Apical extrusion of root canal filling material during the removal of gutta-percha and resilon

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SUMMARY
Introduction Root canal filling material may be extruded during retreatment through the apical foramen and cause flare-up or chronic infection. The aim of this study was to compare the apical extrusion of gutta-percha and resilon filling materials during retreatment using hand and rotary instruments.

Methods Sixty extracted single-rooted teeth with single, straight canal were selected. Canals were prepared with ProTaper Universal rotary system to a size F2. Two groups (30 teeth in each) were filled with gutta-percha or resilon points, respectively. In both groups teeth were randomly divided into the three subgroups (10 teeth in each), based on the instruments used for retreatment: Hedstrom hand files and two rotary groups- ProTaper and Twisted File instruments. Apical extrusion was detected visually, using a 4-degree scoring system. Mean scores were calculated and analyzed statistically (t-test and ANOVA). The level of significance was set at p < 0.05.

Results Under tested experimental conditions, the type of canal filling material did not have significant effect on the results of apical extrusion during retreatment. Significantly more material was extruded in the resilon group when manual, Hedstrom file was used (1.80 ± 1.13) than rotary ProTaper (0.60 ± 0.70) and Twisted File (0.50 ± 0.71).

Conclusions The use of a rotary technique is recommended to minimize apical extrusion, especially when resilon obturation material is removed during retreatment.

Keywords: apical extrusion; gutta-percha; resilon; retreatment; root canal obturation; rotary instruments

INTRODUCTION

Non-surgical retreatment is often indicated as the first choice to eliminate or reduce persistent microbial infection of the root canal system. During this procedure, thorough removal of filling material is an important factor, since it enables adequate chemo-mechanical instrumentation and disinfection of the root canal system, in order to reestablish healthy periapical tissues [1]. One inherent problem related to all root canal treatment procedures is the extrusion of intracanal debris and irrigants through the apical foramen into the periapical tissue that could result in inflammation even infection, as both may be contaminated with microorganisms. This could lead to an interappointment flare-up, postoperative pain, delayed healing or even treatment failure as an undesirable occurrence, both for patient and practitioner [1, 2].

It is generally accepted that none of the currently available instruments and techniques can prepare root canals or remove root-filling material without producing apical extrusion. However, selecting the appropriate retreatment technique could minimize the risk of apical extrusion, even though it may not be prevented [3–6]. During mechanical instrumentation, the number and virulence of extruded microorganisms are decisive and critical factors that determine the extent of the periradicular reaction [6].

Although this qualitative factor is not under the control of the practitioner, selecting techniques such as crown-down instrumentation to provide a gradual approach to the apical end is important. This allows the control of the amount of irritants extruded peripherally [2]. One of the major tasks of dental practitioner during root canal treatment procedures is to use instruments and techniques that minimize the amount of apically extruded debris in order to avoid or minimize irritation of the periapical tissues [6, 7]. The most often used hand files for retreatment are the Hedstrom files. Recently, several nickel-titanium (NiTi) rotary instruments have been specially designed to remove obturation material. The Protaper Universal Retreatment system (Dentsply, Maillefer, Ballaigues, Switzerland) contains three instruments with various tapers and tip diameters: D1 (size 30/.09 taper), D2 (size 25/.08 taper) and D3 (size 20/.07 taper). Also, a new type of instruments-Twisted File (SybronEndo, Orange, CA, USA) has become available, but it has not been specially designed for the removal of obturation materials. The Twisted File system has been developed through a specific manufacturing process [8]. These files have twisted design, not ground surface treatment, triangular cross-section, variable pitch and safe-ended tip that allow their use in retreatment cases. The manufacturer claims that Twisted Files can be used to remove obturation materials. To the
author’s knowledge, no studies are present in the current literature on the apical extrusion of gutta-percha and resilon during their removal with Twisted Files and only one study evaluated the cleaning efficacy of Twisted File instruments in retreatment procedures [9].

Until now, several materials have been used to fill root canals, with gutta-percha being the most popular. However, gutta-percha has two major drawbacks: no adhesion to the canal walls and inability to strengthen the teeth [9]. Recently, a new obturation material has been developed that has some properties similar to gutta-percha. Resilon (Resilon Research LLC, Madison, CT, USA) is a thermoplastic synthetic polymer-based root filling material that bonds to dentinal walls when used in conjunction with an adhesive root canal sealer (Epiphany/Real Seal) and forms a “monoblock” within the canal [10]. The retreatment efficacy of this material has been examined, although not in such extent as gutta-percha, while the apical extrusion during resilon removal has been examined in two studies only [11, 12].

The aim of this study was to compare in vitro the influence of different filling materials (gutta-percha and resilon) and different instruments (Hedstrom files, ProTaper Retreatment and Twisted Files) on the degree of apically extruded debris during retreatment.

**METHODS**

**Teeth selection and preparation**

Sixty extracted single-rooted teeth with single, straight canals without previous root canal treatment and with completely developed root apices were selected. To standardize specimen lengths, all teeth were shortened to 16 mm by removing the crown (with a fissure diamond bur) and standardized specimen lengths, all teeth were shortened to 16 mm by removing the crown (with a fissure diamond bur) in a high-speed handpiece under copious water cooling). After the root canal orifice was identified, canal patency was confirmed with a size 10 K-file (Sensing Flexor Reamer, Dentsply, Maillefer, Ballaigues, Switzerland) until it was visible at the apical foramen. Working length was determined 1 mm short from the observed length. Primary root canal preparation was performed with a NiTi rotary system—ProTaper Universal (Dentsply, Maillefer, Switzerland). Canals were enlarged in a crown-down technique to a size 25 (F2) at working length, for all teeth. Canal irrigation was performed between each successive instrument with 2 ml of 5.25% sodium hypochlorite (NaOCl). Before obturation, a final rinse was performed with 10% citric acid for one minute, to remove smear layer, followed by a rinse with 10 ml of distilled water. The teeth were randomly divided into 2 groups of thirty teeth each (n = 30). After drying with paper points, all root canals were filled using cold lateral compaction technique. One group was filled with gutta-percha points (Protaper Universal F2, Dentsply, Maillefer, Switzerland) and an epoxy sealer (AHplus, Dentsply, Detrey GmbH, Germany); the other group was filled with resilon points (Resilon Research LLC, Madison, CT) and an adhesive, methacyrylate sealer (RealSeal, Root Canal Sealant, SybronEndo, Kerr Corporation, USA). Additional warm vertical compaction of the obturation material was carried out with pluggers. The coronal surface of the resilon group was light cured for 40 seconds, according to the manufacturer’s instruction. Total length of the root canal fillings did not exceed more than 15 mm, so the volume of filling material was approximately equal for all specimens. Obturation quality was confirmed radiographically, in buccolingual and mesiodistal directions. Access openings were sealed with a temporary filling material (Citodur, Dorident, Austria) and samples were stored at 37°C in 100% humidity for 14 days, to allow for complete setting of the sealer.

**Retreatment methods**

Before beginning the retreatment procedure, teeth from both groups (n = 30) were randomly divided into the three groups of ten teeth each, based on the instruments used for retreatment. Each set of instruments was used to retreat maximally 5 root canals and after that discarded. All instruments were used respecting the manufacturer’s instructions. Rotary instruments were used with an endodontic electric motor (X-Smart, Dentsply, Maillefer, Ballaigues, Switzerland) in a crown-down sequence.

In the group 1, hand instrumentation was performed with Hedstrom files (Sensing Hedstrom Dentsply, Maillefer, Switzerland) from size 40–20, in a circumferential quarter-turn push-pull motion and by pushing against the root canal walls until working length was reached. Re-preparation of the canal apical part was carried out with Hedstrom files from size 20 to size 40. In group 2, ProTaper Retreatment instruments (Dentsply, Maillefer, Switzerland) were applied, using D1 file to remove filling material from the coronal portion of the root canal, whereas the material from the middle and the apical third was removed using D2 and D3 files, respectively, using a brushing action with lateral pressing movements. D3 was taken to the working length. After that, ProTaper Universal files size F3 (#30) and F4 (#40) were used, to enlarge the apical preparation. In group 3, Twisted File (TF) instruments (SybronEndo, CA, USA) were used in the following sequence: TF #25/.08 taper instrument was applied in the coronal third and followed by #30 and #35/.06 taper instruments, until reaching the working length. Then, TF #40/.04 was used to enlarge the apical portion of the canal and again TF #25/.08 to additionally clean the canal walls.

During retreatment, the flutes of all instruments were frequently cleaned and 2 ml of 5.25% NaOCl was used after each instrument and also for final irrigation of the canal. Material removal was considered complete when the working length was reached and no more material could be seen on the last instrument and during irrigation. After re-preparation, the canals were irrigated with 10% citric acid for one minute, to remove the smear layer. The canals were finally flushed with 10 ml of distilled water. The same operator performed primary root canal preparation, obturation and retreatment and the procedure was done in the same manner for all samples.
Apically extruded debris

The amount of apically extruded material during the retreatment procedure was detected visually. A different person who was blinded to the experimental group assignment performed scoring of apically extruded debris. The following score system was used [3,11]:
0 – no extruded debris, no filling material escaping through the foramen
1 – minimal extruded debris, small amounts of filling material escaping through the foramen
2 – moderate extruded debris, greater amounts of filling material escaping through the foramen
3 – severe extruded debris, even greater amounts of filling material escaping through the foramen.

Statistical analysis

The obtained data are presented in tables and numerically processed by standard descriptive methods. Mean scores of apically extruded material were calculated. The data were analyzed statistically by t-test and one-way analysis of variance (ANOVA). Analysis was performed with SPSS (version 20) at a significance level $p < 0.05$.

RESULTS

The mean scores and standard deviations (SD) of apical extrusion for each group of material and for each group of tested instruments are presented in Table 1 and 2. The results indicated that in both groups of materials, all of the tested instruments caused apical debris extrusion to some degree. Comparison by t-test of the mean scores for apical extrusion during gutta-percha and resilon removal (Table 1) did not show statistically significant differences between the two materials ($p=0.101$). The highest mean score for apical extrusion (Table 2) was present in the resilon group of material during retreatment with Hedstrom files (1.80±1.13), while the samples that showed the lowest mean score were observed in the gutta-percha group of material when Twisted File instruments were used (0.80 ± 0.39). The difference between these two results was statistically significant (ANOVA, Post Hoc; $p = 0.027$). Analysis of the results by ANOVA in both groups of materials revealed statistically significant differences between instruments only during resilon removal ($p = 0.004$; Table 2). Further statistical analysis with Post Hoc tests indicated that the difference was significant between manual Hedstrom files (1.80 ± 1.13) and the two rotary instruments used, ProTaper (0.60 ± 0.70) and Twisted File (0.50 ± 0.71).

DISCUSSION

Even during primary root canal instrumentation debris such as dentin chips, necrotic pulp tissue, microorganisms and irrigants may be extruded into the periradicular tissues [13]. Successfull non-surgical retreatment depends on complete removal of pre-existing filling material from the canal, where it would be crucial to clean the apical foramen [14]. However, this could promote apical transportation and force obturation material into the periapical tissues [15]. In addition, extrusion during retreatment may be accompanied by solvents, necrotic tissue, bacteria or irrigants, which might be introduced into the apical region [11].

In the present study, apical extrusion was evaluated during removal of gutta-percha and resilon. The results showed that the type of obturation material did not have a significant impact on the mean scores of apical extrusion, although the mean score was higher during resilon removal. Other studies also evaluated the extrusion of obturation material during retreatment [7,15,16,17], but these studies observed only the removal of gutta-percha. Apical extrusion during removal of different materials (gutta-percha, resilon and resin-coated gutta-percha) was compared in one study with a visual technique and a 4-degree scoring system [11]. The authors concluded that the type of filling material did not play a statistically significant role on the amount of apically extruded material, which is consistent with the findings of the presented study. Another group of authors [12] evaluated apical extrusion during gutta-percha and resilon removal using a quantitative method, however the results regarding the difference between the two materials were also not statistically significant.
Using an instrumentation technique that minimizes apical extrusion would be advantageous. Therefore, this aspect should always be investigated for a newly developed root canal instrumentation system [13]. This study evaluated three different instruments (Hedstrom, ProTaper and Twisted File) during retreatment and their impact on apically extruded material. The present study showed that in vitro, all of the tested instruments produced apical extrusion of obturation material and these results are consistent with other apical extrusion studies [7, 11, 12, 14, 16, 18]. As already mentioned, no studies are present in the current literature on the apical extrusion during retreatment with Twisted File instruments. In the present study the highest mean score of extruded material during retreatment was observed in the manual Hedstrom group and the lowest when Twisted File rotary instruments were used. The results of the present study are in agreement with previous retreatment studies that also compared hand and engine-driven instruments and their impact on apical extrusion [7, 12, 14, 16, 17]. This could be explained with rotation and a crown-down preparation technique during instrumentation, which tends to pull dentinal debris into the flutes of the file and direct it toward the coronal part of the canal [3, 19]. Also, rotary movements produce a certain degree of frictional heat which might plasticize the obturation material and facilitate removal [3]. Based on the results of this study, it can be concluded that Twisted File instruments, although not primarily intended for use in retreatment, can be associated with the extrusion of smaller degree of apical debris during material removal. However, these instruments should also be tested in different conditions of experimental set up and in relation to other retreatment efficiency indicators such as canal wall cleanliness, time of retreatment and frequency of instrument fracture.

The majority of investigations used a quantitative method to determine the amount of apically transported material and debris, by collecting and measuring their amount in grams [12, 13, 16, 20, 21]. In some studies the amount of apically extruded filling material during retreatment was detected visually and evaluated with a scoring system [3, 11, 14], as in the present study. Criticism of this kind of evaluation methodology can be made due to the existence of a certain degree of subjectivity as well as less precision in assessing the extruded material amount. However, the reaction of periapical tissues does not depend so much on the quantity of extruded material, as much of its infectious and antigenic potential and the host defense system. It must be emphasized that the results of in vitro studies should not be directly extrapolated to clinical situations. Transported material amount can be lesser in vivo because the presence of periapical tissues may act as a natural barrier against apical extrusion [6].

Further studies on material extrusion with different engine-driven instruments that can be used in retreatment will be needed for clarifying the importance of torque and rotational speed. Also, instruments with reciprocating movements should be evaluated [14, 22, 23]. Moreover, apical extrusion during removal of other obturation materials, such as resilon should be examined in a greater extent.

CONCLUSION

Under the conditions of this in vitro study, all retreatment techniques produced apical extrusion of filling material. The difference between results for apical extrusion for the two materials tested (gutta-percha and resilon) was not statistically significant. However, rotary Twisted File and ProTaper instruments resulted in significantly less debris extrusion compared to hand instruments (Hedstrom files) while removing resilon. There was no significant difference among the two rotary instruments. Therefore, the use of a rotary technique can be recommended to minimize apical extrusion, especially when resilon is removed during retreatment.

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Apikalna ekstruzija materijala za kanalno punjenje tokom uklanjanja gutaperke i resilona

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UVOD

Nehirurški retretman često je indikovan kao terapija izbora kako bi se uklonila ili bar smanjila uporna mikrobna infekcija u kanalnom sistem kanona zuba. Tokom ovog postupka, temeljno uklanjanje materijala za kanalno punjenje je važan faktor koji omogućava adekvatnu hemomehaničku instrumentaciju i dezinfekciju kanalnog sistema, kako bi se omogućilo određivanje količine apikalno ekstrudiranog materijala iz kanalnog sistema kona, primenom različitih instrumenata. U skoroj vremenu je izučeno nekoliko niti-titanijumskih (NiTi) rotirajućih instrumenata posebno namenjenih za uklanjanje opturacionih materijala iz kanalnog sistema kanona zuba. Nehtivok pa je korišćen za uklanjanje opturacionih materijala iz kanalnog sistema kanona zuba. Univerzalni sistem Protaper Retreatment (Dentsply, Maillefer, Ballaigues, Švajcarska) sadrži tri instrumenta različite količine prebačenih i prebačenih inačica, od kojih je najučinkovitija između prostornih prebačenih inačica. Ovo je dobio dovesti do akutne egzacerbacije ili nastanka hronične infekcije. Cilj ovog istraživanja bio je da se ispitaju apikalne ekstruzije materijala tokom uklanjanja gutaperke i resilona, primenom različitih instrumenata.

Materijal i metode rada

Istraživanje je sprovedeno na 60 jednokorenih, jednokanalnih ekstrahovanih bolesti zuba. Primarna preparacija kanona korena vršena je rotirajućim instrumentima tipa ProTaper Universal, do veličine F2. Zubi su podeljeni u dve grupe od po 30 zuba (n = 30) i opturisani gutaperka, odnosno resilon poenima. Svaka grupa je dalje podeljena na tri podgrupe (n = 10) u odnosu na instrumente korišćene za retretman: ručni, Hedstrom i rotirajući, ProTaper odnosno Twisted File instrumenti. Stepen apikalno ispičenih materijala ocenjen je vizualno, pomoću četvorostupenog skala. Izračunate prosečne vrednosti su statistički analizirane (t-test i ANOVA). Prag značajnosti definisan je kao p < 0.05.

Rezultati

U datim uslovima ispitivanja vrsta materijala za punjenje kanona nije imala značajna uticaja na rezultate apikalne ekstruzije. U toku retretmana. Stepen apikalno ispičenih materijala bio je najveći u resilon grupi posle upotrebe turbija Hedstrom, (1,80 ± 1,13) i rezilona (1,80 ± 1,13) i rezilona (1,80 ± 1,13) i rezilona (1,80 ± 1,13). U porastu se različitosti značajnosti različitog značajnosti različitog značajnosti različitog stepea apikalne ekstruzije, u odnosu na instrumente uklanjanja, odnosno rotirajući instrumenti, ProTaper (0,60 ± 0,70), odnosno Twisted File (0,50 ± 0,71).

Zaključak

U toku retretmana materijala iz kanalnog sistema kona, primenom različitih instrumenata, tako i za terapeuta, primenom različitih instrumenata, tako i za terapeuta, primenom različitih instrumenata, tako i za terapeuta, primenom različitih instrumenata, tako i za terapeuta, primenom različitih instrumenata, tako i za terapeuta, primenom različitih instrumenata, tako i za terapeuta.

Ključne reči: apikalna ekstruzija; gutaperka; opturacija kanala korena; resilon; rotirajući instrumenti

KRATKA SADRŽAJ

Uvod: Tokom uklanjanja kanalnog punjenja materijal se može ispitati kroz apekse u periradikularnim tkivima, što može dovesti do akutne egzacerbacije ili nastanka hronične infekcije. Cilj ovog istraživanja bio je da se ispita apikalna ekstruzija materijala tokom uklanjanja gutaperke i resilona, primenom različitih instrumenata.

Materijal i metode rada: Istraživanje je sprovedeno na 60 jednokorenih, jednokanalnih ekstrahovanih bolesti zuba. Primarna preparacija kanona korena vršena je rotirajućim instrumentima tipa ProTaper Universal, do veličine F2. Zubi su podeljeni u dve grupe od po 30 zuba (n = 30) i opturisani gutaperka, odnosno resilon poenima. Svaka grupa je dalje podeljena na tri podgrupe (n = 10) u odnosu na instrumente korišćene za retretman: ručni, Hedstrom i rotirajući, ProTaper odnosno Twisted File instrumenti. Stepen apikalno ispičenih materijala ocenjen je vizualno, pomoću četvorostupenog skala. Izračunate prosečne vrednosti su statistički analizirane (t-test i ANOVA). Prag značajnosti definisan je kao p < 0.05.

Rezultati: U datim uslovima ispitivanja vrsta materijala za punjenje kanona nije imala značajna uticaja na rezultate apikalne ekstruzije. U toku retretmana. Stepen apikalno ispičenih materijala bio je najveći u resilon grupi posle upotrebe turbija Hedstrom, (1,80 ± 1,13) i resilona (1,80 ± 1,13). U porastu se različitosti značajnosti različitog značajnosti različitog stepea apikalne ekstruzije, u odnosu na instrumente uklanjanja, odnosno rotirajući instrumenti, ProTaper (0,60 ± 0,70), odnosno Twisted File (0,50 ± 0,71).

Zaključak: U toku retretmana materijala iz kanalnog sistema kona, primenom različitih instrumenata, tako i za terapeuta, primenom različitih instrumenata, tako i za terapeuta, primenom različitih instrumenata, tako i za terapeuta, primenom različitih instrumenata, tako i za terapeuta.

Ključne reči: apikalna ekstruzija; gutaperka; opturacija kanala korena; resilon; rotirajući instrumenti
Nedavno je razvijen novi materijal za opturaciju, koji je po načinu primene sličan gutaperki. Resilon (Resilon Research LLC, Madison, CT, SAD) jeste materijal za punjenje kanala korena na bazi termoplastičnog sintetičkog polimera koji se vezuje za dentinske zidove kanala korena kada se koristi zajedno sa odgovarajućom adhezivnom pastom (Epiphany / Real Seal) i tako formira “monoblok” unutar samog kanala [10]. Efikasnost uklanjanja ovog materijala iz kanala je ispitivana, mada ne u tolikoj meri kao gutaperka, dok je apikalna ekstruzija tokom uklanjanja resilona ispitana dosad samo u dve studije [11, 12].

Glije ove studije bio je poređenje uticaja različitih materijala za punjenje (gutperke i resilona) i različitih instrumenata (Hedstrom, ProTaper Treatment i Twisted File) na stepen apikalnom ekstrudiranog materijala tokom retretmana kanala u eksperimentalnim uslovima.

**MATERIJAL I METODE**

**Odabir i priprema zuba**

Odabran je šezdeset ekstrahovanih jednokorenenih zuba sa jednim, ravnim kanalom bez prethodnog tretmana kanala i sa potpuno razvijenim vrhom korena. Da bi se standardizovale dužine uzoraka, svi zubi su skraćeni na 16 mm uklanjanjem krunice (dijamantskim svrdlom za turbin i vodenim hlade- njem). Posle identifikacije ulaza u kanal potvrđena je prohodnost kanala turijom veličine 10 K (Senses FlexReamer, Dentsply, Maillefer, Ballaigues, Švajcarska) sve dok njen vrh nije postao vidljiv na apikalnom otvoru korena. Radna dužina je određena za 1 mm kraće od posmatrane dužine. Primarna preparacija kanala koren izvedena je pomoću mašinskog, NiTi rotirajućeg sistema – ProTaper Universal (Dentsply, Maillefer, Švajcarska). Kanali svih zuba su preparisani krucično-apeskom (crowndown) tehnikom do veličine 25 (F2), do radne dužine. Uklanjanje kanala sprovedeno je između svagih instrumenata sa po 2 ml 5,25% natrijum-hipohlorita (NaOCl). Pre opturacije kanala su isprani 10% limunskom kiselinom u trajanju od jednog minuta, radi uklanjanja razmnog sloja, a zatim sa 10 ml destilovane vode. Zubi su nasmiješeni dodeljeni u dve grupe od po trideset zuba u svakoj (n = 30). Posle sušenja kanala papirnim poenima (AHplus, Dentsply, Detrei GmbH, Nemacka); druga grupa je napunjena resilona poenima (Resilon Research LLC, Madison, CT) i adhezivnom, metamikralnom pastom (RealSeal, Root Canal Seamlant, Sibkendo, Kerr Corporation, USA). Dodatna vertikalna kompakcija kanalnog punjenja izvršena je pomoću vertikalnog kompaktera i nabijača. Koronarna površina kanalnog punjenja resilona grupe je svetlosno polimerizovana u trajanju od 40 sekundi, prema uputstvu proizvođača. Ukupna dužina ispuna kanala korena nije prelazila više od 15 mm, tako da je zapremina materijala za punjenje bila približno jednaka u svim uzorcima. Kvalitet opturacije kanala koren potvrđen je radiografski iz bukolingvalnog i meziodistalnog pravca. Koronarni deo korena zuba zapečaćen je materijalom za privremeno zatvaranje (Citodur, Dorident, Austria) i uzorci su čuvani na 37°C u 100% vlažnoj sredini tokom 14 dana, kako bi se omogućilo potpuno vezivanje paste za opturaciju.

**Metode retretmana**

Pre započinjanja retretmana zubi u obe grupe materijala (n = 30) nasumično su podeljeni u tri grupe od po deset zuba, na osnovu instrumenata koji su korišćeni za uklanjanje materijala za opturaciju. Svaki set instrumenata korišćen je za retretman maksimalno pet korenskih kanala i posle toga odbačen. Svi instrumenati su korišćeni po usklađenim uputama proizvođača. Rotirajući instrumenati su pokretani pomoću endodontskog elektromotora (X-Smart, Dentsply, Maillefer, Ballaigues, Švajcarska) u crown-down maniru.

U grupi 1 ručna instrumentacija izvedena je turijama Hedstrom (Senses Hedstrom Dentsply, Maillefer, Švajcarska) veličine 40–20, uz blago potiskivanje vrha instrumenta u materijal, rotaciju za četvrtinu kruga i izvlačenje instrumenta potiskivanjem uz zidove kanala korena, sve do postizanja radne dužine. Ponovna preparacija apikalnog delna kanala obavljena je turijama Hedstrom do veličine 40. U grupi 2 primenjeni su instrumeni ProTaper Treatment (Dentsply, Maillefer, Švajcarska), korišćenjem instrumenata D1 za uklanjanje materijala za punjenje iz koronarnog dela kanala, dok je materijal iz srednje i apikalne trećine uklonjen pomoću instrumenata D2 i D3, korišćenjem blagog pritisaka apikalno uz bočni pritisak na zidove kanala (tzv. pokreti četkanja). Instrument D3 je dosegao radnu dužinu. Posle toga korišćeni su instrumeni ProTaper Universal veličine F3 (# 30) i F4 (# 40), radi učvršćivanja apikalnog dela preparacije. U grupi 3 instrumeni Twisted File (TF) (SybronEndo, CA, USA) korišćeni su prema sledećem re- dosledu: u koronarnoj trećini je primenjen instrument TF # 25 / konicnosti 0,08, a zatim instrumenati # 30 i # 35 / konicnosti 0,06, do dostizanja radne dužine. Zatim je korišćen TF # 40 / 0,04 za proširivanje apikalnog dela kanala i ponovo TF # 25 / konicnosti 0,08, za dodatno čišćenje bočnih zidova kanala.

Tokom retretmana navoju svih instrumenata često su čišćeni i kanali ispirani sa 2 ml 5,25% NaOCl posle svakog instrumen- ta, kao i posle završenog retretmana. Retretman je smatran završenim kada je postignuta radna dužina i na poslednjem instrumentu, kao i u toku irrigacije, nije više bio vidljiv materijal. Posle toga kanali su jedan minut ispirani rastvorom 10% limunskih kiseline, kako bi se uklonio razmazni sloj, a nakon toga destilovanim vodom u količini od 10 ml. Primarno pripazili, opturaciju i retretman kanala sproveda je jedna osoba, kako bi postupak bio obavljen na isti način za sve uzorke.

**Procena apikalne ekstruzije materijala**

Količina apikalno isistnutog materijala tokom postupka retretmana posmatrana je vizualno. Ocenjivanje količine apikalno ekstrudovanog materijala i debrisa izvršilo je drugo lice, kome nije bilo poznato pripadnost uzoraka eksperimentalnim grupama. Korišćen je sledeći sistem za ocenjivanje [3, 11]:

0 – bez vidljive ekstruzije debrisa i materijala za punjenje kroz foramen; 1 – minimalna, jedva primetna količina istisnutog materijala i debrisa kroz foramen; 2 – umerna, lako primetna količina materijala za punjenje isistnutih kroz foramen; 3 – ekstruzija znatne količine materijala za punjenje kroz foramen.

**Statistička analiza**

Dobijeni podaci su predstavljeni u tabelama i numerički obrađeni po standardnim deskriptivnim metodama. Izračunate su srednje

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vrednosti rezultata apikalno ekstrudiranog materijala. Podaci su statistički analizirani pomoću t-testa i jednosmerne analize varijanse (ANOVA). Analiza je izvršena pomoću programa SPSS (verzija 20) na nivou značajnosti p < 0,05.

**REZULTATI**

Srednje vrednosti i standardna devijacija za apikalnu ekstruziju za svaku grupu materijala i za svaku grupu testiranih instrumenata predstavljeni su u tabelama 1 i 2. Rezultati su pokazali da su u obe grupe materijala svi ispitivani instrumenti doveli do apikalne ekstruzije debrisa u nekom stepenu. Poređenje srednjih vrednosti pomoću t-testa, dobijenih za apikalnu ekstruziju tokom uklanjanja gutaperke i resilona (Tabela 1), nije ukazalo na statistički značajne razlike između dva materijala (p = 0,101). Najveća količina apikalnog isnutog materijala (Tabela 2) bila je prisutna u grupi kada je resilon uklanjan turpijama Hedstrom (1,80 ± 1,13), dok su uzorci sa najmanjom količinom isnutog materijala primećeni u gutaperka grupa kada su korišćeni instrumenti Twisted File (0,11 ± 0,33). Razlika između ova dve rezultate je bila statistički značajna (ANOVA, Post-hoc; p = 0,027). Analiza rezultata pomoću ANOVA u obe grupe materijala otkrila je statistički značajne razlike između instrumenta samo tokom uklanjanja resilona (p = 0,004; Tabel 2). Dalja statistička analiza sa post-hoc testovima pokazala je da je razlika bila značajna između ručnih, Hedstrom turpija (1,80 ± 1,13) i dva rotirajuća instrumenta, ProTaper (0,60 ± 0,70) i Twisted File (0,50 ± 0,71).

**DISKUSIJA**

Čak i tokom primarnih instrumentacije kanala korena, dentisti opilici, nekrotično pulpno tkivo, mikroorganizmi i sredstva za irigaciju se mogu isnutiti u periradikularna tkiva [13]. Uspešno sprovođenje nehirurškog retretmana zavisit od potpunog uklanjanja postojećeg materijala za punjenje iz kanala, pri čemu je najvažnije očistiti apikalni foramen [14]. Međutim, time bi se stvorila određeni stepen trenja, što može dodatno omekšati materijal za punjenje i olakšati njegovo uklanjanje [15]. Ova pojava bi se mogla objasniti rotacijom i krunično-apeksnom tehnikom instrumentacije, kojom se teži da se dentinski debris i ostaci materijala povuku u navoje instrumenta i usmere prema koronarnom delu kanala [3, 19]. Takođe, pod vene instrumentacije stvara se određeni stepen trenja, što može dodatno omekšati materijal za punjenje i olakšati njegovo uklanjanje [3]. Na osnovu rezultata ove studije može se zaključiti da su ispitivani instrumenti Twisted File, iako nisu prvenstveno namenjeni u svrhu retretmana, doveli do istiskivanja manjeg stepena apikalnog debrisa tokom uklanjanja materijala. Međutim, ovaj aspekt treba istražiti za novorazvijeni sistem za retretma i njihov uticaj na stepen apikalno istisnutog materijala.

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ZAKLJUČAK

U uslovima ove in vitro studije, sve ispitivane metode retetmana proizvele su apikalnu ekstruziju materijala za punjenje. Razlika između rezultata dobijenih za apikalnu ekstruziju tokom uklanjanja dva testirana materijala (gutaperka i resilon) nije bila statistički značajna. Međutim, rotirajući instrumenti Twisted File i ProTaper doveli su do značajno manje ekstruzije materijala u poređenju s ručnim instrumentima (turpije Hedstrom) u toku uklanjanja resilona. Razlika u rezultatima između dva rotirajuća instrumenta nije bila statistički značajna. Zbog toga se upotreba rotirajućih instrumenata generalno može preporučiti za smanjenje apikalne ekstruzije materijala, naročito kada se tokom retetmana uklanja resilon.