



Evaluation of apically extruded debris during removal of gutta-percha and Resilon™ using different instrumentation techniques

Procena apikalno ekstrudiranog debrisa tokom uklanjanja gutaperke i Resilona™ primenom različitih tehnika instrumentacije

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Abstract

Background/Aim. Apical extrusion of material is considered as one of the very important factor for endodontic treatment success. Microorganisms, necrotic tissue, filling material and irrigants, which can be extruded apically during endodontic retreatment, may jeopardize the success of the therapy. The aim of this *in vitro* study was to quantitatively evaluate the amount of apically extruded debris during endodontic retreatment of teeth obturated with two different materials, using one hand and three rotary instrumentation techniques. **Methods.** Ninety-six extracted single-rooted teeth were endodontically treated and enlarged to size 40 using BioRaCe system, and then randomly divided into 8 groups of 12 specimens each. Half of the specimens were obturated with gutta-percha and AH Plus® sealer and another half with RealSeal SE system, using lateral condensation technique. Retreatment was performed using: Hedström files; ProFile rotary files; ProTaper Retreatment system and D-RaCe system. Apically extruded debris was collected in pre-weighed Eppendorf tubes and evaluated using an electronic microbalance. Data were analyzed statistically using *t*-test and analysis of variance. **Results.** In the AH Plus/gutta-percha group, all tested rotary instruments gave significantly less extruded debris compared with Hedström files ($p < 0.05$). In the RealSeal group, there was significant difference between D-RaCe and Hedström instruments ($p < 0.05$). **Conclusion.** All retreatment techniques resulted in apical extrusion. D-RaCe system produced significantly less extruded debris compared to hand files. No significant difference was found when comparing two instruments specially designed for retreatment: D-RaCe and ProTaper systems.

Key words:
 root canal filling materials; gutta-percha; pit and fissure sealant; dental instruments; methods.

Apstrakt

Uvod/Cilj. Apikalna ekstruzija materijala se smatra jednim od veoma važnih faktora za uspešnost endodontske terapije. Mikroorganizmi, nekrotično tkivo, opturacioni materijal i irigansi koji mogu biti ekstrudirani apikalno tokom endodontskog retreatmana mogu ugroziti uspeh terapije. Cilj ovog istraživanja je bio da se kvantitativno proceni količina apikalno ekstrudiranog debrisa tokom endodontskog retreatmana zuba opturiranih sa dva različita materijala, primenom jedne ručne i tri rotirajuće instrumentacione tehnike u *in vitro* uslovima. **Metode.** Ukupno 96 ekstrahovanih jednokoreni zuba su endodontski lečeni i prošireni primenom BioRaCe sistema (završni proširivač 40/0.04), a zatim nasumično podeljeni u osam grupa od po 12 zuba. Polovina uzoraka je bila opturirana gutaperkom i AH Plus® silerom, a druga polovina RealSeal SE sistemom, korišćenjem tehnike hladne lateralne kondenzacije. Retretman je obavljen primenom: Hedström ručnih instrumenata, ProFile rotirajućih instrumenata, ProTaper Retreatment sistema i D-RaCe sistema. Apikalno ekstrudirani debris je sakupljan u prethodno izmerene Eppendorf epruvete a procena je obavljena primenom elektronske mikrovage. Podaci su statistički analizirani primenom *t*-testa i analizom varijanse. **Rezultati.** U AH Plus/gutaperka grupi, kod svih ispitivanih rotirajućih instrumenata dobijeno je značajno manje ekstrudiranog debrisa u poređenju sa Hedström instrumentima ($p < 0,05$). U RealSeal grupi, bila je prisutna statistički značajna razlika između D-RaCe i Hedström instrumenata ($p < 0.05$). **Zaključak.** Apikalna ekstruzija debrisa je bila prisutna kod svih ispitivanih tehnika retreatmana. Primenom D-RaCe sistema dobijeno je značajno manje ekstrudiranog debrisa u poređenju sa ručnim instrumentima. Pri upoređivanju instrumenata specijalno dizajniranih za retreatman – D-RaCe i ProTaper sistema, nije utvrđeno prisustvo statistički značajne razlike.

Ključne reči:
 zub, materijali za punjenje korenskog kanala; gutaperka; zub, zalivači jamica i fisura; stomatološki instrumenti; metodi.

Introduction

Irritants such as microorganisms, necrotic tissue, filling material and root canal irrigants can be extruded apically during endodontic retreatment. Apical extrusion of material is considered as one of the very important factors for endodontic treatment success. A number of studies over the past decades have shown transportation of apically extruded material to some degree¹⁻⁴. The amount of extruded debris may vary depending on the techniques of preparation and design of the instruments used⁵⁻⁸. Therefore, appropriate retreatment technique should be selected to remove the preexisting filling material as much as possible while minimizing the amount of apical extrusion³.

Numerous studies showed various outcomes concerning the amount of apically extruded debris when hand instruments were used compared to rotary. Bharathi et al.⁹ measured significantly less extruded debris after retreatment with ProFile instruments, compared to manual Hedström instruments. In another study, rotary instruments (Mtwo and Reciproc instruments) proved to be more successful than Hedström instruments while removing gutta-percha/AH Plus sealer¹⁰.

A new root canal filling material, RealSeal SE system (SybronEndo, Orange, CA, USA) was recently introduced to the market. It consists of Resilon™ cones and Realseal SE self-etch sealer. Resilon™ like gutta-percha is a biocompatible filling material and the clinical outcome and obturation quality are similar, too¹¹. Only few authors have investigated the importance of extrusion in the periapical tissues during retreatment of Resilon™ based obturation materials^{12,13}.

Also, no studies can be found in the current literature concerning the amount of apically extruded debris during retreatment procedure on samples obturated with RealSeal SE system using D-RaCe rotary files.

The aim of this *in vitro* study was to compare the amount of apically extruded material during endodontic retreatment of teeth obturated with two different materials, using one hand and three rotary instrumentation techniques¹.

Methods

Specimen selection

This *in vitro* study was carried out on 96 human mandibular premolars, freshly extracted for orthodontic or periodontal reasons. Teeth with mature apices and straight root canal (< 10°) were selected according to the Schneider method¹⁴.

Samples with incomplete root formation, the presence of external resorption, two or more root canals, localized or diffuse calcifications were excluded from the study. Periodontal tissue, organic debris and calculus were mechanically removed from the root surface after immersion of the samples in a 2.5% sodium hypochlorite solution for 8 hours.

Root canal preparation and obturation

After accessing the cavity and removing the pulp tissue, the canal patency and working length determination was established with a size 10 K-type file (Dentsply Maillefer, Ballaigues, Switzerland). Crowns were cut to a level of 15 mm from the apical foramen in order to standardize the amount of filling material. The working length of each canal was visually determined to 1 mm short of the major apical foramen. Root canal preparation was performed with a crown-down technique using rotary Bio-RaCe instruments (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland). For preparation of the coronal third instrument BR0 (25/0.08) was used. Middle third was instrumented with BR1 (15/0.05), BR2 (25/0.04) and BR3 (25/0.06) instruments, and apical third with BR4 (35/0.04) and BR5 (40/0.04) instruments. Each instrument was used according to the protocol allowed (4 times for simple root canal anatomy as recommended). Instruments were driven by low-torque rotary engine motor Rooter (FKG Dentaire SA, La Chaux de Fonds, Switzerland), with the torque control set to 1N/cm and at constant speed of 600 rpm, and inserted in root canal in movement. Canal⁺ (Septodont, Saint-Maur-des-Fossés, France) was used as lubricant and chelating agent. Apical third patency was enabled using a size 10 K-type file between every rotary instrument. Each root canal was irrigated with 2 mL of 3% NaOCl solution between all instrument changes. Final irrigation was carried out with 17% ethylenediamine tetraacetic acid (EDTA) for smear layer removal. The residual irrigants were removed with 9 mL of distilled water. After instrumentation and irrigation, roots were dried with sterile paper points.

The roots were randomly divided into 8 groups of 12 specimens each (Table 1). Forty-eight teeth (groups 1, 2, 3, and 4) were obturated with gutta-percha and AH Plus[®] sealer (Dentsply DeTrey, Konstanz, Germany) using lateral condensation technique. Another forty-eight specimens (groups 5, 6, 7 and 8) were filled with RealSeal SE system (SybronEndo, Orange, CA, USA), using lateral condensation technique. The coronal surface of RealSeal groups was light cured for 40 s. Cavities were sealed with GC Fuji II (GC

Table 1

Experimental groups		
Specimens (n)	Retreatment technique	Filling material
12	Hedström	RealSeal SE
12	ProFile	Gutta-percha/AH Plus [®]
12	PTUS	RealSeal SE
12	D-RaCe	Gutta-percha/AH Plus [®]
12	Hedström	Gutta-percha/AH Plus [®]
12	ProFile	RealSeal SE
12	PTUS	Gutta-percha/AH Plus [®]
12	D-RaCe	RealSeal SE

PTUS – ProTaper Universal Retreatment System.

¹Note: Resilon is a trademark of Resilon Research, LLC.

Corporation, Tokyo, Japan). Teeth were radiographed in bucco-lingual and mesio-distal directions to evaluate the quality of obturation. Roots were then incubated in saline at 37°C (INCUCCELL, MMM Group, München, Germany) for 3 weeks in order to complete setting of filling material.

Retreatment techniques

In groups 1 and 5 the obturation material was removed using Gates-Glidden drills and Hedström files (VDW GmbH, München, Germany). The coronal third of the root canal fillings were removed using Gates-Glidden drills sizes from 6 to 4 at 300 rpm using crown-down technique. Hedström files sizes 35, 30 and 25 were used sequentially in a crown-down manner for removal of the filling material from the middle and apical thirds until working length was achieved. Apical enlargement was performed with Hedström files up to size #40.

In groups 2 and 6 the obturation material was removed using ProFile rotary instruments (Dentsply Maillefer, Ballaigues, Switzerland), with crown-down technique following the manufacturer's instruction. Instruments were inserted into the canal in constant rotation with light apical pressure, with rotation speed set at 300 rpm. For removal of filling material from coronal third, three instruments were used consecutively: ProFile size 3 and 2 orifice shapers O.S.3 (40/0.06), O.S.2 (30/0.06) and 25/0.06; for the middle third of the root canal: 20/0.06 and 25/0.04 and for the apical third: 20/0.04, 25/0.04 with apical enlargement to size 40, 0.04 taper.

In groups 3 and 7 the obturation material was removed using ProTaper Universal Retreatment System (PTUS) (Dentsply Maillefer, Ballaigues, Switzerland) and with the crown-down technique, as recommended by the manufacturer. Each of three instruments D1 (30/0.09), D2 (25/0.08) and D3 (20/0.07) were sequentially used each for every third of the root canal and were manipulated in a brushing action with lateral pressing movements. Rotational speed was set at 500 rpm, and torque control at 1 N/cm as recommended. After complete removal of filling material, the final canal preparation was performed with finishing ProTaper instruments F3 (30/0.09) and F4 (40/0.06) at working length.

In groups 4 and 8 the obturation material was removed using D-RaCe rotary system (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) and with the crown-down technique, as recommended by the manufacturer. DR1 (30/0.10) instrument was used for removal of filling material from the coronal third of the root canal. Instrument was inserted into the canal in constant movement, with rotational speed set at 1000 rpm, and torque control set at 1.5 N/cm as recommended, using rotary engine motor Rooter (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland). For removal of filling material from the middle and apical thirds, DR2 (25/0.04) instrument was used, with light apical pressure, with rotational speed set at 600 rpm, and torque control set at 1 N/cm as recommended. Further apical preparation was performed with BioRaCe instruments (FKG Dentaire, La Chaux-de-Fonds, Switzerland) BR3 (25/0.06), BR4 (35/0.04) and BR5 (size 40/0.04) at 600 rpm.

During retreatment procedure all samples were irrigated with 3% NaOCl solution between instruments. Canal⁺ (Sep-

todont, Saint-Maur-des-Fossés, France) was used as the lubricant during instrumentation. Final irrigation was performed with 17% EDTA solution followed by distilled water. Canal patency was preserved by stainless steel K files, which was used to establish a glide path before introducing next instrument. Each instrument was cleaned from adherent debris after its use. All instruments were discarded after use in three root canals except DR2 instrument, which is recommended for single use. Rotary NiTi-instruments were driven by low-torque rotary engine motor Rooter (FKG Dentaire SA, La Chaux de Fonds, Switzerland), according to the manufacturer's instructions. Retreatment was considered to be finished when no more gutta-percha or Resilon™ could be seen on the instruments, and the walls of the canal were smooth and free of visible debris.

Debris collection and measurement

Apically extruded debris was collected using a modification of the experimental model described by Myers and Montgomery¹⁵ (Figure 1). Every tooth was secured for instrumentation and debris collection by passing the sample through an opening in a rubber stopper. Eppendorf tube, in which all of the apically extruded debris was collected, was placed below root, so the root apex hung within the receptor tube. Removable rubber stopper, together with specimen and adjusted Eppendorf tube, was placed on the opening of 20 mL volume glass vial. The needle was inserted in the rubber stopper of glass vial to equalize the internal and external pressures. All vials were covered with cofferdam in order to prevent the operator from viewing debris extrusion during retreatment, to ensure data objectification. No contact with collecting tube was possible. Before retreatment, each Eppendorf tube was marked and weighed using the microbalance (OHAUS Pioneer™ Balance, PA214C, Parsippany, NJ, USA).

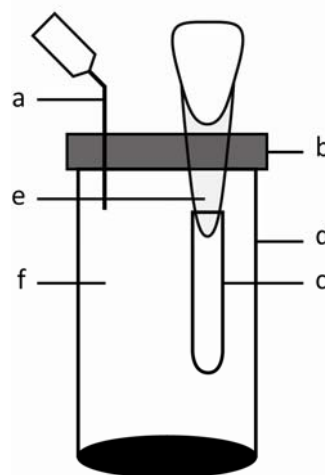


Fig. 1 – Assembly prepared for the evaluation of apically extruded debris during retreatment.

a) disposable needle inserted in the rubber stopper of glass vial to equalize the internal and external pressures; b) rubber stopper to hold the root; c) Eppendorf tube for debris collection; d) glass vial acting as a holder to this assembly; e) root; f) air.

After the retreatment procedure was finished, teeth were separated from the receptor tube and each apical root surface was washed with 0.2 mL of distilled water into the tube, for removing debris still attached to the root. After the removal of the specimens, the collecting tubes were stored in an incubator (INCUCCELL, MMM Group, München, Germany) at 70°C for 5 days to evaporate the moisture before weighing the dry debris. An electronic microbalance (OHAUS Pioneer™ Balance, PA214C, Parsippany, NJ, USA) with an accuracy of 0.1 mg was used for weighing the tubes. Three consecutive measurements were taken for each tube, and the mean value was recorded. The dry weight of extruded debris was calculated by subtracting the weight of the empty tube from the weight of the tube containing the extruded debris.

Statistical analysis

Statistical analysis of the amount of the extruded debris was performed with *t*-test with Bonferroni correction and analysis of variance (ANOVA) combined with *post hoc* Scheffe's multiple comparison tests. Statistical significance level was established at 0.05.

Results

When comparing the amount of apically extruded debris concerning the obturation material for each instrument individually, *t*-test showed no significant difference (Table 2).

In samples obturated with gutta-percha and AH Plus® sealer, ANOVA test showed significant difference in the amount of extruded debris between the tested instruments (Table 3). Results of the post hoc Scheffe's test showed no significant difference between tested rotary instruments. D-RaCe, ProFile and ProTaper instruments gave significantly less extruded debris compared to Hedström hand files (Table 3).

In samples obturated with RealSeal SE system, ANOVA test showed significant difference for the amount of extruded debris between the tested instruments (Table 3). Post hoc Scheffe's test showed significant difference only between D-RaCe and Hedström instruments. A significantly lower amount of debris was measured when D-RaCe instruments were used compared to Hedström instruments (Table 3).

Discussion

Apically extruded debris is considered as one of the reasons for endodontic treatment failure, but also has a large impact on retreatment procedure failure. It has been convincingly demonstrated that periapical pathological lesions consistent with apical periodontitis, may be caused by foreign bodies present within the periapical tissues¹⁶. Also, the inflammatory response is likely to be more severe with the increase of the amount of apically extruded debris¹⁷.

Methods of evaluation of apically extruded debris are different in various studies, but some can be comparable. Few studies used visual evaluation, directly or on radiography^{12, 18–23}. This is a qualitative method of evaluation where one can't have insight into the amount of material extruded through the apical foramen. Compared with an analytical balance, visual examination is not an accurate method of evaluation²⁴.

In the present study, quantitative evaluation method of apically extruded debris provided numerical results comparable to results of other authors^{3, 9, 10, 25, 26}. A significantly higher amount of apically extruded debris was recorded during retreatment when hand instruments were used in comparison to rotary instruments, which is consistent with results of other studies^{3, 9, 10}. Bharathi et al.⁹ measured significantly less extruded debris after retreatment with ProFile instruments, compared to hand Hedström files and Hedström files in com-

Table 2

Comparison of apically extruded debris regarding the filling material for each instrument individually

Filling material/Retreatment techniques	DF	<i>t</i> -value	<i>p</i> -values
AH Plus® gutta-percha (Hedström)/RealSeal (Hedström)	22	1.76	0.0927
AH Plus® gutta-percha (ProFile)/RealSeal (ProFile)	22	0.71	0.4854
AH Plus® gutta-percha (PTUS)/RealSeal (PTUS)	22	0.35	0.7328
AH Plus® gutta-percha (D-RaCe)/RealSeal (D-RaCe)	22	1.72	0.1002

PTUS – ProTaper Retreatment System; DF – degree of freedom.

Table 3

Weight of apically extruded debris during retreatment of samples obturated with gutta-percha and AH Plus® sealer and with RealSeal SE systems

Retreatment technique	Weight of debris (g), $\bar{x} \pm SD$	
	Gutta-percha/AH Plus® sealer	RealSeal System
Hedström	0.0069 ± 0.0016 ^a	0.0056 ± 0.0019 ^a
ProFile	0.0044 ± 0.0028 ^b	0.0038 ± 0.0016 ^{b, a}
PTUS	0.0044 ± 0.0028 ^b	0.0037 ± 0.0016 ^{b, a}
D-RaCe	0.0036 ± 0.0018 ^b	0.0025 ± 0.0014 ^b
ANOVA	<i>p</i> = 0.0007	<i>p</i> = 0.0005

\bar{x} – arithmetic mean; SD – standard deviation; PTUS – ProTaper Retreatment System. Scheef's post hoc test – means followed by the same letters are not significantly different (*p* > 0.05).

combination with a solvent. Also, rotary instruments (Mtwo and Reciproc) proved to be more successful than Hedström files concerning the amount of apically extruded debris¹⁰.

In the study of Topçuoğlu et al.²⁷, all evaluated retreatment techniques caused the apical extrusion of debris. Investigators concluded that hand files produced significantly more debris than ProTaper, D-RaCe, and R-Endo rotary systems, while there was no statistical difference among rotary systems, which is in compliance with the results of the present study.

Findings of previous studies indicate that the rotary instruments tend to direct debris coronary rather than apically^{3,9,10,25}. It can be assumed that the crown-down technique, which enables faster elimination of gutta-percha from coronal third of the root canal, reduced possibility of debris extrusion during the removal of the remaining sealer from the apical third, allowing evacuation of the contents in the coronal direction. The reason why crown-down technique was used in retreatment procedure is the fact that it has been proved for less debris extrusion when compared to other techniques¹.

However, it should be noted that there are conflicting results regarding the amount of extruded material comparing hand vs. rotary instruments. A study conducted by Somma et al. resulted with significantly greater amount of apically extruded debris when rotary instruments were used. This disagreement may be referred to the scoring method that was used to assess the amount of debris, which may be less sensitive than quantitative evaluation of debris that was used in the present study.

The design of instruments might have an impact on the quantity of extrusion through the apical foramen^{1,3,5,7,8,28}. Two out of three rotary instruments used in the present study, are specially designed for endodontic retreatment. When using those instruments in the retreatment procedure, less transportation of root canal content in periapical tissue should be expected. D-RaCe system consists of DR1 and DR2 instruments, which are designed with alternating cutting edges as well as a triangular cross section. The first instrument, D1, as DR1 instrument in PTUS, has an active working tip to facilitate the initial penetration of the filling material.

According to Duncan and Chong²⁹, the amount of the extruded material does not necessarily depend on the technique used for root canal filling removal. Some of the authors have concluded that the amount of apically extruded material was not significantly different after comparing various instrumentation techniques^{18-23, 26, 27}. However, all of these studies used visual evaluation of the extruded debris.

Only few studies have compared the amount of apically extruded material during retreatment of teeth filled with Resilon™ system^{12, 13}. In the present study, the measured amount of apically extruded material was significantly lower after removing RealSeal system from the root canal, compared to the amount of debris measured after the removal of gutta-percha and AH Plus® sealer, but without any significant difference. This indicates that the type of filling material did not play a significant role in the amount of apically extruded debris, which is in compliance with the results of other authors¹².

In Al-Haddad and Che study¹³, during removal of RealSeal™, no significant difference was found between groups regarding obturation technique or type of files used during retreatment.

Conclusion

In the present study, apical extrusion was recorded during retreatment of teeth obturated gutta-percha/AH Plus® sealer and RealSeal SE system and the lowest amount of debris was measured after the use of D-RaCe instruments, and the highest amount when using Hedström files, with a significant difference ($p < 0.05$). There was significantly less debris when using rotary instruments versus hand instrumentation technique ($p < 0.05$). Between tested rotary instruments, no difference in apically extruded debris was found ($p > 0.05$). Further research on the amount of apically extruded debris is required, with the application of instruments specially designed for removal of different obturation materials, on both straight and curved root canals.

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