Original Article

Evaluating the Efficacy of the ProTaper Rotary Retreatment Technique to Remove Gutta-Percha in terms of Operating Time and the Amount of Gutta-Percha Left in the Canal

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ABSTRACT

Background and Purpose: MTA-based sealers have recently been introduced, which can be used as fillers in root treatments owing to their good biological properties. This study is to evaluate the retreatment capability of MTA-based sealer compared to AH-26 resin sealer mandibular premolar teeth using the ProTaper retreatment system.

Materials and Methods: In this experimental-laboratory study, 64 single-rooted mandibular premolar extracted teeth were collected using the ProTaper system with a size ranging to F3[30,9%] and were randomly divided into two groups of 32 according to the type of sealer. Then, they were filled out following the instructions of the manufacturer. For this aim, resin sealer (AH-26), gutta-percha with lateral compression method for the canals group 1, and gutta-percha and MTA sealer (Endoseal MTA) method for the canals group 2 were used. Removal of all specimens was done using ProTaper rotary retreatment system, and the time needed for this work was recorded consequently. In the next step, the specimens were longitudinally cut using a diamond disc, and digital periapical radiographs for each piece were prepared. The residual of the filling material in the radiographic image was calculated using Mann-Whitney (non-parametric) test. The level of significance was considered to be ($P<0.05$).

Findings: The residual of sealer was significantly higher in the group filled with MTA-based sealer compared to that of the group filled with AH-26 sealer ($p<0.05$). The time needed to remove the canal-filling material in the group filled with MTA-based sealer was significantly higher ($p<0.05$).

Results: The results of the present study showed that the residuals after retreatment in the canal walls are significantly higher if MTA-based sealer is used, and the ProTaper retreatment system is not able to completely remove this sealer from the root canal.

Keywords: MTA-based sealer, AH-26 sealer, retreatment, ProTaper

Introduction

Several problems, including necrotic tissue, bacterial biofilm, coronal leakage, recurrent caries, and cracked teeth, can cause the periapical disease once the root canal is treated. The etiological factors and the previous filling material should be completely removed to improve repairing and healing (1). Removing the filling material inside the canal (gutta-percha and sealer) and creating a Crono-Apical path can make access to the necrotic tissue and bacteria that caused the disease easier (2). It can also clean the canal space and dentin tubules both chemically and mechanically (3).

Recently, new canal-filling materials, such as MTA-based sealers, have been introduced to the market, which can treat root canals successfully (4). The manufacturers of these materials claim that these materials, with their unique physical and biological properties, will transform dentistry (5). The ability to remove these new sealers from the canal with the present retreatment techniques is not clear, and not many studies on this issue have been conducted so far. A more healthy apical tissue and less inflammation can be seen in MTA-based sealers compared to other sealers. The most specific sign of tissue reaction to MTA-based sealer is the presence of connective tissue a week after surgery (6). The primary inflammation in response to this sealer in the tissue arises from several factors, including high pH, the heat produced during setting, as well as the formation of cytokines 1 and 6 (7).

Considering the conducted study, none of the canals filled with MTA-based sealer was completely removed from the filling material, and the residual material was observed at least in one segment. In the group filled with AH-26 sealer, 21.9% of the specimens showed no sealer in the radiograph, which probably was due to the inability of radiography to detect a very small amount of the residuals. If the entire surface of the canal is taken, MTA-based sealer leaves more residual material after retreatment on the canal walls than the resin sealer. This significant difference between the two sealers may be due to the consistency of the sealers based on calcium silicate, which is very high after setting and, consequently, resists the tools and techniques used for retreatment. Calcium ion is released after setting, and the presence of this ion in phosphate-containing liquids can stimulate the formation of hydroxyapatite crystals in the middle and apical 1/3 of the canal, which in turn, creates a strong chemical bond between this material and the walls of the canal. It also can increase the ability to seal after setting compared to the resin sealers (8). Thus, MTA can be a good candidate and the selected material for filling the root canal.

However, MTA is not recommended as a common orthograde filling material since the sandy and non-recyclable trait of the filled path has challenged using this material in the root canal systems(9). Some MTA-based sealers are MTA fillapex, MM-MTA, bioaggregat, Endoseal MTA, etc. (4). Endoseal MTA as pozzolan-based MTA with fine powder particles has recently been introduced to the market. Pozzolan cement is the main component of the sealer. Once a pozzolanic reaction is formed, this material creates a cement containing hydraulic calcium and water, and its prepared substance (pre-mixed one) provides a suitable fluid with sufficient consistency so that it can be injected using a narrow plastic syringe head placed easily in the root canal (10).

Some of the desired mechanical properties include fast setting time (around 12 min.), high washout resistance in comparison to other commercial MTAs in the market, as well as biological traits such as good tissue compatibility, mineralization potential, and odontogenic effects of Pz-MTA cement. MTA Fillapex has been used in almost all studies done on the MTA-based sealer, which is of lower bond strength but greater solubility in comparison to Endoseal MTA (11, 12). A study on Endoseal MTA sealer was conducted by Yeon jee (2015). Using SEM and EDS analysis, it was shown in this study that When the root canal was obturated with GP and Pz-MTA sealer, enhanced biomineralization of the dentinal tubules beyond the penetrated sealer tag was confirmed under the SEM observation. Mineralized apatite structures (calcium/phosphorous ratio, 1.45-1.89) in dentinal tubules were detected at 350-400 μm from the tubule orifice, and the pre-crystallization seeds were also seen along the intra- and/or inter-tubular collagen fiber. Intratubular biomineralization depth was significantly increased in all PBS pretreated(13).

Several studies have noted when the retreatment process is completed, some amount of filling material and debris remains on the canal walls regardless of the type of the used device, of filling material, and use or not using solvents(14). Since MTA sealer has many advantages, the possibility of retreatment of it is of great importance to investigate. Therefore, this study aims at investigating the efficacy of the retreatment of MTA sealer in comparison to AH-26 sealer in Single canal extracted teeth using the ProTaper rotary system.

Materials and Methods

The present experimental-laboratory study is a controlled intervention one. The population was single-canal direct premolar teeth of humans, which had been extracted due to various reasons such as periodontal diseases, non-restorability, or orthodontic treatments. The sample size of each group was calculated using G*Power software, and the entered data as follows: type 1 error rate (α = 0.05), type 2 error rate (β = 0.2), considering (power=80%) equivalent to 32 teeth in each group (64 teeth in total). The availability sampling method was used.

In this study, the inclusion criteria for single-rooted and single-canal teeth of the extracted mandibular premolar were:

- Not observing any calcification, pulp stone, or clear root obstruction after examining the PA radiograph.
- Having straight roots
- Not observing any resorption, fracture, or defects in the roots after examining by radiographs or eyes
- Having a closed apex and the same size as the apical foramen
- Not undergoing root canal treatment before

One hundred single-root mandibular premolars were collected. Sixty-four of them were finally selected using periapical proximal and buccal radiographs. The teeth suffering from curvature, canal obstruction (calcification), pulp stone, resorption, fracture, crack, or previous root treatment were excluded. The experiment was started after removing the residuals of soft tissue and mass on the surface of the crown and root using manual devices. The selected specimens were disinfected in 5.25% sodium hypochlorite for 5 minutes. Then they were kept in a 1% thymol solution.

Preparation

A high-speed handpiece (Bien Air, Switzerland) and a carbide fissure bur (Tizkavan, Iran) were used to cut the crown of all the specimens s so that a standard root length of 15 mm and a smooth surface as a reference point could be created (Teeth with shorter length were excluded). When instrumentation was completed, the #10 K-File(Dentsply Maillefer Switzerland) was introduced into the canal until the apical foramen to confirm canal patency and cleaning. Then, 1 mm of the length was reduced and considered as the working length(14mm). If file 15 had not had enough grip during the 14mm working length, the specimen was excluded.

The specimens were mounted 5 mm below the reference point in the acrylic. In fact, 10 mm of each specimen was covered by the acrylic, and 5 mm remained observable outside the acrylic. The aims were both the direct detection of the placement of the tooth in the acrylic and enough stability of the tooth in the mount so that it could not be separated from the mount during cutting, under force and vibrations of the disc.

Then, the specimens were numbered, and a unique number was assigned for each one. The canals were prepared after managing the glide path with file # 20. For this aim, brushing movement and crown down technique by ProTaper rotary system [Dentsply Maillefer Switzerland] and ENDO MATEDT rotary motor [NSK, Japan] according to the manufacturer's instructions, respectively from Sx to F3 [#30,0.09] with speed equal to 300 RPM and a torque of 2.2. were used. The specimen was excluded from the study if file breakage or over-instrumentation was seen. Cleaning was done using 2 ml of 5.25% hypochlorite between each file, and patency was checked with the #10 K files. Each specimen was rewashed with 2 ml of normal saline, and the smear layer was removed with one milliliter of 17% EDTA [SinaTeb Iran] for one minute and then 5 ml of 5.25% hypochlorite. All washing solutions were used with a 25-G needle [1/2 inch, Vecto], 1 mm shorter than the working length. The normal saline was used for the final washing of the canal. The specimens were divided into two groups of 32 according to the type of sealer and the filling technique based on the instructions of the manufacturer (the type of sealer used for the obturation of each specimen was determined randomly using WinPepi software):

Group 1: gutta-percha and AH-26 sealer with lateral compaction technique

Group 2: gutta-percha and MTA-based sealer with single-cone technique

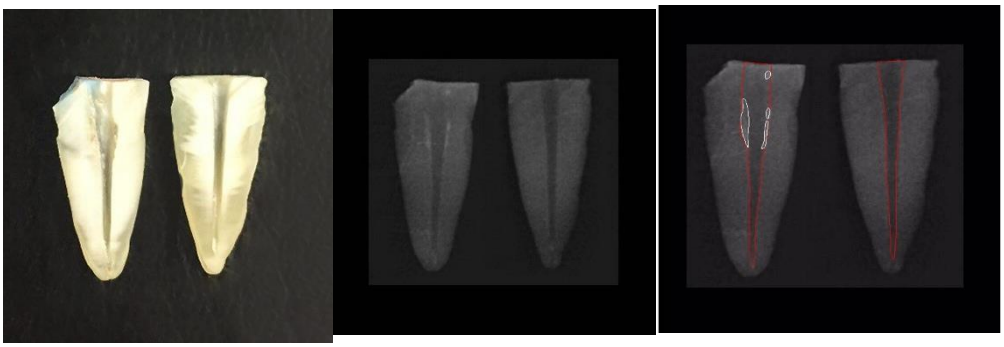
The specimens were dried using a paper point. In the first group, the main gutta-percha cone [MAC#35/4% Ariadent, Iran] was extended to the working length. Then, if the length of the radiograph of the main cone was appropriate, it was coated with AH-26 sealer [Dentsply De Trey Germany], and then the whole canal was filled with several secondary guttae [#15/2% Ariadent, Iran] and stainless steel spreader [#25Dentsply, Maillefer, Switzerland] using lateral compaction technique. In the second group, Endoseal MTA sealer (Maruchi, Wonju, Korea) was injected into the canal using a special needle up to 1.3 coronal inside the syringe. Then selected gutta-percha [#35/0.04 Dentsply Maillefer Switzerland] was extended to the working length.

In the next step, Gutta-percha was removed from the 2 mm coronal portion of the canal by heat carrier. The path was created to the working length using 0.2ml chloroform [Sinabartar, Iran] and K-File [#15, Dentsply, Maillefer, Switzerland]. the rotary retreatment system [Dentsply Maillefer Switzerland] ProTaper (with ENDO MATE DT engine [NSK, Japan] at 500 rpm and torque equal to 2.2 with minimum apical pressure, brushing movement and crown down technique was used to remove the filling materials inside the canal. According to the manufacturer's instructions, files D1 [0.09/30], D2 [0.08/25], and D3 [0.07/20] were used in the coronal, middle, and apical parts, respectively, until reaching the WL. It was continued until debris and gutta-percha were not seen on the flutes of the D3 file, and it did not go out of the canal during washing with saline. Then, 2 ml of 5.25% sodium hypochlorite(NaOCl) was poured into the canal, and the final apical preparation was carried out using ProTaper rotary file [F4#40/0.06, Dentsply Maillefer Switzerland] trying to reach the working length. The canal was cleaned using a 5.25% hypochlorite solution between each file, and the files were replaced after fivefold use. The given specimen was removed if any

error was seen during the retreatment process. The final cleaning was done using 5ml of normal saline solution and dried with a paper point. The time needed for the entire retreatment process was measured and recorded using a stopwatch. All stages of initial preparation, root canal filling, and re-treatment of the canals were carried out by one operator.

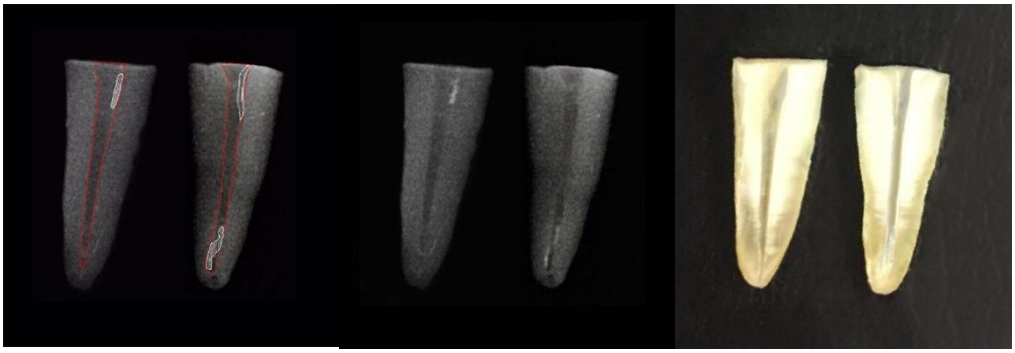
Analyzing the residual filling material (RFM)

A diamond disk of the [Nemo Fannavarane Pars Iran] CNC machine available in the equipment center at Tehran University of Science and Technology was used to cut the specimens in the buccolingual direction of the longitudinal section(Figures 1, 2 a) and digital periapical radiographs of each half (with conditions same for all specimens) was prepared(Figures 1,2 b). All radiographs were transferred to the AutoCAD2013 software (Mechanical Desktop Power Pack Desktop; Microsoft Redmond WA). The difference between the canal wall and the residual filling material was evaluated based on their radiopacity difference. The area of each case was calculated by the operator using AutoCAD after drawing the boundaries of the canal space and those of the residual filling material. Then, the ratio of the areas to each other and, as a result, the percentage of the residual material in the canal walls were presented (Figure 1,2 c). The endodontist and radiologist not present during the work process investigated the results from AutoCAD considering the amount of the residual filling material in the canal wall.



(c) (b) (a)

Figure 1: Longitudinal section of halves filled with AH-26 sealer after retreatment; a: photograph, b: digital periapical radiograph, c: AutoCAD analysis



(c) (b) (a)

Figure 2: Longitudinal section of the halves filled with Endoseal MTA sealer after retreatment; a: photograph, b: digital periapical radiograph, c: AutoCAD analysis

Findings

The examined specimens included two groups of 32 mandibular premolar teeth with straight roots and a single canal. The first group was filled with gutta-percha and AH-26 sealer, and for the second one, MTA and gutta-percha sealer were used (Table 1). The data for comparing the efficacy of the retreatment of the filled canals were collected and inputted into the computer using SPSS 21 statistical software. The results are reported below:

Table 1: Relative frequency distribution of sealers used in canal retreatment

[3] Sealer	[2] Number	[1] Percentage
[6] AH-26	[5] 32	[4] AH5026
[9] MTA	[8] 32	[7] 50

Seven specimens filled with resin sealer out of all specimens (21.9%) showed no detectable residual in the radiographic image, and 100% of the specimens filled with MTA sealer showed filling in the canal walls. A significant difference ($p<0.005$) was observed between the two groups in terms of the presence or absence of residual filling material in the canal walls (Table 2).

Table 2: Relative frequency distribution of the presence or absence of residual filling material in the canal walls

	MTA		AH-26	
	Percentage	Number	Percentage	Number
With residual	100%	32	78.1%	25
Without residual	0	0	21.9%	7

The Kolmogorov-Smirnov test of normality was used to analyze the data. A P-value less than 0.05 was obtained ($p<0.05$), which indicated the data were not normal. Nonparametric tests were also used to analyze the data. The Mann-Whitney test and the P-value less than 0.05 indicated that there was a significant difference between the amounts of sealer residuals in the canal wall in the two types of sealer. The median and mean values showed that this amount in MTA is more than that in 26-AH(Table 3)

Table 3: Determining and comparing the amount of the residual sealer in the canal wall in two types of sealer

Sealer	Mean(percentage)	Median	Standard deviation	P-value
AH-26	8.38	5.32	9.9	<0.001
MTA	32.48	26.5	20	

Moreover, the Mann-Whitney test and the P-value indicated that there was a significant difference between the time needed to remove the canal filling material in both types of sealer. The median and mean values showed that this amount in MTA is more than that in 26-AH(Table 4).

Table 4: Determining and comparing the time needed to remove the residual sealer in the canal wall in two types of sealer

Sealer	Mean(percentage)	Median	Standard deviation	P-value
AH-26	2.5	2.38	0.38	<0.001
MTA	3.47	3.35	0.39	

Discussion

According to the results found in the present study, it appears that the removal of Endoseal MTA during retreatment is more difficult compared to MTA and AH26 sealers, and more time is needed to remove the canal filling materials. In this study, the filling material was removed using the ProTaper retreatment system. Many studies have confirmed the effectiveness, cleaning efficacy, and safety of Protaper (15, 16). ProTaper rotary files are three flexible files designed for removing filling material from the coronal, middle, and apical 1/3 of the canal. The better performance of the ProTaper system can be related to its design. D1, D2, and D3 files have a convex triangular cross-section with 3 progressive convergences and progressive length, which give them this chance to remove both gutta-percha and the surface layer of dentin during the removal of canal filling materials. Moreover, the specific design of the flutes (greater distance from each other and negative cutting angle) and the rotational movements of the ProTaper retreatment files lead to placing the filling material inside the canal into the flutes of the file and directing it towards the mouth of the canal. On the other hand, the rotary movements of the files create a certain degree of frictional heat, which can plasticize the consistency of gutta-percha. Softened gutta-percha has less resistance to removal and, as a result, is removed easily (17).

Using effective solvents on gutta-percha has been helpful during the retreatment process to soften and facilitate the penetration of the devices into it and thus its removal from the root canal system (18, 19, and 20). Moreover, they can help remove more amount of debris removed from the apical foramen and reduce the time to reach the initial working length during retreatment (18). In this regard, chloroform is the most commonly used solvent. Its efficacy for gutta-percha has been proven, and it is of a long history of clinical use. Although chloroform is likely to be carcinogenic, it is safe if it is handled in a controlled manner in the clinic (19, 20). It has been shown in previous studies that chloroform is quite an effective solvent for resin sealers (21,22). Hanan(2015) showed that chloroform was more efficacy than other solvents used in this study. The dissolution rate of MTA fillapex in chloroform solvent in the first 5 and 10 minutes was less than that of AH- 26(23).

In addition, Anastasia(2015) (24) and Carpenter(2014) (25) showed that chloroform could soften MTA fillapex

resin matrix; however, the chloroform solvents are not very effective in removing bioceramic sealers.

Therefore, here the advantages of chloroform for removing the materials inside the canal were used in both groups. Some techniques to check out the residual filling material inside the canal included longitudinal sectioning of the tooth and its evaluation using radiography(26), direct observation with photography or microscope (27), transparent evaluation, use of cone beam computed tomography (CBCT) as well as micro-computed technology(micro-CT) (28,29). If the tooth is cut into halves using a diamond disc (longitudinal cutting technique), it is inevitable to loss of a part of the specimen, and the residual filling material inside it is inevitable. The biggest disadvantage of evaluating with radiography is that the obtained image is a 2D image of a 3D structure, and the small amount of residual debris in the canal is not seen in the radiograph due to image distortion (30). According to the ISO standard, root-canal filling materials should have a radiopacity of at least 3 mm aluminum, although the radiopacity of gutta-percha is higher than this number. As Melahat's study (2009) showed, the radiopacity of PRoroot MTA (2.9081 mm aluminum) and AH-26 (2.2816 mm aluminum) is lower than the standard level. Ultimately, using gutta-percha (5.0448mm aluminum) can increase the radiopacity of the filling material inside the canal. According to that study, AH plus was of the highest radiopacity. The reason was the difference in the radiopaque material of such sealers (31). Calcium tungstate in the structure of AH-26 and bismuth trioxide in MTA is the radiopaque agents in such sealers. Thus, it is possible that the small amount of the residuals (sealer AH- 26) in the canal walls may not be detected in the radiographic images during the retreatment of the root. This technique is not accurate for evaluating the amount of residual sealer inside the canal due to the artifact caused by the material inside the canal in the images, the low density of the material inside the canal, and consequently, the impossibility of accurate observation in CBCT (33). Recently, micro-CT technology has been introduced to evaluate canal preparation and removal of filling material inside the canal (30). At present, the best method for evaluation is Micro-CT technology as a non-invasive method, which can produce a 3D image. This method overcomes the disadvantages of radiography and eliminates the error and bias of the person who analyzes the image (3). Unluckily, at present, we have no access to this technology. Although using the microscope to confirm the complete removal of the residuals in the canal walls is very accurate, using it in clinical conditions is not possible. Nevertheless, the success rate of retreatments carried out in the clinic using radiographic confirmation of removing residuals in the canal was reported to be between 74% and 98% (36, 35), which indicates that in clinical conditions, an accuracy as much as that of the microscopic vision to ensure removing residuals in the canals is not needed. In the present study, a longitudinal section and evaluation of the results using radiography were done. This technique suffers from some problems, but it is of availability and the best one for retreatment in clinical conditions.

This study was done on the single canal and straight teeth to eliminate the effect of root anatomical complications on material removal as much as possible. Generally, here the time needed to remove the canal filling material in the MTA group was significantly more than that of AH-26. More time was needed to remove Endosel MTA due to its hardness, its penetration into the dentine tubules (14), and its resistance to the usual retreatment techniques. In fact, the difference in the hardness of the sealers made the time needed to remove them differently. In the group obturated by lateral compression technique, secondary guttas, and resin sealer, the result was more and faster removal of the filling material by the solvent. It was because of the larger volume of gutta-percha in the canal compared to the group filled with single cone method and the greater effect of chloroform on resin sealer and gutta-percha compared to MTA sealer.

In this study, the initial working length was obtained again in all the specimens of both groups. As Anastasia's study shows, if the main cone is used during the working length, the initial working length is obtained in 100% of the specimens (27). In this study, as in the present study, ultrasonic was used besides chloroform, rotary devices, and hand files. In our study, all the main cones were placed in the single-cone method during the operation according to the manufacturer's instructions. It can be said that if the root treatment fails due to the re-entry and the presence of micro-organisms inside the root (errors such as under obturation, Lodge and etc.) or if the gutta-percha is placed shorter than the original length in the clinic in the single cone method, to penetrate and remove the filling from the apical part to access the apical foramen will be more difficult, especially if retreatment is needed in the future.

Uzungolu et al. (37) examined the retreatability of root canals using Bioceramic, MTA, and Resin-based sealers. The results of their study indicated that there was more remaining filling material in the coronal third of the canals in the single-cone GP/iRoot SP group compared to lateral compaction of GP/AH-26 and single-cone GP/MTA Fillapex. In addition, The TWL in single-cone GP/MTA Fillapex was significantly shorter than the other groups. The results of this study, which used Micro CT for evaluation, were consistent with the results of our study in terms of the amount of residual sealer. The reason for the difference between both studies (in terms of TWL) can be due to the difference in the type of sealer used. As told earlier, MTA Fillapex is of higher solubility and lower bond strength ratio compared to Endoseal

MTA, so it is easier to remove it. In our study, the total time of the retreatment process was calculated, but in the study done by Uzungolu, TWL was calculated. Thus, it is obvious that to reach the working length; the recorded time is more due to the attempt to remove the central core of gutta-percha, while in calculating the total time of the retreatment process, most of the recorded time is spent removing the filling material (mostly sealer in canals filled with MTA sealer) on the canal walls.

Conclusion

The results obtained from this experimental-laboratory study showed that the ProTaper retreatment system is not able to remove Endoseal MTA completely from the canal walls. In addition, the residual filling material in the teeth filled with it is significantly higher than the samples filled with resin sealer. Although these new sealers are of many advantages and are easy obturation techniques, their complete removal from the canal is not possible and time-consuming if any retreatment is needed.

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