rpm and a torque of 300 g/cm.

Group 3 (NRT GPR): NRT GPR files were used in crown down technique to remove the filling material in the root canal according to the instructions. 2S file was used in the coronal two third of the root canal and 4N file was used to remove the filling material near the apex about 1-2 mm. H file was then used to remove the remaining filling material till the working length.

During retreatment, root canals were irrigated with 2 ml of distilled water after each file preparation. The retreatment procedure was considered complete when no debris of the filling material was observed on the instruments and the canal walls were smooth. Breakage/deformation of the instrument was recorded. All retreatment procedures were carried out by one operator. Each file was discarded after being used five times.

Evaluation: The amount of remaining Gutta Percha was evaluated. The specimens were photo documented with digital X-ray photographs in buccolingual and mesiodistal directions. The images were analyzed with Image J 2X (Rawak Software Inc., Stuttgart, Germany) software and the value of the residual filling material on the canal walls was represented by the number of pixels (Fig. 1).

In order to value the residual filling material on the canals walls, the brightness and contrast of the figures were adjusted in the software to eliminate the visualization of root canal wall. Then the visible residual material in root canals were measured and inverted into digital pixels.

A stopwatch was used to record the total time

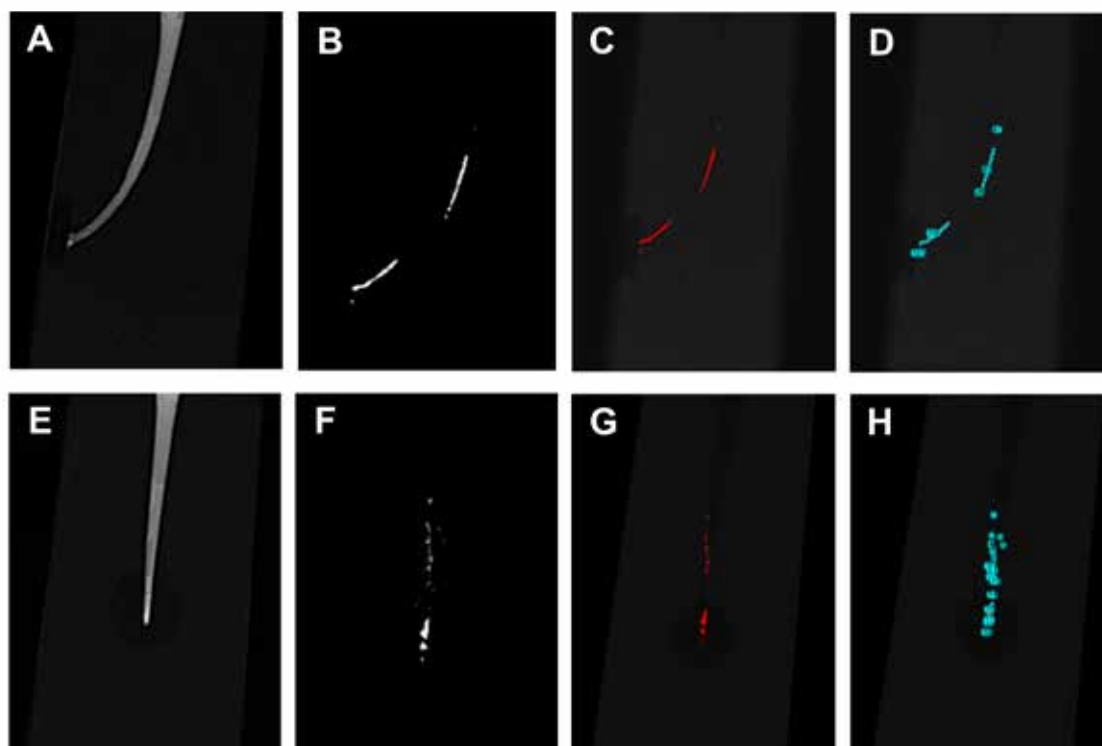


FIGURE 1. Assessment of residual gutta-percha using Image J 2X software in buccolingual (A, B, C, D) and mesiodistal (E, F, G, H) directions. (A, E) After root canal obturation and (B, F) the residual filling material, in the root canal recorded by digital X-ray photograph (C, G) Defining the outline of remaining gutta-percha and (D, H) measuring the surface area by Image J 2X

required for each group. The total time was considered to be the time elapsed from the moment the instruments were first entered in the canal to the end of the retreatment, excluding the time required for the irrigation and instrument replacement.

The amount of debris was measured using an analytical balance. The debris of the apical part was collected in a petri dish by washing the apex with 1 ml distilled water. The petri dishes were stored in an incubator at 68°C for 3 days to evaporate the moisture before weighing the dry debris. The weight of debris was determined by subtracting the weight of the petri dishes from the weight of the petri dishes containing dried debris.

Statistical analysis: Data was analyzed by IBM SPSS statistics for Windows, version 20.0, using one-way ANOVA in order to compare the differences between the groups with a significance level of $p < 0.05$.

RESULTS

The results of the amount of remaining root canal filling material are presented in table 1 and figure 2. The ProTaper Universal Retreatment groups had significantly more residual gutta-percha and sealer compared to the H-files and NRT GPR files from either buccolingual or mesiodistal view ($p < 0.05$). There was no statistically significant difference between H-files and NRT GPR files ($p > 0.05$). The residual fillings of root canal wall were mostly located in one third of the apex (Fig. 3).

The time required to remove the filling material is reported in table 2 and figure 4. The ProTaper Universal Retreatment files and NRT GPR files were significantly faster than H-files ($p < 0.05$). There was no statistically significant difference

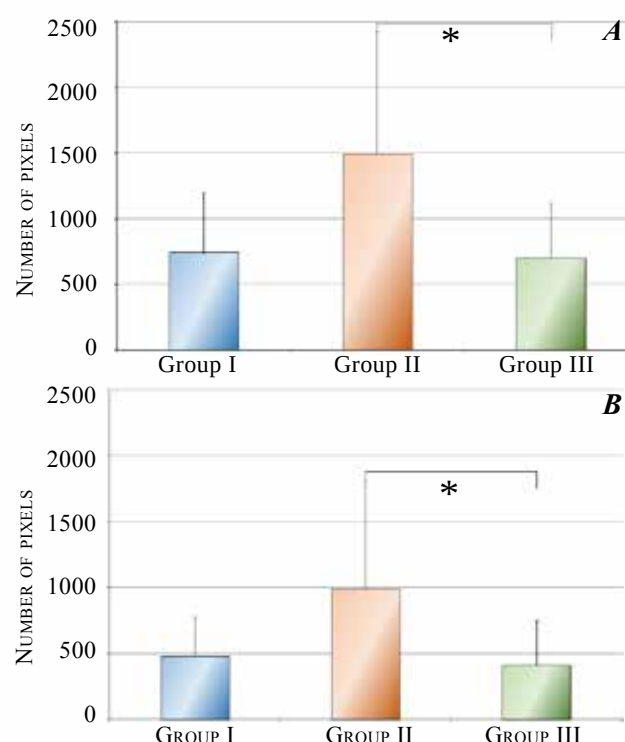


FIGURE 2. Residues of buccolingual (A) and mesiodistal (B) directions root canal fillings in each group.

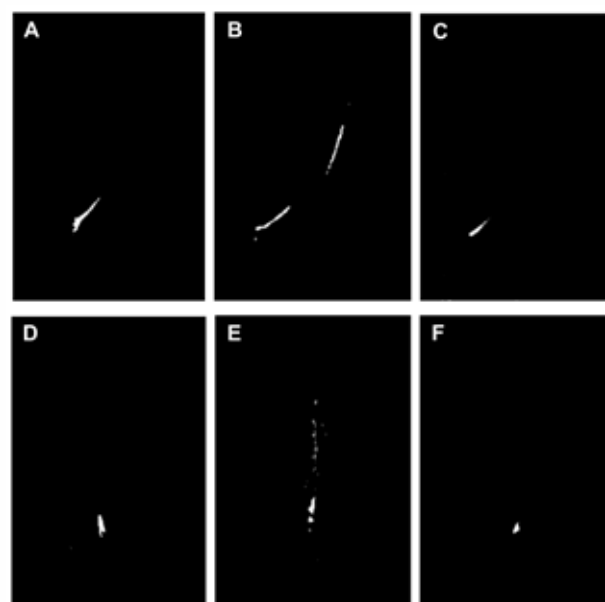


FIGURE 3. The residual fillings in buccolingual direction (A, B, C), mesiodistal direction (D, E, F) in each group showed that most of the residual fillings in root canal wall were located in one third of the apex. The images of residual root fillings after root canal retreatment in H file group (A, D), ProTaper retreatment system group (B, E) and Mani GPR group (C, F).

TABLE 1.

The amount of remaining filling material on canal walls in 3 groups ($\bar{x} \pm SD$, $n=10$)

Groups	Buccolingual	Mesiodistal
H-files	744.40±453.41	482.00±297.73
ProTaper Universal Retreatment	1494.60±987.8	991.80±826.47
NRT GPR	702.80±414.59	412.00±335.62

NOTE: Values are expressed as the number of pixels.

TABLE 2.

Time required to removal the filling material and Weight of apically extruded debris in 3 groups ($\bar{x} \pm SD$, n=10)

Groups	Time	Apically extruded debris (mg)
H-files	1066.80 $\pm$ 268.06	0.2 $\pm$ 0.1
ProTaper Universal Retreatment	252.00 $\pm$ 108.83	0.3 $\pm$ 0.2
NRT GPR	266.90 $\pm$ 91.37	0.1 $\pm$ 0.07

between ProTaper Universal Retreatment and NRT GPR files ($p > 0.05$).

The weights of the extruded debris are shown in table 2 and figure 5. The NRT GPR files produced significantly less debris than the ProTaper Universal Retreatment ($p < 0.05$). There was no statistically significant difference between H-files and NRT GPR files ($p > 0.05$). There was also no statistically significant difference between H-files and ProTaper Universal Retreatment files ($p > 0.05$).

DISCUSSION

The complete removal of root filling material is the most crucial step of root canal retreatment for further preparation and disinfection of the root canal system [Stabholz A, Friedman S, 1988]. According to the reports, most previous studies in endodontic retreatment focused on the straight root canals of single rooted teeth [Cheung G, 1996; Ferreira J et al., 2001; Schirrmeister J et al., 2006], while few retreatment studies experimented with

curved root canals [Rödig T et al., 2014; Sağlam BC et al., 2014]. As mentioned earlier, Schäfer E. and co-authors studied the bending of total 1163 root canals of 700 teeth in vitro other than the third molars, the results showed that 84% of them were curved root canals [Schäfer E et al., 2002]. It is reported that the usage of nickel titanium rotary files during preparation may cause apical offset and failure in clearing the walls at the curvature of the root canal. In addition, the operating view of the canals is limited by the curvature, even with the use of an operating microscope [Kunert G et al., 2010]. Since it is relatively difficult and arduous to remove the filling material from curved root canals, it is necessary and of significance to assess the retreatment efficacy in curved root canals. The aim of the present study was to compare the cleanliness of root canal walls after retreatment using ProTaper Universal Retreatment, NRT GPR nickel-titanium (NiTi) systems and Hedstrom hand files in curved root canals.

Simulated curved canals in resin blocks are widely used in the evaluation of treating varied root canal formations with different instruments [Hülsmann M et al., 2005]. In our study, simulated curved canals in resin blocks were used to standardize the samples in order to obtain reliable results by comparison after eliminating variables caused by root canal bending patterns observed in actual teeth in vitro/in vivo.

Several methods have been used to evaluate the remaining filling material in the root canals, such as sagittal cleavage, transparent specimen, radiography, micro-tomography and so on. However, in

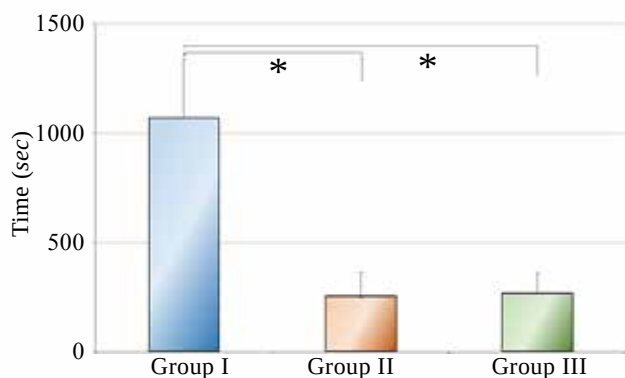


FIGURE 4. Time required to removal the filling material in each group

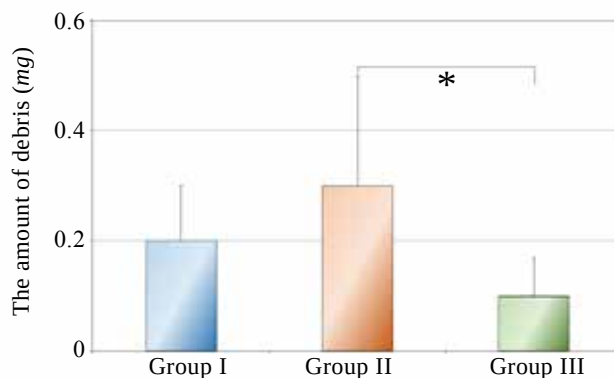


FIGURE 5. Weight of apically extruded debris in each group

the process of sagittal cleavage of the teeth, the destruction of teeth will inevitably lead to the loss of residual filler debris, affecting the accuracy of measurement [Dall'Agnol C et al., 2008]. As a non-destructive method, computer tomography scanning can accurately evaluate the amount of remaining filling material at the three-dimensional level. However, the cost of computer tomography scanning is relatively high and might cause large radiation exposure to the operator. Therefore, radiological method was selected in this study. Since the radiographic images only provide two-dimensional images of three-dimensional objects, in this experiment we took images in both the buccolingual and mesiodistal direction to reduce the error of the experimental results.

At present, the researches on root canal retreatment mainly focus on the contrast between the NiTi rotary system and the hand instruments. However, the experimental results are quite different due to the differences of experimental instruments, root canal shapes and evaluation techniques. Unal G. and co-authors [Unal G et al., 2009] showed that hand instruments performed better than NiTi rotary instruments in curved root canal retreatment; Gergi [Gergi R, Sabbagh C, 2007] showed no significant difference between hand instruments and NiTi rotary instruments in the retreatment of curved root canals. However, in the retreatment of straight root canals, Kasra [Karamifar K et al., 2017] found that the NiTi rotary instruments performed better than hand instruments. In the present study, there was significantly more residual filling material in the ProTaper Universal retreatment group compared to the H-files and NRT GPR files ($p < 0.05$), and the NRT GPR files had the least amount of the remaining filling material, while the results are in contrast to that of Joseph M. and co-authors [Joseph M et al., 2016]. The reason for this discrepancy may lie in the differences in root canal morphology and the operating method of the NRT GPR files. In the present study, 4N file was selected to remove the filling material 1~2 mm away from the apical foramen. A hand H-file was then used to remove the remaining 1~2 mm filling material from the apical part to prevent the step or

perforation. H-files are smaller in taper than rotary instruments and make it easier to approach the lateral canal walls [Fang Y et al., 2012], thus, the combination of NiTi rotary instruments and hand files can better remove the filling material in the apical part of the root canals. However, no group of instruments could completely remove the filling material in the root canals in the present study. Most of the residual filling material in all three groups remained concentrated in the apical third of the root canals, which is consistent with most of the findings by other researchers [Gergi R, Sabbagh C, 2007; Unal G et al., 2009; Ozyurek T, Ozsezer-Demiryurek E, 2017]. This could be due to anatomic variations at the apical third of the root canal and the curvature of the root canal, which enhances the difficulty of operation.

A large number of studies have shown that NiTi rotary instruments are more efficient than hand instruments during the root canal retreatment, and can significantly reduce the fatigue of the operators [Somma F et al., 2008; Ozyurek T, Ozsezer-Demiryurek E, 2017]. In this study, the ProTaper Universal Retreatment system took less time to remove the filling material than not only H files, but also NRT GPR files. Although both ProTaper Universal Retreatment files and NRT GPR files are NiTi rotary instruments, the combination of hand H-files with NRT GPR retreatment to remove the residual 1~2 mm gutta-percha in apex of the root canal is more time-consuming compared with the ProTaper Universal Retreatment system used alone.

Debris extruded through the apical foramen contains organic or inorganic residues, irrigant solutions etc., which are not conducive to the healing of apical lesions [Siqueira J, 2003; Seltrzer S, Naidorf I, 2004], and can lead to postoperative discomfort. In this study, the ProTaper Universal Retreatment extruded more debris than the H-file, which is consistent with the conclusion of Somma F. and co-authors [Somma F et al., 2008]. The NRT GPR extruded a minimal amount of debris. The reason may be the frictional heat and plasticization of gutta percha with the rotary instruments, whereas the deep helical grooves of the NRT GPR increase the elimination space of the softened gutta percha

and make it easier to roll it in the file blade edge resulting in less debris.

One ProTaper Universal Retreatment D3 file fracture was found in this study. Previous experiments have shown that taper is an important factor that affects the instrument's breakage [Unal G et al., 2009]. Therefore, the large taper of the ProTaper Universal Retreatment system may increase the risks of its fracture. As for the NRT GPR, it is hard to fracture it near the tip part, because the stress concentration does not occur due at the non-cutting tip [Joseph M et al., 2016]. NRT GPR is constructed so as to have only one cutting edge, which greatly reduces the possibility of file breakage. In addition,

the 3N and 4N of NRT GPR files are made of NiTi material with 5 mm of memory tips and better flexibility. The fracture at the neck of the file makes it more convenient to remove it from the root canal if inadvertently fracture occurs during preparation.

CONCLUSION

None of the retreatment group showed complete removal of the filling material in the root canal. The NiTi rotary instruments are faster than the hand files. The NRT GPR is better than the ProTaper Universal Retreatment system in its cleaning efficacy and minimizes apically extruded debris.

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REFERENCES

1. Akpınar KE, Alunbaş D, Kuştarıcı A. The efficacy of two rotary NiTi instruments and H-files to remove gutta-percha from root canals. *Med Oral Patol Oral Cir Bucal*. 2012; 17(3): e506-511
2. Cheung GS. Endodontic failures-changing the approach. *Int Dent J*. 1996; 46(3): 131-138
3. Dall'Agnol C, Hartmann MS, Barletta FB. Computed tomography assessment of the efficiency of different techniques for removal of root canal filling material. *Brazil Dent J*. 2008; 19(4): 306-312
4. Fang YY, Lin ZM, Chen JF. The effectiveness of manual and mechanical instrumentation for the retreatment of root canal. *J Pract Stomatol*. 2012; 28: 85-89
5. Farge P, Nahas P, Bonin P. In vitro study of a Nd:YAP laser in endodontic retreatment. *J Endod*. 1998; 24(5): 359-36
6. Feng J, Qi P, Guo F. Survey of the cause of endodontic revision and the difficulty of clinical management. *Journal of China-Japan Friendship Hospital*. 2004; 18: 207-209
7. Ferreira JJ, Rhodes JS, Ford TR. The efficacy of gutta-percha removal using profiles. *Int Endod J*. 2001; 34(4): 267-274
8. Friedman S, Stabolz A, Tamse A. Endodontic retreatment -- Case selection and technique. *Retreatment techniques. J Endod*. 1990; 16(11): 543-549
9. Gergi R, Sabbagh C. Effectiveness of two nickel-titanium rotary instruments and a hand file for removing gutta-percha in severely curved root canals during retreatment: An ex vivo study. *Int Endod J*. 2007; 40(7): 532-537
10. Hülsmann M, Peters OA, Dummer PMH. Mechanical preparation of root canals: shaping goals, techniques and means. *Endod Topics*. 2005; 10: 30-76
11. Joseph M, Ahlawat J, Malhotra A, Murali-Rao H, Sharma A, Talwar S. In vitro evaluation of efficacy of different rotary instrument systems for gutta percha removal during root canal retreatment. *J Clin Exp Dent*. 2016; 8(4): e355-e360
12. Joseph M, Ahlawat J, Malhotra A, Rao M, Sharma A, Talwar S. In vitro evaluation of efficacy of different rotary instrument systems for gutta percha removal during root canal retreatment. *J Clin Exp Dent*. 2016; 8(4): e355-e360
13. Karamifar K, Mehrasa N, Pardis P, Saghiri MA. Cleanliness of canal walls following

- gutta-percha removal with hand files, RaCe and RaCe plus XP-Endo finisher instruments: A photographic in vitro analysis. *Iran Endod J.* 2017; 12(2): 242-247
14. Kunert GG, Camargo Fontanella VR, de Moura AA, Barletta FB. Analysis of apical root transportation associated with ProTaper Universal F3 and F4 instruments by using digital subtraction radiography. *J Endod.* 2010; 36(6): 1052-1055
 15. Ozyurek T, Ozsezer-Demiryurek E. Efficacy of protaper NEXT and Protaper universal retreatment systems in removing gutta-percha in curved root canals during root canal retreatment. *J Istanbul Univ Fac Dent.* 2017; 51(2): 7-13
 16. Rödig T, Kupis J, Konietschke F, Dullin C, Drebenstedt S, Hülsmann M. Comparison of hand and rotary instrumentation for removing gutta-percha from previously treated curved root canals: A microcomputed tomography study. *Int Endod J.* 2014; 47(2): 173-182
 17. Saad AY, Al-Hadlaq SM, Al-Katheeri NH. Efficacy of two rotary NiTi instruments in the removal of gutta percha during root canal retreatment. *J Endod.* 2007; 33(1): 38-41
 18. Sağlam BC, Koçak MM, Türker SA, Koçak S. Efficacy of different solvents in removing gutta-percha from curved root canals: A microcomputed tomography study. *Aust Endod J.* 2014; 40(2): 76-80
 19. Schäfer E, Dies C, Hoppe W, Tepel J. Roentgenographic investigation of frequency and degree of canal curvatures in human permanent teeth. *J Endod.* 2002; 28(3): 211-216
 20. Schirrmeister JF, Hermanns P, Meyer KM, Goetz F, Hellwig E. Detectability of residual Epiphany and gutta-percha after root canal retreatment using a dental operating microscope and radiographs-an ex vivo study. *Int Endod J.* 2006; 39(7): 558-565
 21. Seltrzer S, Naidorf JJ. Flare-ups in endodontics: I. Etiological factors. *J Endod.* 2004; 30(7): 476-481
 22. Siqueira JF Jr. Microbial causes of endodontic flare-ups. *Int Endod J.* 2003; 36(7): 453-463
 23. Somma F, Cammarota G, Plofino G, Grande NM, Pameijer CH. The effectiveness of manual and mechanical instrumentation for the retreatment of three different root canal filling material. *J Endod.* 2008; 34(4): 466-469
 24. Stabholz A, Friedman S. Endodontic retreatment - case selection and technique Part 2: Treatment planning for retreatment. *J Endod.* 1988; 14(12): 607-61
 25. Unal GC, Kaya BU, Taç AG, Keçeci AD. A Comparison of the efficacy of conventional and new retreatment instruments to remove gutta-percha in curved root canals: An ex vivo study. *Int Endod J.* 2009; 42(4): 344-350