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## Učinkovitost sustava ProTaper Universal Retreatment™ i ručne tehnike u endodontskoj reviziji

### Effectiveness of the ProTaper Universal Retreatment™ System and the Manual Technique in Endodontic Retreatment

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#### Sažetak

**Svrha istraživanja:** Željela se procijeniti učinkovitost sustava ProTaper Universal Retreatment™ i ručnih instrumenata kod endodontske revizije korištenjem dvaju otapala gutaperki – Orange Oila i Eucalyptola. **Materijali i metode:** Odabrano je 40 meziobukalnih korijena. Podijeljeni su u četiri skupine po 10 uzoraka: I. skupina – punjenje je uklonjeno sustavom ProTaper Universal Retreatment™ i otapalom Orange Oilom; II. skupina – korijeni su očišćeni sustavom ProTaper Universal Retreatment™ i otapalom Eukaliptolom; III. skupina – uporabljene su pilice Hedström i K-proširivači te otapalo Orange Oil; IV. skupina – punjenje je uklonjeno pilicama Hedström i K-proširivačima te otapalom Eukaliptolom. Uzorke su pregledala tri endodonta ne bi li pronašli ostatke materijala za punjenje. Statistička analiza obavljena je testovima Fisher Exact, Hi-kvadrat i Mann-Whitney. Postavljena granica značajnosti bila je 0,05. **Rezultati:** I. skupina – uklonjeno je 73,3 posto materijala iz koronarne trećine, 46,7 posto iz srednje i 23, 3 posto iz apikalne; II. skupina – uklonjeno je 83,3 posto materijala iz koronarne trećine, 43 posto iz srednje i 40 posto iz apikalne; III. skupina – uklonjeno je 90 posto materijala iz koronarne trećine, 80 posto iz srednje i 70 posto iz apikalne; IV. skupina – uklonjeno je 100 posto materijala iz koronarne trećine, 80 posto iz srednje i 63,3 posto iz apikalne. **Zaključak:** K-proširivačima i pilicama Hedström postignuti su bolji rezultati negoli sustavom ProTaper Universal Retreatment™ u uklanjanju materijala za punjenje, bez obzira na to koje se otapalo upotrijebilo.

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#### Adresa za dopisivanje

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#### Ključne riječi

gutaperka; otapala; stomatološki instrumenti; revizija; zubna pulpa, komora

#### Uvod

Ponovna endodontska obrada potrebna je ako je, nakon primarne terapije, infekcija i dalje prisutna i nekirurški je pristup prvi izbor (1) sa sličnim postotkom uspjeha kao i kirurški (2). Prema mišljenju Somme i njegovih suradnika, strojnim NiTi-instrumentima ostvaruju se bolji rezultati u slučaju endodontske revizije (3). U istraživanju Hülsmana i kolega (4) strojni instrumenti su se pokazali bržima nego li ručni. Njihova druga prednost je manja mogućnost perforacije i sigurniji su u terapiji zakrivljenih korijenskih kanala (5–7).

Strojni sustav ProTaper Rotary™ unaprijeđen je u sustav ProTaper Universal™ u koji su uključeni instrumenti za oblikovanje, završnu obradu i reviziju (8). U odnosu prema prvom sustavu, u taj novi, osuvremenjeni, dodana su tri instrumenta za reviziju – D1, D2, D3, zatim za završnu obradu – F4 i F5 te opturator ProTaper™ i šiljci gutaperke. Sustavom ProTaper Universal™ željelo se olakšati uklanjanje materijala za punjenje. Svaki instrument ima različitu dužinu, konicitet i promjer apikalnog vrška. Tako D1 ima aktivni vršak

#### Introduction

Endodontic retreatment is indicated when, following initial or primary endodontic treatment, the existing infection persists and nonsurgical retreatment is the first option (1), with a percentage of success similar to that obtained by endodontic treatment (2).

In the cases which require retreatment, the rotary instruments manufactured with nickel titanium (NiTi) show better results than the manual instruments, according to Somma *et al.* (3). In studies by Hülsmann *et al.* (4), the rotary systems were considered faster than the manual ones. Other advantages of using the rotary systems are that they take less time to prepare and they ensure the safety of curved canal treatment (5-7).

The ProTaper Rotary™ system has been upgraded to the ProTaper Universal™ system, which includes shaping, finishing and retreatment instruments (8). With respect to the original kit, the new system was integrated with 3 new ProTaper™ retreatment files, D1, D2, D3, two new ProTaper™ finishing files, F4 and F5, and with the ProTaper™ obturator

kako bi se olakšalo prodiranje u materijal za punjenje, dug je 16 milimetara i ima promjer 0,30 milimetara te nagib od 0,09 posto. Instrument D2 služi za uklanjanje materijala iz srednje trećine korijena i dug je 18 milimetara s promjerom vrška od 0,25 milimetara te nagibom od 0,08 posto. Instrumentom D3 uklanja se materijala iz apikalne trećine korijena, dug je 22 milimetra, ima vršak promjera 0,20 milimetara i konicitet od 0,07 posto te prvi postiže punu radnu dužinu (WL) (9).

Prema mišljenju Koste i suradnika (10), kako bi se pojednostavnilo uklanjanje materijala za punjenje iz korijenskih kanala a da se pritom zubi ne oštete, liječnici se moraju koristiti otapalima koja ga rastvaraju.

Svrha istraživanja bila je procijeniti učinkovitost sustava ProTaper Universal Retreatment™ i ručnih instrumenata kod endodontskih revizija koristeći se dvama otapalima gutaperke – Orange Oilom i Eucalyptolom.

## Materijali i metode

### Odabir uzoraka

Stotinu meziobukalnih kanala prvih kutnjaka dobiveno je od Banke zuba triju odjela – za protetiku te oralnu i facijalnu kirurgiju Stomatološkog fakulteta Federalnog sveučilišta Pernambuco, nakon što je istraživanje odobrilo Etičko povjerenstvo Središta za medicinske znanosti.

### Instrumentacija korijenskih kanala

Studenti dodiplomske nastave Stomatološkog fakulteta Federalnog sveučilišta Pernambuco izradili su pristupne kavitete te korijene obradili instrumentima. Za određivanje radne dužine (WL-a) uporabili su K-instrument #10 (Dentsply-Maillefer, Ballaigues, Švicarska) tako da su ga unosili sve dok vrh nije bio vidljiv na zubnom otvoru. Radna dužina određena je tako da je bila jedan milimetar kraća od dužine dobivene mjerenjem prvim instrumentom. Uzorci su do caklinsko-cementne granice uronjeni u autopolimerizirajuću polietilensku smolu Cristal (Assunção Representações e Comércio Ltda, Recife, Brazil), stavljeni u plastične kalupe za ledene kockice (Plasútil, Bauru, Brazil) i stabilizirani na anatomsom vratu voskom #7 (Wilson, Sao Paulo, Brazil). Izvađeni su nakon 48 sati. Kako bi se spriječio ulazak i polimerizacija smole u apikalni foramen korijenski su otvori/apeksi zapečaćeni voskom (Wilson, Polidental Indústria e Comércio Ltda, Sao Paulo, Brazil). Korijenski kanali obrađeni su tehnikom instrumentacije Double-Flared (11) instrumentima NiTiFlex (Dentsply-Maillefer, Ballaigues, Švicarska). Prošireni su do master-apikalnog instrumenta #25.

Ispiranje korijenskih kanala obavljeno je tek pripremljenom otopinom 1-postotnog natrijeva hipoklorida (Roval, Recife, Brazil) i etilenskom diamintetraoctenom kiselinom (EDTA-om) (Biodinâmica, Paraná, Brazil) kao kelirajućom otopinom. Irigacija se obavljala na početku instrumentacije, nakon svake promjene instrumenata i na kraju biomehaničke preparacije korijenskih kanala.

and gutta-percha points. The 3 ProTaper Universal™ system retreatment files are designed to facilitate the removal of filling material. Each file has different lengths, tapers, and apical tip diameters. The D1 instrument has an active tip to facilitate initial penetration into the filling material; the D1 instrument has a length of 16 mm, a tip of 0.30 mm, and a 0.09% taper. The D2 instrument for removal of filling material at the level of the middle third of the root has a length of 18 mm, a tip of 0.25 mm, and a 0.08% taper. The D3 instrument for apical filling removal with a length of 22 mm, a tip of 0.20 mm, and a 0.07% taper is used to reach the working length (WL) (9).

According to Kosti *et al.* (10), to facilitate the removal of filling material without damaging the tooth, chemical solvents have been used to dissolve the filling material.

Thus, the aim of the present study was to evaluate the effectiveness of the ProTaper Universal Retreatment™ system and manual files in endodontic retreatment using two gutta-percha solvents, Orange Oil and Eucalyptol.

## Materials and Methods

### Sample selection

One hundred mesiobuccal canals of human mandibular first molars obtained from the Tooth Bank of the Department of Prosthetics and Oral and Facial Surgery of the Federal University of Pernambuco were selected with the approval of the Ethics in Research Committee of the Center of Health Sciences of the University.

### Root canal preparation

The root canals were instrumented by undergraduate students of the Federal University of Pernambuco. Coronal access was made. To determine the WL, a #10K-file (Dentsply-Maillefer, Ballaigues, Switzerland) was inserted into the mesiobuccal canal until it was visible at the apical foramen. The WL was calculated to be 1 mm less than the length obtained with this initial file. The samples were imbedded in autopolymerisable polyethylene resin Cristal (Assunção Representações e Comércio Ltda, Recife, Brazil) to the level of the cemento-enamel junction, using a mould consisting of a plastic tray used for making ice blocks (Plasútil, Bauru, Brazil), stabilised through the anatomical neck by a bar of #7 wax (Wilson, Sao Paulo, Brazil) and removed from the mould after 48 h. In order to prevent the resin from entering the apical foramen and polymerising inside it, the apices of the specimens were sealed with wax (Wilson, Polidental Indústria e Comércio Ltda, Sao Paulo, Brazil). The canals were instrumented by the Double-Flared Instrumentation Technique (11) with the NiTiFlex files (Dentsply-Maillefer, Ballaigues, Switzerland). The root canals were enlarged to a master file size of #25.

A freshly prepared 1% sodium hypochlorite solution (Roval, Recife, Brazil) was used in conjunction with ethylenediaminetetraacetic acid (Biodinâmica, Paraná, Brazil) as a chelating agent for irrigating the root canals. The irrigation was performed at the start of the instrumentation, between the changes of instrument, and at the end of the biomechanical preparation.

## Punjenje korijenskih kanala

Korijenski kanali osušeni su sterilnim papirnatim šiljcima i napunjeni gutaperkom tehnikom hladne lateralne kondenzacije (Dentsply-Maillefer, Ballaigues, Švicarska) sa cementom na bazi cinkova oksid-eugenola (Fill Canal sealer, Dermo Laboratórios LTDA, Rio de Janeiro, Brazil). Pristupni kaviteti privremeno su zatvoreni Cavitom (3M ESPE, Seefeld, Njemačka). Zubi su stavljeni u gazu natopljenu fiziološkom otopinom koja se mijenjala svaka dva tjedna i pohranjeni na temperaturi od 37°C i 100 posto vlažnosti tijekom 10 godina.

## Procjena punjenja

Zubi su slikani u vestibulo-oralnom i meziodistalnom smjeru kako bi se procijenila kvaliteta punjenja korijenskih kanala. Nakon razvijanja radiograme su analizirala tri endodonta. Svaki je procijenio 200 rtg-snimaka gledajući ih pod peterostrukim povećanjem (CRS, Sao Paulo, Brazil) i slijedeći navedene kriterije (12):

- dužinu punjenja korijenskog kanala: punjenje završava jedan do dva milimetra od radiološkog apeksa;
- homogenost punjenja: punjenje je odgovarajuće tamo gdje je radioopakni materijal u korijenskom kanalu potpuno homogen i nema prostora između materijala i stijenki kanala.

Za istraživanje su bili odabrani samo zubi s čijom su se procjenom složili svi ispitivači. Postavljenim kriterijima odgovaralo je 40 od 100 početnih uzoraka.

## Tehnika revizije

Uzorci su nasumce podijeljeni u četiri skupine po 10 uzoraka:

I. skupina – punjenje je iz korijenskih kanala uklonjeno sustavom ProTaper Universal Retreatment™ (Dentsply/Maillefer, Baillaigues, Švicarska). Instrumenti su odabrani prema uputama proizvođača. Kanali su obrađeni instrumentima Crown-down, a uporabljen je ProTaper D1 za uklanjanje materijala za punjenje iz koronarnog dijela kanala, a ProTaper D2 i ProTaper D3 primijenjeni su za instrumentaciju srednje i apikalne trećine korištenjem lateralnog/bočnog pritiska i pokreta kao pri četkanju zuba. Instrument ProTaper D3 uveden do pune radne dužine (WL) (3) uporabom otapala Orange Oil (Orange Oil, Phormula Ativa, São Paulo, Brazil). Uporabljen je i električni motor (Driller Endo-Pro Torque, Sao Paulo, Brazil) sa 600 okretaja u minuti i zakretnim momentom od 3,5 N/cm.

II. skupina – punjenja iz korijenskih kanala uklonjena su sustavom ProTaper Universal Retreatment™ i otapalom Eucalyptolom (Biodinâmica, Paraná, Brazil)

III. skupina – punjenja korijenskih kanala uklonjena su pilicom Hedström i K-proširivačem (Dentsply-Maillefer, Ballaigues, Švicarska) uz korištenje otapala Orange Oila. Instrument #15 oprezno je umetnut u korijenski kanal dok se nije naišlo na otpor. Tehnikom Crown-down uporabljene su pilice Hedström od veličine 45 do 15. Nakon toga je apikalno širenje obavljeno postupno K-proširivačem u veličinama 15, 20 i 25.

## Canal obturation

The root canals were dried with sterile paper points and filled with gutta-percha (Dentsply-Maillefer, Ballaigues, Switzerland) and a zinc oxide-eugenol-based sealer (Fill Canal sealer, Dermo Laboratórios LTDA., Rio de Janeiro, Brazil) using a cold lateral condensation technique. Accesses to the cavities were temporarily sealed with Cavit (3M ESPE, Seefeld, Germany). The teeth were embedded in gauze containing saline solution, which was renewed every 2 weeks, and were stored at 37°C in 100% humidity for 10 years.

## Evaluation of the obturation

Buccolingual and mesiodistal radiographs were taken to evaluate the quality of the root canal filling. After processing, the radiographs were mounted in slide frames to allow them to be evaluated by the three examiners, who were specialists in endodontics. Each examiner evaluated the 200 radiographs, viewing them on a magnifier-viewer with the aid of a fivefold magnifier (CRS, Sao Paulo, Brazil) according to the criteria below (12):

- Length of the root filling: root filling ending 1-2mm from the radiographic apex.
- Root canal seal: seal adequate when radiopaque material in the root canal was homogenous and no space was seen between the material and the walls of the canal.

Only the specimens for which there was agreement between the three evaluators were included in the study. Forty of the 100 specimens initially selected were in accordance with the criteria established.

## Retreatment technique

Subsequently, the specimens were randomly divided into four groups composed of 10 specimens each:

Group 1 – the root canal fillings were removed by means of the ProTaper Universal Retreatment™ System (Dentsply/Maillefer, Baillaigues, Switzerland). The retreatment files were used according to the manufacturer's instructions. The canals were instrumented in a crown-down sequence using ProTaper D1 file to remove filling material from the coronal portion of the root canal, whereas the middle and apical third of the canals were instrumented using ProTaper D2 and ProTaper D3 files, respectively, using a brushing action with lateral pressing movements. ProTaper D3 file was taken to the working length (3), using Orange Oil (Orange Oil, Phormula Ativa, São Paulo, Brazil) as a solvent solution. The electric motor (Driller Endo-Pro Torque, Sao Paulo, Brazil) was used at a speed of 600 rpm at 3.5 N/cm torque.

Group 2 – the root canal fillings were removed by means of the ProTaper Universal Retreatment System™, using Eucalyptol (Biodinâmica, Paraná, Brazil) as a solvent solution.

Group 3 – the root canal fillings were removed by using Hedström and K-files (Dentsply-Maillefer, Ballaigues, Switzerland), using Orange Oil as a solvent solution. A #15K-file was inserted gently into the root canal until resistance was met. Hedström files from size 45 to 15 were used in a crown-down technique. After this step, apical widening was carried out with the 15, 20, and 25 K-files in incremental order.

IV. skupina – punjenja korijenskih kanala uklonjena su pilicama Hedström i K-proširivačem (Dentsply-Maillefer, Ballaigues, Švicarska) te otapalom Eucalyptolom.

#### Procjena uklanjanja punjenja

Primijenjeni kriteriji za procjenu uklanjanja gutaperke temelje se na onima Hülsmanna i suradnika. (4). Revizija se smatrala završenom kada je posljednji instrument dosegnuo radnu dužinu i na njemu, kada je izvučen, više nije bilo materijala za punjenje kanala.

#### Procjena čistoće zida korijenskog kanala

Nakon uklanjanja materijala zubi su ponovno radiografski snimljeni iz dvaju smjerova te su ih analizirala tri specijalista endodoncije. Njihov je zadatak bio ocijeniti učinkovitost uklanjanja materijala iz pojedinih trećina korijenskog kanala. Ocjene su bile sljedeće:

Ocjena 1: materijal za punjenje u cijelosti je uklonjen, nema radiopaciteta koji bi upućivali na ostatke;

Ocjena 2: radiopakni ostaci upućuju na ostatke materijala za punjenje – od jednoga do tri komadića kraća od dva milimetra;

Ocjena 3: radiopakni ostaci upozoravaju na ostatke materijala za punjenje duže od četiri milimetra.

Podaci su zabilježeni na odvojenim karticama. Rezultati su uvršteni u tablice i statistički obrađeni.

#### Statistička analiza

Analiza je obavljena deskriptivnom i inferencijalnom tehnikom za obradu podataka. Za inferencijalnu tehniku rabio se Fisherov i Mann-Withneyjev test jer nisu bili zadovoljeni preduvjeti za Hi-kvadrat. Učinjen je i Cohen-Kappinov test za potvrdu usklađenosti ispitivača. Postavljena je granica pouzdanosti od 0,05.

#### Rezultati

Orange Oil u kombinaciji s pilicama Hedström i K-proširivačima uklonio je 90 posto materijala za punjenje iz koronarne trećine, 80 posto iz srednje i 70 posto iz apikalne. To otapalo u kombinaciji sa sustavom ProTaper Universal Retreatment™ očistilo je 73,3 posto materijala za punjenje iz koronarne trećine, 46,7 posto iz srednje i 23,3 posto iz apikalne. Korištenjem otapala Eucalyptola te pilica Hedström i K-proširivača uklonjeno je 100 posto materijala za punjenje iz koronarne trećine, 80 posto iz srednje i 63,3 posto iz apikalne. ProTaper Universal Retreatment™ u kombinaciji s otapalom Eucalyptolom očistio je 83,3 posto materijala za punjenje uz koronarne trećine, 43,3 posto iz srednje i 40 posto iz apikalne (tablica 1.).

U tablici 2. predstavljeni su rezultati usporedbe dviju metoda, ovisno o trećinama korijena i korištenom otapalu. Pozornost privlači činjenica da su prosjeci ocjena vrijednosti viši za strojni sustav nego za ručni. Osim toga, statistički je značajna razlika između dviju korištenih metoda u srednjoj ( $p=0,035$ ) trećini s Eucalyptolom kao otapalom i u apikalnoj trećini s Eucalyptolom ( $p=0,035$ ) i Orange Oilom ( $p=0,023$ ).

Group 4 – the root canal fillings were removed by using Hedström and K-files, using Eucalyptol as a solvent solution.

#### Evaluation of filling removal

The criteria adopted to determine gutta-percha removal were based on those described by Hülsmann *et al.* (4). Retreatment was deemed complete when the last file reached the WL, and there was no filling material covering the instrument.

#### Evaluation of the canal wall cleanliness

After the filling material removal, buccolingual and mesiodistal radiographs were taken and evaluated again by three specialists in endodontics blinded to the techniques, who determined the effectiveness of the filling material removal according to the root canal third and the following scores:

Score 1: the filling material was completely removed, no radiopaque image suggestive of remaining filling material being observed;

Score 2: radiopaque image suggestive of remaining filling material was observed from one to three small portions less than 2 mm in length;

Score 3: radiopaque image suggestive of remaining filling material was observed in portions greater than 4 mm in length.

The data were recorded on individual record cards. The results were tabulated and submitted to statistical analysis.

#### Statistical analysis

Descriptive and inferential techniques were used to analyze data. The inferential techniques employed the Fisher and the Mann-Whitney tests, since the conditions for using the chi-square test were not present. The Cohen's kappa test was obtained in order to verify the agreement between the examiners. A level of significance of .05 was adopted.

#### Results

The Orange Oil associated with Hedström and K-files removed 90% of the filling material in the coronal third, 80% in the middle third, and 70% in the apical third, whereas the Orange Oil associated with ProTaper Universal Retreatment™ System removed 73.3% of the filling material in the coronal third, 46.7% and 23.3% in the middle and apical third, respectively. Using Eucalyptol as a solvent, Hedström and K-files removed 100% of the filling material in the coronal third, 80% and 63.3% in the middle and apical third, respectively. The ProTaper Universal Retreatment™ System removed 83.3% of the filling material in the coronal third, 43.3% in the middle third, and 40% in the apical third (Table 1).

Table 2 shows the results of the tests comparing the two methods according to root third and solvent employed. Attention is drawn to the fact that the averages were higher with the rotary system than with the manual one. There were statistical differences between the two methods in the middle third ( $p=0.035$ ) with Eucalyptol, and apical third with Eucalyptol ( $p=0.035$ ) and Orange Oil ( $p=0.023$ ).

**Tablica 1.** Uklanjanje punjenja prema trećinama korijena, otapalu i metodama  
**Table 1** Filling material removal according to root third, solvent and methods.

Trećina • Third	Otapalo • Solvent	Uklanjanje • Score	Metoda • Method				Ukupno • Total	
			Sustav • System ProTaper Universal Retreatment™		K-proširivač i pilice Hedströen • K-file and Hedströen files			
			n	%	n	%	n	%
Koronarna • Coronal	Orange oil • Orange oil	1	22	73.3	27	90.0	49	81.7
		2	8	26.7	3	10.0	11	18.3
		3	-	-	-	-	0	0.0
Ukupno u apikalnoj trećini – Orange oil • Total in the coronal third – Orange oil			30	100.0	30	100.0	60	100.0
	Eucalyptol • Eucalyptol	1	25	83.3	30	100.0	55	91.7
		2	4	13.3	-	-	4	6.7
		3	1	3.4	-	-	1	1.6
Ukupno u apikalnoj trećini – Eucalyptol • Total in the coronal third – Eucalyptol			30	100.0	30	100.0	57	100.0
Srednja • Middle	Orange oil • Orange oil	1	14	46.7	24	80.0	38	63.3
		2	13	43.3	5	16.7	18	30
		3	3	10.0	1	3.3	4	6.7
Ukupno u apikalnoj trećini – Orange oil • Total in the middle third – Orange oil			30	100.0	30	100.0	60	100.0
	Eucalyptol • Eucalyptol	1	13	43.3	24	80.0	37	61.7
		2	5	16.7	5	16.7	10	16.7
		3	12	40.0	1	3.3	13	21.6
Ukupno u apikalnoj trećini – Eucalyptol • Total in the middle third – eucalyptol			30	100.0	30	100.0	57	100.0
apikalna • Apical	Orange oil • Orange oil	1	7	23.3	21	70.0	28	46.7
		2	12	40.0	7	23.3	19	31.7
		3	11	36.7	2	6.7	13	21.7
Ukupno u apikalnoj trećini - Orange oil • Total in the apical third - orange oil			30	100.0	30	100.0	60	100.0
	Eucalyptol • Eucalyptol	1	12	40.0	19	63.3	31	51.7
		2	3	10.0	10	33.3	13	21.7
		3	15	50.0	1	3.3	16	26.6
Ukupno u apikalnoj trećini – Eucalyptol • Total in the apical third – Eucalyptol			30	100.0	30	100.0	57	100.0

**Legenda • Legend**

Uklanjanje 1 • Score 1 = potpuno uklanjanje • Complete removal; 2 = 1-3 ostatka kraća od 2 milimetra • 1-3 remnants less than 2 mm in length; 3 = materijal duži od 4 milimetra • Material present greater than 4 mm in length; n = broj uzoraka • number of specimens; x = broj procjenjivanja • number of evaluations

**Tablica 2.** Usporedba dviju metoda u odnosu prema trećinama korijena i korištenog otapala  
**Table 2** Comparison of the two methods according to root third and solvent employed.

Trećina • Third	Otapalo • Solvent	Prosjeck uspjehnosti prema metodama • Points average by method	p vrijednost • p value
Koronarna • Coronal	Orange oil	PTUR = 12.00; Ručna • Manual = 9.00	$p^{(1)} = 0.280$
	Eucalyptol	PTUR = 10.00; Ručna • Manual = 10.00	$p^{(1)} = 1.000$
Srednja • Middle	Orange oil	PTUR = 12.1; Ručna • Manual = 8.90	$p^{(1)} = 0.247$
	Eucalyptol	PTUR = 12.89; Ručna • Manual = 7.40	$p^{(1)} = 0.035^*$
Apikalna • Apical	Orange oil	PTUR = 13.50; Ručna • Manual = 7.50	$p^{(1)} = 0.023^*$
	Eucalyptol	PTUR = 12.83; Ručna • Manual = 7.45	$p^{(1)} = 0.035^*$

PTUR = sustav ProTaper Universal Retreatment™ • ProTaper Universal Retreatment™ system;

(\*): statistički značajna razlika 5,0 % • significant statistical difference at 5.0%;

(1): Mann-Whitneyjev test • Mann-Whitney test.



## Rasprava

U Rječniku suvremenog endodontskog nazivlja Američke udruge endodonata (13) objavljenog 1998. godine revizija se opisuje kao postupak koji se obavlja zato da se iz endodontskog prostora ukloni materijal za punjenje te očisti i ponovno oblikuje sustav korijenskog kanala. Obično je terapija prije toga bila neodgovarajuća ili se ponovno kontaminirao sustav korijenskih kanala zbog duljeg izlaganja oralnom okruženju. Uspjeh toga nekirurškog endodontskog zahvata povezan je s potpunim uklanjanjem materijala za punjenje (1). Velike su razlike u mnogobrojnim tehnikama koje se primjenjuju. Somma *i suradnici* (3) pokazali su da se instrumentima od NiTi-a postižu najbolji rezultati u usporedbi s ručnima. No, to se ne slaže s rezultatima ovog istraživanja u kojemu se revizijama provedenima sustavom ProTaper Universal Retreatment™ nisu postigli bolji rezultati od onih dobivenih ručnim instrumentima.

Instrumenti D1, D2 i D3 iz sustava ProTaper Universal Retreatment™ indicirani su za uklanjanje materijala za punjenje iz koronarne, srednje i apikalne trećine. Slično „shaping“ i „finishing“ instrumentima, sustav za reviziju ima konveksni poprečni presjek, ali D1 ima radni vršak koji olakšava ulazak u materijal za punjenje (14). U ovom istraživanju je instrument D1 bio manje učinkovit u koronarnoj trećini nego li pilice Hedström i K-proširivači. U istraživanju Hülsmanna i njegovih kolega (4) strojni instrumenti se smatraju bržima od ručnih, što se slaže s nalazima Schirrmeistera *i suradnika* (15). Velika prednost strojnih instrumenata jest sigurnost uporabe u zakrivljenim kanalima (6, 7).

Kao i u našem istraživanju, i Hülsmann sa suradnicima (4) zaključio je da bi nakon obrade strojnim instrumentima, toplinom i otapalima, zahvat trebalo završiti ručnom instrumentacijom kako bi se temeljito očistili zidovi korijenskih kanala.

Rezultati našeg istraživanja potvrdili su nalaze Gergija *i suradnika* (16) koji su usporedili pilice Hedström sa strojnim instrumentima ProTaper i R-Endo. Ni jednim od testiranih sustava ili ručnim instrumentima nije se mogao potpuno očistiti materijal za punjenje sa zidova korijenskih kanala. U istraživanju Schirrmeistera *i suradnika* (17), a oni su usporedili strojni rotary-sustav RaCe™ s pilicama Hedström, rezultati su pokazali da su ručni instrumenti brži od strojnih, no dodatno nisu postigli razliku u kvaliteti uklanjanja materijala, što se poklapa s rezultatima Gergija *i kolega* (16). Naši rezultati ne slažu se s posljednjim istraživanjima jer smo dobili statistički značajnu razliku u uklanjanju materijala za punjenje korijenskog kanala između sustava ProTaper Universal Retreatment™ i ručnih instrumenata. Potrebno je istaknuti da su Gergi *i suradnici* (16), procjenjujući apikalne trećine korijenskog kanala, našli veće količine preostalog materijala za punjenje, što se slaže s rezultatima našeg istraživanja. Schirrmeister *i suradnici* (15) istaknuli su da je u radu sa sustavom ProTaper bio veći rizik od frakture nego li s ručnim instrumentima, a to se ne slaže s mišljenjem Gergija *i suradnika* (16). Ta manja opasnost od loma kod primjene pilica Hedström može se pripisati manjoj zakrivljenosti kanala korištenih uzoraka kod središnjeg sjekutića u gornjoj čeljusti,

## Discussion

In 1998, the Glossary of Contemporary Terminology for Endodontics of the American Association of Endodontists (13) defined retreatment as a procedure performed to remove filling material from the pulp cavity, and also to clean and shape the root canal system again. It is usually performed because the original treatment was not appropriate or because of recontamination of the root canal system by exposure to the oral cavity for long periods. The success of nonsurgical endodontic retreatment is directly related to the complete filling material removal (1). However, there are major differences between the techniques employed. Somma *et al.* (3) showed that rotary instruments manufactured with NiTi presented the best results when compared with manual instruments. Nevertheless, their results are in disagreement with those of the present study, in which the endodontic retreatment performed with the ProTaper Universal Retreatment™ System did not show better results than those obtained with manual instrumentation.

The D1, D2 and D3 instruments of the ProTaper Universal Retreatment™ System are indicated, respectively, for the filling material removal from the coronal, middle and apical thirds. Similar to the shaping and finishing instruments, the retreatment series have a convex cross section; however, D1 has a working tip that facilitates its initial penetration into filling materials (14). The present study showed that the D1 was less efficient than the Hedström and K-files in this third.

In a study conducted by Hülsmann *et al.* Bluhm (4), the rotary methods were considered faster than the manual ones, in agreement with the findings of Schirrmeister *et al.* (15). Another advantage of using the rotary system is that the treatment of curved canals is safe (6, 7).

As in the present study, Hülsmann *et al.* (4) concluded that the use of rotary instruments, heat or solvent solutions in endodontic retreatment procedures should be executed by manual instrumentation in order to achieve a thorough cleaning of the root canal walls.

The results of the present study are corroborated by those of Gergi *et al.* (16), which compared Hedström files and the rotary instruments, ProTaper and R-Endo. None of the systems tested by them, nor the manual files, were capable of completely removing filling material from the interior of the root canal.

In a study conducted by Schirrmeister *et al.* (17) comparing the RaCe™ rotary system with the Hedström files, it was observed that the manual files were faster than the rotary system and, in addition, showed no differences in the quantity of the remaining material, which is in agreement with the studies of Gergi *et al.* (16). However, the results of the present study are in disagreement with those of the latter, since statistically significant differences were observed between the ProTaper Universal Retreatment™ System and manual files in the filling material removal. It is particularly noteworthy that Gergi *et al.* (16), on evaluating the apical third of the root canals, found a larger amount of remaining filling material, which is in agreement with the results of the present study.

što olakšava penetraciju pilica Hedström i sprječava njihovo pucanje. U našem istraživanju nisu zapažene frakture ni kod jedne skupine testiranih instrumenata.

Prema istraživanjima Barletta *i suradnika* (18), na prvim donjim kutnjacima korištenjem Endo-Gripe i K-proširivača te sustava Profile 04 za uklanjanje materijala za punjenje iz korijenskih kanala, pilicama Hedström očišćeno je manje materijala nego strojnim sustavom. Taj je rezultat u skladu s istraživanjem Maciela *i suradnika* (19) koji su se koristili strojnim sustavima ProTaper i K3 te su dobili bolje rezultate negoli ručnim instrumentima, poput pilica Hedström. Schirrmeister *i suradnici* (5) usporedili su ProTaper Universal i RaCe s K-instrumentima te zaključili da ručni instrumenti uklanjaju manju ili u najboljem slučaju istu količinu materijala za punjenje kao i strojni, što je varijanca rezultata ovog istraživanja.

Kosti *i suradnici* (10) usporedili su učinkovitost uklanjanja gutaperke Profile instrumentima s instrumentima Hedström u kombinaciji sa svrdlima Gates-Glidden, no ni na jedan način nije se uspjelo potpuno ukloniti materijal za punjenje, posebice u apikalnoj trećini. Istaknuli su također da nisu uočili veće razlike u učinkovitosti uklanjanja materijala za punjenje, što je u proturječju s rezultatima ovog istraživanja.

Za sva navedena istraživanja u kojima su se strojni instrumenti pokazali boljima u čišćenju materijala za punjenje, u objašnjenju razlika u odnosu prema ovom istraživanju ključan bi čimbenik mogao biti protok vremena između punjenja i njegova uklanjanja.

U dosadašnjim istraživanjima proteklo je vrijeme iznosilo sedam dana do jedne godine, a u ovom istraživanju prošlo je 10 godina, što je bliže kliničkoj svakodnevnici.

Druga važna činjenica koja se mora istaknuti jest da se u mnogim istraživanjima, za razliku od ovoga, liječnici nisu koristili zubima sa zakrivljenim korijenskim kanalima. Zakrivljeni kanali danas su standard u kliničkoj endodonciji, no čine veću poteškoću kod revizije. Istraživanja u kojima se rabe zubi s tim karakteristikama otkrivaju pravu učinkovitost korištenih instrumenata u uklanjanju materijala za punjenje kanala.

S obzirom na testirana otapala, malo je istraživanja koja su ispitala njihovu učinkovitost. Tanomaru-Filho *i suradnici* (20) zaključili su da Xilol, Eucalyptol i Orange Oil imaju svojstvo otapanja. Xilol je bio najučinkovitiji u otapanju standardne gutaperke, a ostala dva bila su bolja u otapanju termoplastične gutaperke. Kao i Tanomaru-Filho *i suradnici* (20), otapanje Xilola, Eucalyptola, Chloroforma i Orange Oila procjenjivali su Magalhães *i njegovi kolege* (21) te su zaključili da je Xilol najbolji, a ostalim su otapalima postigli uglavnom iste rezultate. Rezultati obaju timova slažu se s onima dobivenima u ovom istraživanju u kojemu nije pronađena veća razlika između Orange Oila i Eucalyptola u učinkovitosti uklanjanja gutaperke.

Furthermore, Schirrmeister *et al.* (15) detected that the ProTaper System had a greater risk of fracture than the manual files, which is in disagreement with Gergi *et al.* (16). This lower risk of fracture when Hedström files are used may be due to the small root curve of the specimen used, a maxillary central incisor, thus facilitating penetration of the Hedström files and preventing their fracture. Nevertheless, in the present study no fractures were observed in either of the two instruments tested.

According to Barletta *et al.* (18) studies conducted with first mandibular molars, using Endo-Gripe associated with K files and the Profile.04 system for the filling material removal from root canals, revealed that the Hedström instruments removed less filling material than the rotary system. This result agrees with that of Maciel *et al.* (19), in which the ProTaper and the K3 rotary systems achieved a better performance than manual systems such as the Hedström during the filling material removal from the interior of root canals. Schirrmeister *et al.* (5), in a study comparing the ProTaper Universal and RaCe with K files, observed that the manual instrument removed less, or at most, an equal amount of filling material than the rotary ones, which varies from the present study.

Kosti *et al.* (10) compared the efficacy of the Profile rotary instrument with the Hedström files in combination with the Gates-Glidden drill in the gutta-percha removal, noting that neither of the methods employed was totally effective, especially in the apical third. They also mentioned that the two systems did not present any significant differences in the filling material removal, which is in disagreement with the present study.

In all the above-mentioned studies in which the rotary system was shown to be more efficient, the factor lapse of time between the filling and removal may be the key factor in explaining the divergence in relation to the present study. In the former, this period ranged from seven days to a year, while in the latter it was ten years, which is more in accordance with clinical reality.

Another important factor to be highlighted is the fact that many of the studies, unlike the present one, do not use teeth with a curved canal. Curved canals are now the norm in current clinical endodontics and represent a greater difficulty in endodontic retreatment. The studies in which the teeth present this characteristic reveal the real efficiency of the instruments employed in the removal of root canal filling materials.

Regarding the tested solvent solutions, there are few studies attesting their solvent ability. Tanomaru-Filho *et al.* (20) concluded that the solvents Xilol, Eucalyptol, and Orange Oil showed solvent capacity. Xilol was more efficient for conventional gutta-percha removal and the other solvents were more efficient for thermoplastic gutta-percha removal. In agreement with Tanomaru-Filho *et al.* (20), Magalhães *et al.* (21) evaluated the solvent capacity of Xilol, Eucalyptol, Chloroform and Orange Oil and observed that Xilol was the best solvent, while the others presented the same results among them. Both researches are in accordance with the results obtained in the present study, in which Orange Oil and Eucalyptol did not present significant difference concerning gutta-percha removal efficiency.

## Zaključak

U uvjetima testiranja i u sklopu ograničenja ispitivanja *in vitro*, može se zaključiti da je ovo istraživanje pokazalo razlike između dviju primijenjenih metoda. Ručnom tehnikom s K-proširivačem i pilicama Hedström postignuti su bolji rezultati nego sustavom ProTaper Universal Retreatment™ u uklanjanju materijala za punjenje iz korijenskih kanala, bez obzira na korištena otapala.

## Conclusions

Under the tested conditions and within the limitations of this *in vitro* study, it may be concluded that the present study revealed differences between the two methods. The manual technique with K-file and Hedström files achieved better results than the ProTaper Universal Retreatment™ system in the filling material removal from the root canals, regardless of the solvent solution used.

### Abstract

**Purpose:** The aim of this study was to evaluate the effectiveness of the ProTaper Universal Retreatment™ system and manual files in endodontic retreatment using two gutta-percha solvents, Orange Oil and Eucalyptol. **Material and methods:** Forty mesiobuccal roots were used. The specimens were divided into four groups composed of 10 specimens each: Group 1, the filling material was removed by means of the ProTaper Universal Retreatment™ System + Orange Oil; Group 2; ProTaper Universal Retreatment™ System + Eucalyptol; Group 3, Hedström and K-files + Orange Oil; Group 4, Hedström and K-files + Eucalyptol. The specimens were subsequently evaluated by three endodontists to verify the presence of any remaining filling material. Statistical analysis was carried out by means of the Fisher Exact test, chi-square test and the Mann-Whitney test adopting a significance level of .05. **Results:** Group 1 removed 73.3%, 46.7% and 23.3% of the filling material in the coronal, middle and apical thirds, respectively. Group 2 removed 83.3% of the filling material in the coronal third, 43.3% in the middle third, and 40% in the apical third. Group 3 removed 90% of the filling material in the coronal third, 80% in the middle third, and 70% in the apical third. Group 4 removed 100%, 80%, and 63.3% of the filling material in the coronal, middle and apical thirds, respectively. **Conclusion:** K-file and Hedström files achieved better results than the ProTaper Universal Retreatment™ system in the filling material removal, regardless of the solvent solution used.

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### Key words

Gutta-Percha; Solvents; Dental Instruments; Retreatment; Dental Pulp Cavity

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