Original Article

In Vitro Comparison of Efficacy of Neolix and ProTaper Universal Retreatment Rotary Systems in Removal of Gutta-Percha Combined with Two Different Sealers

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KEY WORDS
Retreatment;
AH26;
Ni- Ti;

Received: October 2018;
Revised: April 2019;
Accepted: May 2019;

ABSTRACT

Statement of the Problem: The complete removal of filling material is an important step to regain access to the entire canal and facilitate the disinfection of the root canal system. Rotary nickel–titanium (NiTi) instruments systems have been proposed as an effective removal technique for root canal retreatment.

Purpose: The aim of this study was to evaluate the efficacy of Neolix rotary system and ProTaper Universal retreatment system in the removal of gutta-percha combined with two different sealers.

Materials and Method: In vivo study, eighty extracted human permanent mandibular premolars were prepared using the ProTaper Universal rotary system to an apical size 30 (F3/0.06). The specimens were randomly divided into 4 groups (n=20) and subsequently filled with lateral condensation of gutta-percha and two sealers: AH-26 and Sure-Seal Root. The teeth were stored for 4 weeks at 37°C and 100% humidity and then retreated by one of the following rotary systems: Neolix or ProTaper Universal retreatment system. Teeth were then grooved and monitored under a stereomicroscope with 8× magnification. The images were transferred to the computer and the amount of filling material that remained on the root canal walls was scored using AutoCAD 2017 version 1.1software. Results were analyzed using one-way analysis of variance test and post hoc Tukey-HSD test ($p< 0.05$).

Results: The mean percentage of remaining gutta-percha and sealer was significantly higher in apical third in all groups ($p< 0.01$). Post hoc Tukey test showed that there is significantly higher residual filling material in the group filled with gutta-percha and Sure-Seal Root sealer and retreated by Neoniti rotary system compared with other groups in both coronal and middle third of the canal.

Conclusion: The Neoniti rotary system was as effective as ProTaper Universal retreatment system in retreatment of gutta-percha and AH-26 sealer but was significantly less effective in groups obturated with Sure-Seal Root sealer.

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Cite this article as: Sadat Shojaee N, Vakilinezhad E, Shokouhui MM. In Vitro Comparison of Efficacy of Neolix and ProTaper Universal Retreatment Rotary Systems in Removal of Gutta-Percha Combined With Two Different Sealers. *J Dent Shiraz Univ Med Sci.* December 2019; 20(4): 285-291.

Introduction

Nonsurgical root canal retreatment is indicated when previous treatment fails [1-2] The effective removal of filling materials is essential to regain the access to the entire canal, and improve the root canal disinfection and debridement and placing a consistent, homogenous filling [3].

Several techniques have been used to remove root filling materials, employing various instruments which include manual instruments with chemical solvents such

10.30476/DENTJODS.2019.77825.

as chloroform, eucalyptol, orange oil [4-6], heat pluggers [7-8], ultrasonic [9-11] reciprocating systems [12] and nickel–titanium (Ni–Ti) rotary systems [13]. Recently, dedicated Ni–Ti rotary retreatment systems have been developed [14]. Many studies [15-19] have shown that the use of rotary systems in retreatment is more effective and time saving in removing gutta-percha.

The most commonly used filling material is gutta-percha. The use of a sealer in conjunction with gutta percha has been recommended to improve the bond of gutta percha to the dentine [20]. A wide variety of sealers has been used and new products continue to be marketed. Sure-Seal Root™ (Gyeonggi-do, South Korea) is a recently introduced premixed-injectable root canal sealing material that utilizes bioceramic technology. According to the manufacturer, this biocompatible calcium silicate sealer can chemically bond to the dentin with hydroxyapatite formation [21]. AH-26 root canal sealer (Dentsply Maillefer, Ballaigues, Switzerland) is an epoxy resin based sealer and strongly adhesive to both dentine and gutta-percha [22].

The ProTaper Universal system (Dentsply Maillefer, Ballaigues, Switzerland) has three retreatment instruments include D1, D2 and D3. D1 has a cutting tip and designed for removing filling materials from the coronal section of the root canal, and D2, D3 used to remove filling material from middle and apical portions of canals respectively. They have various tapers and diameters at the tip and the full lengths of these retreatment files are 16 mm for D1, 18 mm for D2 and 22 mm for D3. ProTaper Universal system was used as a golden standard system to which new file systems are compared [23-26].

Recently a newly NiTi rotary system was introduced to the market. Neoniti (Neolix, Châtres-la-Forêt, France) is a rotary file system with nonhomogeneous rectangular cross section and multiple taper. It consists of one C1 and three A1 with different tip sizes (#20, #25 and #40) files [14]. The manufacturer claims that this file has special abrasive properties resulting in faster root canal preparation and higher flexibility due to heat treatment process delivered to the file [27-28]. It is manufactured using a newly developed wire cut electrical discharge machining (WEDM) process. Some studies [29-30] reported that these systems are effective in retreatment procedure.

The aim of this study was to evaluate the efficacy of ProTaper Universal retreatment system and a single file Neolix system used during the removal of root fillings comprising gutta-percha and two different sealers.

Materials and Method

Specimen preparation

A total of 80 extracted human permanent mandibular premolars with a patent and single canal, verified radiographically, were selected. Soft tissue and calculus were mechanically removed from the root surfaces and then stored in a 0.1% thymol solution. Access cavities were prepared with high-speed diamond burs under water coolant. The crowns were flattened to stabilize a reference point and leave a uniform root length of 20 mm. Following the access preparation, a size 15 K-file (Dentsply, Maillefer, Ballaigues, Switzerland) was introduced into the canal until it was visible at the apical foramen. The working length was established as 0.5 mm short of this point.

Preparation of root canals

A single operator prepared all samples. The root canals were prepared by using ProTaper Universal treatment system (Dentsply, Maillefer, Ballaigues, Switzerland). The cervical and middle thirds of the canals were flared using the ProTaper SX and S1 rotary instruments and the canals were then finished using instruments F1, F2 and F3. An electric motor powered (Endomate DT, NSK, Japan) was used for all NiTi instruments in accordance with the manufactures' recommendations for speed and torque. Instruments were discarded after preparing of four canals. A 2.5% sodium hypochlorite (NaOCl) solution was used for irrigation during cleaning and shaping and 17% ethylenediaminetetraacetic acid (EDTA) was applied for 1 min after NaOCl to remove smear layer. Then the root canals were dried using paper points.

Filling of root canals

All canals were filled with lateral condensation technique up to the orifice level. Then the samples randomly were divided in two groups based on the sealers used and in the next part each group was divided into two subgroup based on the retreatment techniques. Finally we have four experimental groups (n=20) according to the sealer and retreatment technique. In two

groups, each one of the following sealers was used: AH-26, Sure-Seal Root. The sealers were prepared according to the manufacturer's instructions. In Sure-Seal Root groups, the sealer was introduced into the canal by injecting the sealer into the coronal third of the canal with an intracanal tip attached to the syringe. In AH-26 groups, a size 30/0.02 gutta-percha point was dipped in sealer and inserted into the canal until it reached the working length. Lateral condensation technique was use for obturation of all experimental groups. The access cavities were filled with Cavisol temporary filling material. The teeth were kept in an incubator for 4 weeks at 37°C and 100% humidity to allow the sealer to set.

Removal of filling material

The retreatment process of different experimental groups was done by two different NiTi rotary systems namely ProTaper Universal system (Dentsply, Maillefer, Ballaigues, Switzerland) and Neolix (Neolix, châtres-la-Forêt, France) as follows. Group 1; obturated with gutta-percha (GP) and AH-26/ Retreated with Neolix, group 2; obturated with GP and Sure-Seal Root/ Retreated with Neolix, group 3; obturated with GP and AH26/ Retreated with ProTaper Universal retreatment system, and finally group 4; obturated with GP and Sure-Seal Root/ Retreated with ProTaper Universal retreatment system.

The coronal filling was removed to access the canal orifice. A drop of solvent (chloroform) was placed in the chamber of each tooth and then increments of chloroform (0.1 ml) were placed to soften gutta-percha.

In groups 1 and 2, Neoniti C1 instrument of the Neolix rotary system was used for removal of filling material from coronal third of the canals and Neoniti A1 was introduced to the working length. The rotary file was used with the electrical VDW endomotor (Munich, Germany) were used at 300-500 rpm and 1.5 N/cm torque with pecking and brushing motions as recommended by the manufacturer [31].

In groups 2 and 4, ProTaper Universal system (Dentsply, Maillefer, Ballaigues, Switzerland) was used and root canal preparation was done using crown-down technique according to the manufacturer's instructions by using the electrical VDW motor. The D1, D2, and D3 files were used sequentially in a pecking motion [29] toward the apex until they reached the working length. Each NiTi instrument was discarded after being used four times.

During filling removal, irrigation was done using a total of 25 mL 2.5% NaOCl solution per tooth followed by irrigation of 5 mL 17% EDTA for 3 min to remove the smear layer. Then final irrigation with 5 mL 2.5% NaOCl for each specimen was performed.

Filling removal evaluation

Bucco-lingual grooves were made on the teeth with a diamond disk and then sectioned longitudinally. Both halves of the root canal were photographed using Dino-Lite pro (Dunwell Tech, USA) at 8× magnification. The photographs of the samples were analyzed using AutoCAD software to assess the residual filling material. No attempt was made to distinguish between gutta-percha and sealer. The areas of filling remnants were traced and measured by the same software. Mean percentage of the remaining filling materials were calculated for each third of the root canal and compared. Figure 1 shows the macroscopic photographs of the specimens each representing the experimental groups.

Statistical Analysis

The One-way analysis of variance test and post hoc Tukey-HSD test were used to identify differences between the experimental groups at the apical, middle, and coronal levels ($p< 0.05$).

Results

The mean percentage value of remaining filling material in coronal, middle and apical thirds and total canal area following each technique and sealer are given in Table 1. With regard the comparison of canal thirds, the mean percentage of remaining filling material was significantly higher in apical third in all groups ($p< 0.05$).

When comparing the sealers, the only significant difference was detected between AH26/Neolix group and SureSeal Root /Neolix group in both middle ($p< 0.01$) and coronal thirds ($p< 0.01$) and total canal area of the canals ($p< 0.01$). In comprising the retreatment technique, Tukey test showed significant differences between Sure-Seal Root/ProTaper and Sure-Seal Root/ Neolix groups in coronal ($p< 0.01$) and middle ($p< 0.01$) thirds and total canal area ($p< 0.01$).

Discussion

A major concern for all clinicians is complete removal

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Figure 1: Specimens representing groups 1, 2, 3 and 4 (left to right)

of preexisting filling material from root canals to achieve successful nonsurgical root canal retreatment [32]. This procedure is essential to allow further cleaning, shaping, and removing the infected residual necrotic tissue and microbes in the root canal system [32-33]. While different techniques were used to achieve this purpose [4, 7, 9, 34], the present study investigated two NiTi rotary file system to retreat obturated root canals with different sealers.

Various methodologies have been used to access the remaining filling material in the canals such as radiography [19], splitting the roots longitudinally [35], and computed tomography. In this study, the teeth were grooved longitudinally and split. Then directly visualized under a stereomicroscope and photographs were taken as proposed in other studies [36-37]. The examination under scanning electron microscopy enhanced the inspection of filling material residues and it has been shown to be more effective compared with radiographic techniques [38].

This technique is considered a simple and efficient method for inspection of the root canal walls but it has an objection, which is displacement of the filling material that might occur during splitting and affect the accuracy of scoring [39]. In the current study, root canal walls were evaluated in three sections of coronal, middle and apical. The results of this study revealed that independent of the type and technique of retreatment the highest amount of filling material was remained in apical portion. This result was in consistent with results of some other studies [19, 37, 40]. This has been attributed to the increased anatomical variation in apical portion of the canal and the less accessibility to clean this section [19].

In this study, only significant difference was observed between the sealer and filling material residues in the groups retreated by Neolix. Two types of sealer were used in this study: a bioceramic sealer (Sure-Seal Root) and a resin based sealer (AH-26). The results of the present study showed that regardless of the retreat-

Table 1: Mean ± Standard Deviation (SD) percentage value of remaining filling material for the experimental groups the coronal, middle and apical third and total canal area.

	n	Coronal third Mean(SD)	Middle third Mean(SD)	Apical third Mean(SD)	Whole canal Mean(SD)
Group1	40	0.164159^{aA} (0.1747303)	0.194393^{aA} (0.1999148)	0.297108^{B} (0.7546685)	0.176266^{a} (0.1517215)
Group2	40	0.261492^{bA} (0.1936765)	0.442678^{bA} (0.2734195)	0.339030^{B} (0.2317056)	0.326303^{b} (0.1799765)
Group3	40	0.153931^{aA} (0.1674304)	0.143259^{aA} (0.2353055)	0.160622^{B} (0.1362298)	0.137570^{a} (0.0904984)
Group4	40	0.193389^{aA} (0.2019916)	0.133463^{aA} (0.1279252)	0.197717^{B} (0.1642163)	0.168265^{a} (0.1067260)

Within the same column, different lowercase superscript letters show significant differences in experimental groups ($P<0.05$).
Within the same rows the different uppercase superscript letters show significant differences in each third of the root canal ($P<0.05$).

ment technique, the largest amount of remnant was seen in the canals, which were filled using AH-26. In line with these results, Uzunoglu *et al.* [39] concluded that bioceramic sealer (iRoot sp) was more difficult to remove from root canal walls than resin based sealer (AH-plus). However, these results are contrary to the findings of Ersev *et al.* [41] who reported that bioceramic sealer (Endosequence) showed similar remnants with those of resin based (AH-plus). This may be attributed to the following factors: different methodology between two studies (splitting roots in this study versus digital radiography) and adhesion properties of Endosequence and Sure-Seal Root sealer. Different sealers have different constituents and adhesion behaviors. Adhesion to the dentin is an important property, which is related to the ease of removal [42]. In a study conducted by Nagas *et al.* [43], it was shown that bioceramic sealer has higher dentin bond strength than resin-based sealer. According to the manufacturer, Sure-Seal Root is a bioceramic sealer and has a good dentinal bond strength, which explains the difficulty of removal from dentinal walls during retreatment procedure.

In the present study, two rotary files were evaluated in retreatment procedure: ProTaper Universal retreatment system and Neolix file. The results showed that considering the amount of obturation residues, there is no significant difference among the debridement ability of these retreatment files. Khoshbin *et al.* [44] in an *in vitro* study reported that no significant difference was observed between the debridement ability of Neolix and ProTaper systems in both 0-5 and 5-10 mm of the root canal. Although the ProTaper rotary file system tested in the study of Khoshbin's study was not from the retreatment file series, the results were comparable to the results of our study. Searching the literature yielded little data about the retreatment ability of Neolix rotary system. Neolix is a newly introduced NiTi file with special manufacturing process known as wire cut electrical discharge machining. The manufacturer claims that this rotary file has high cutting (shear) efficacy and optimal flexibility enabling the operator to have a suitable tactile sense while performing circumferential filing motion. In addition, special characteristics like high flexibility and surface hardness in combination with rectangular cross-section and cutting edges results in better cleaning and shaping ability of oval-shaped root canals and suggested for retreatment of root canal [44].

In an *in vitro* study, Fatima *et al.* [45] reported the higher efficacy of the ProTaper/Neoniti instruments in removing gutta percha when compared to ProTaper/ WaveOne instruments during retreatment process. In this study, the ProTaper Universal retreatment system was used to initiate retreatment for all experimental groups. Spirals running around the ProTaper instruments produce both cutting and softening actions and remove large amounts of gutta percha through retreatment process. In the present study, ProTaper Universal retreatment system and Neolix were compared with each other and the results showed no significant difference between these two systems. Compared to the results of Fatima *et al.*, it can be suggested that Neoniti instrument may be attributed to use alone in retreatment process due to its comparable results to ProTaper system [45].

In this study, the ability of Neoniti file for retreatment was compared with ProTaper Universal retreatment system. Given that Neolix is a new marketing single file, comparing it with other file rotary systems in retreatment process could be suggested.

Conclusion

Both Neolix rotary system and ProTaper Universal retreatment system left filling materials on the root canal walls mostly at the apical region. Neolix rotary system was less effective in removing Sure-Seal Root sealer compared to ProTaper Universal retreatment system.

Conflict of Interest

None declared.

References

[1] Siqueira JF Jr, Rôças IN. Clinical implications and microbiology of bacterial persistence after treatment procedures. J Endod. 2008; 34: 1291-1301.

[2] Torabinejad M, Corr R, Handysides R, Shabahang S. Outcomes of nonsurgical retreatment and endodontic surgery: a systematic review. J Endod. 2009; 35: 930-937.

[3] Ruddle CJ. Nonsurgical retreatment. J Endod. 2004; 30: 827-845.

[4] Wilcox LR, Krell KV, Madison S, Rittman B. Endodontic retreatment: evaluation of gutta-percha and sealer removal and canal reinstrumentation. J Endod. 1987; 13: 453-457.

[5] Friedman S, Moshonov J, Trope M. Efficacy of removing glass ionomer cement, zinc oxide eugenol, and epoxy resin sealers from retreated root canals. Oral Surg Oral Med Oral Pathol. 1992; 73: 609-612.

[6] Schirrmeister JF, Wrbas KT, Schneider FH, Altenburger MJ, Hellwig E. Effectiveness of a hand file and three nickel-titanium rotary instrumentsfor removing gutta-percha in curved root canals during retreatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006; 101: 542-547.

[7] Friedman S, Stabholz A, Tamse A. Endodontic retreatment--case selection and technique. 3. Retreatment techniques. J Endod. 1990; 16: 543-549.

[8] Friedman S, Mor C. The success of endodontic therapy--healing and functionality. J Calif Dent Assoc. 2004; 32: 493-503.

[9] Krell KV, Neo J. The use of ultrasonic endodontic instrumentation in the re-treatment of a paste-filled endodontic tooth. Oral Surg Oral Med Oral Pathol. 1985; 60: 100-102.

[10] Jeng HW, ElDeeb ME. Removal of hard paste fillings from the root canal by ultrasonicinstrumentation. J Endod. 1987; 13: 295-298.

[11] Wilcox LR. Endodontic retreatment: ultrasonics and chloroform as the final step in reinstrumentation. J Endod. 1989; 15: 125-128.

[12] Masiero AV, Barletta FB. Effectiveness of different techniques for removing gutta-percha during retreatment. Int Endod J. 2005; 38: 2-7.

[13] Ring J, Murray PE, Namerow KN, Moldauer BI, Garcia-Godoy F. Removing root canal obturation materials: a comparison of rotary filesystems and re-treatment agents. J Am Dent Assoc. 2009; 140: 680-688.

[14] 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: 532-537.

[15] Hülsmann M, Bluhm V. Efficacy, cleaning ability and safety of different rotary NiTi instruments in root canal retreatment. Int Endod J. 2004; 37: 468-476.

[16] Schirrmeister JF, Wrbas KT, Meyer KM, Altenburger M J, Hellwig E. Efficacy of different rotary instruments for gutta-percha removal in root canal retreatment. J Endod. 2006; 32: 469-472.

[17] Betti LV, Bramante CM. Quantec SC rotary instruments versus hand files for gutta-percharemoval in root canal retreatment. Int Endod J. 2001; 34: 514-519.

[18] Imura N, Kato AS, Hata GI, Uemura M, Toda T, Weine F. A comparison of the relative efficacies of four hand and rotaryinstrumentation techniques during endodontic retreatment. Int Endod J. 2000; 33: 361-366.

[19] Ferreira JJ, Rhodes JS, Ford TR. The efficacy of gutta-percha removal using ProFiles. Int Endod J. 2001; 34: 267-274.

[20] Belli S, Ozcan E, Derinbay O, Eldeniz AU. A comparative evaluation of sealing ability of a new, self-etching, dual-curable sealer: hybrid root SEAL (MetaSEAL). Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008; 106: e45-e52.

[21] Sure-endo corp. Sure-Seal Root, bioceramic sealing material. Available at: http://www.suredent.com/en/seal/01.htm

[22] Lee KW, Williams MC, Camps JJ, Pashley DH. Adhesion of endodontic sealers to dentin and gutta-percha. J Endod. 2002; 28: 684-688.

[23] Bürklein S, Hinschitza K, Dammaschke T, Schäfer E. Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals of extracted teeth: Reciproc and WaveOne versus Mtwo and Protaper. Int Endod J. 2012; 45: 449-461.

[24] Pirani C, Ruggeri O, Cirulli PP, Pelliccioni GA, Gandolfi MG, Prati C. Metallurgical analysis and fatigue resistance of WaveOne and Protaper nickel-titanium instruments. Odontology. 2014; 102: 211-216.

[25] Capar ID, Ertas H, Ok E, Arslan H, Ertas ET. Comparative study of different novel nickel-titanium rotary systems for root canal preparation in severely curved root canals. Journal of Endodontics. 2014; 40: 852-856.

[26] Hiranus S, Pimkhaokham S, Sawasdichai J, Ebihara A, Suda H. Shaping ability of Protaper NEXT, Protaper Universal and iRace files in simulated S-shaped canals. Aust Endod J. 2016; 42: 32-36.

[27] Aminsobhani M, Meraji N, Sadri E. Comparison of Cyclic Fatigue Resistance of Five Nickel Titanium Rotary File Systems with Different Manufacturing Techniques. J Dent (Tehran). 2015; 12: 636–646.

[28] Moazzami F, Khojastepour L, Nabavizadeh M, Seied H-

abashi M. Cone-Beam Computed Tomography Assessment of Root CanalTransportation by Neoniti and Reciproc Single-File Systems. Iran Endod J. 2016; 11: 96-100.

[29] Rios Mde A, Villela AM, Cunha RS, Velasco RC, De Martin AS, Kato AS, et al. Efficacy of 2 reciprocating systems compared with a rotary retreatmentsystem for gutta-percha removal. J Endod. 2014; 40: 543-546.

[30] Zuolo AS, Mello JE Jr, Cunha RS, Zuolo ML, Bueno CE. Efficacy of reciprocating and rotary techniques for removing filling material during root canal retreatment. Int Endod J. 2013; 46: 947-953.

[31] Khoshbin E, Donyavi Z, Abbasi Atibeh E, Roshanaei G, Amani F. The Effect of Canal Preparation with Four Different Rotary Systems on Formation of Dentinal Cracks: An In Vitro Evaluation. Iran Endod J. 2018; 13: 163-168.

[32] Schirrmeister JF, Liebenow AL, Braun G, Wittmer A, Hellwig E, Al-Ahmad A. Detection and eradication of microorganisms in root-filled teethassociated with periradicular lesions: an in vivo study. J Endod. 2007; 33: 536-540.

[33] Stabholz A, Friedman S. Endodontic retreatment--case selection and technique. Part 2: Treatmentplanning for retreatment. J Endod. 1988; 14: 607-614.

[34] Rios Mde A, Villela AM, Cunha RS, Velasco RC, De Martin AS, Kato AS, et al. Efficacy of 2 reciprocating systems compared with a rotary retreatmentsystem for gutta-percha removal. J Endod. 2014; 40: 543-546.

[35] Takahashi CM, Cunha RS, de Martin AS, Fontana CE, Silveira CF, da Silveira Bueno CE. In vitro evaluation of the effectiveness of Protaper universal rotaryretreatment system for gutta-percha removal with or without a solvent. J Endod. 2009; 35: 1580-1583.

[36] Sae-Lim V, Rajamanickam I, Lim BK, Lee HL. Effectiveness of ProFile .04 taper rotary instruments in endodonticretreatment. J Endod. 2000; 26: 100-104.

[37] Kosti E, Lambrianidis T, Economides N, Neofitou C. Ex vivo study of the efficacy of H-files and rotary Ni-Ti instruments to remove gutta-percha and four types of sealer. Int Endod J. 2006; 39: 48-54.

[38] de Carvalho Maciel AC, Zaccaro Scelza MF. Efficacy of automated versus hand instrumentation during root canalretreatment: an ex vivo study. Int Endod J. 2006; 39: 779-784.

[39] Uzunoglu E, Yilmaz Z, Sungur DD, Altundasar E. Retreatability of root canals obturated using gutta-percha with bioceramic, MTA and resin-based sealers. Iran Endod J. 2015; 10: 93-98.

[40] Teplitsky PE, Rayner D, Chin I, Markowsky R. Gutta percha removal utilizing GPX instrumentation. J Can Dent Assoc. 1992; 58: 53-58.

[41] Ersev H, Yilmaz B, Dinçol ME, Dağlaroğlu R. The efficacy of ProTaper Universal rotary retreatment instrumentation to remove single gutta-percha cones cemented with several endodontic sealers. Int Endod J. 2012; 45: 756-762.

[42] Só MV, Saran C, Magro ML, Vier-Pelisser FV, Munhoz M. Efficacy of ProTaper retreatment system in root canals filled with gutta-percha and two endodontic sealers. J Endod. 2008; 34: 1223-1225.

[43] Nagas E, Cehreli Z, Uyanik MO, Durmaz V. Bond strength of a calcium silicate-based sealer tested in bulk or with different main core materials. Braz Oral Res. 2014; 28: 1-7.

[44] Khoshbin E, Shokri A, Donyavi Z, Shahriari S, Salehimehr G, Farhadian M, et al. Comparison of the root canal debridement ability of two single filesystems with a conventional multiple rotary system in long oval-shapedroot canals: In vitro study. J Clin Exp Dent. 2017; 9: e939-e944.

[45] Fatima K, Nair R, Khasnis S, Vallabhaneni S, Patil JD. Efficacy of rotary and reciprocating single-file systems on different access outlines for gutta-percha removal in retreatment: An in vitro study. J Conserv Dent. 2018; 21: 354-358.