

# Komparativna ispitivanja krunicnog zaptivanja metodom poprečnih preseka korena zuba

DOI: 10.2298/SGS0704224M

## Comparative study of coronal sealing ability using root cross sections method

Dejan Marković<sup>1</sup>, Vesna Živojinović<sup>1</sup>, Slavoljub Živković<sup>2</sup><sup>1</sup> Klinika za dečiju i preventivnu stomatologiju Stomatološkog fakulteta u Beogradu<sup>2</sup> Klinika za bolesti zuba Stomatološkog fakulteta u Beogradu<sup>1</sup> Dept. of Pediatric Dentistry, School of Dentistry, Belgrade<sup>2</sup> Dept. of Restorative Dentistry and Endodontics, School of Dentistry, BelgradeORIGINALNI RAD (OR)  
ORIGINAL ARTICLE

### KRATAK SADRŽAJ

**Cilj:** Cilj ovog rada je bio da se ispita kvalitet krunicnog zaptivanja kod zuba opturiranih lateralnom kompakcijom primenom metode poprečnih preseka korena zuba.

**Materijal i metod:** U istraživanjima je korišćeno 98 ekstrahovanih jednokoreni zuba, koji su endodontski obrađeni i podeljeni u dve eksperimentalne grupe. Svi kanali su obrađeni STEP-BACK tehnikom preparacije kanala korena uz primenu 2.5% rastvora NaOCl. Uzorci prve grupe su nakon instrumentacije tretirani rastvorom EDTA radi uklanjanja razmaznog sloja. Svi kanali iz obe grupe su opturirani tehnikom lateralne kompakcije primenom paste SEALAPEX, AH-26 I KETAC-ENDO. Zubi su nakon opturacije potapani u 1% rastvor metilen-plavila tokom 6 dana i potom serijski presečani poprečno na različitoj udaljenosti od gleđno – cementne granice radi evaluacije krunicnog mikropropuštanja. Svaki poprečni presek je posmatran pod mikroskopom na uveličanju 50x.

**Rezultati:** Dobijeni rezultati su generalno pokazali da je u uzoraka opturiranih pastom KETAC-ENDO uočen veći prodor boje nego kod SEALAPEX-a i AH-26. Statistički značajne razlike uočene su u grupi gde razmazni sloj nije uklonjen. Razlika je bila visoko značajna i između uzoraka zuba opturiranih pastom KETAC-ENDO i AH-26 ( $p < .001$ ) i između KETAC-ENDO i SEALAPEXa ( $p < .001$ ).

**Zaključak:** Rezultati ove studije ukazuju da je bolje krunicno zaptivanje ostvareno posle primene paste AH-26 i SEALAPEX nego posle primene KETAC-ENDO cementa.

**Glavne reči:** Krunicno propuštanje, paste za opturaciju, razmazni sloj

### SUMMARY

**Objective:** An in vitro comparison of coronal micro-leakage of three root canal sealers was performed using the dye leakage method.

**Methodology:** Ninety-eight single-rooted human teeth were instrumented and randomly allocated to two groups. In the first group, root canals were treated with EDTA to remove the smear layer. The roots in both groups were obturated using laterally condensed gutta-percha and Sealapex, AH-26 or Ketac-Endo as the sealer. The teeth were suspended in 1% methylene blue dye for 6 days. The teeth were then rinsed, sectioned perpendicular to the long axis and evaluated for coronal dye penetration.

**Results:** In general, Ketac-Endo root canal sealer showed greater dye penetration than Sealapex and AH-26. A statistically significant difference in the coronal penetration of the dye was found in the group with intact smear layer.

**Conclusion:** Highly significant differences between AH-26 and Ketac-Endo ( $p < 0.001$ ) and Sealapex and Ketac Endo ( $p < 0.001$ ) were found.

**Key words:** coronal leakage, sealers, smear layer

Trodimenzionalna hermetična opturacija kanalskog sistema korena zuba biološki inertnim materijalom, kao što je gutaperka u kombinaciji sa različitim pastama, jedan je od osnovnih preduslova uspešnog endodontskog lečenja. Pri tome je neophodno da materijal obezbedi dobro zaptivanje za zidove kanala korena u svim segmentima.<sup>1</sup> Dugo se smatralo da je apeksno zaptivanje glavni razlog za neuspeh, ali je brojnim istraživanjima potvrđeno da je i krunično zaptivanje takođe klinički relevantan faktor za uspeh terapije.<sup>2,3</sup> Međutim, i apeksno i krunično zaptivanje kanala korena zavisi od brojnih faktora, ali pre svega od hemomehaničke preparacije kanala korena, prisustva razmaznog sloja, tehnike opturacije, i vrste paste za opturaciju kanala.<sup>4-8</sup>

Za proveru kvaliteta kruničnog zaptivanja korišćene su brojne metode (bojeni rastvori<sup>5,6,8</sup>) SEM<sup>9</sup>, radioizotopi i trodimenzionalna kompjuterska metodologija.<sup>10</sup> Ipak najpraktičnija i najjednostavnija metoda za ovu vrstu ispitivanja je metoda bojenih rastvora (indijski tuš, metilen plavilo, srebro nitrat) zbog preciznosti, jednostavnosti i praktičnosti.<sup>11</sup>

**Cilj ovog rada** je bio da se ispita kvalitet kruničnog zaptivanja kod zuba opturiranih lateralnom kompakcijom gutaperke i primenom metode poprečnih preseka kanala korena zuba.

## Materijal i metod

Kao materijal korišćeno je 98 ekstrahovanih jednokorenih premolara. Krunice zuba su presećane u predelu gledno-cementne granice dijamantskim diskom i primenom visokoturažne bušilice i uz vodeno hlađenje. Instrumentacija kod svih uzoraka je urađena primenom STEP-BACK tehnike. Radna dužina instrumentacije je određena za 1 mm kraće od dužine endodontskog instrumenta (# 10) kada se pojavi na vrhu korena. Uzorci zuba su instrumentisani do veličine # 50 i tokom instrumentacije ispirani sa 5 ml 2,5% rastvora NaOCl.

Nakon preparacije uzorci zuba su podeljeni u dve grupe (po 45 zuba) a 8 zuba je korišćeno za pozitivnu i negativnu kontrolu. U prvoj grupi preparisani kanali su tretirani 17% rastvorom EDTA i 2,5% rastvorem EDTA radi uklanjanja razmaznog sloja. Finalno ispiranje je urađeno sa 3ml destilovane vode i potom su kanali osušeni papirnim poenima.

Po 45 zuba iz obe grupe je takođe podeljeno u tri podgrupe (po 15 uzoraka) i opturirano lateralnom kompakcijom gutaperke i primenom pasti AH-26, SEALAPEX i KETAC ENDO (Tab. 1). Glavni gutaperka poen je aplikovan u kanal i potiskivan lateralno i apikalno primenom odgovarajućih nabijača i dodavanjem pomoćnih gutaperka poena. Opturacija je kompletirana kada više nije mogao da se plasira nijedan pomoćni gutaperka poen.

The main objective of a successful endodontic treatment is the three-dimensional obturation of the root canal system with a biologically inert material such as gutta-percha in conjunction with various sealers. It is important that obturating materials show a good sealing ability.<sup>1</sup> Although apical leakage is considered a common reason for endodontic failure, coronal microleakage appears to be of equal or greater clinical relevance as a factor of endodontic success.<sup>2</sup> Unfilled access cavity or microleakage through temporary, or even permanent filling materials, may result in root canal contamination.<sup>3</sup> The quality of apical and coronal seal depends on several factors such as chemomechanical preparation, the presence of the smear layer, obturation technique, the type of core material and the sealer.<sup>4,5</sup> Many different methods have been described for the evaluation of coronal microleakage (dye penetration<sup>5,6</sup>, SEM<sup>7</sup>, radioisotopes and three-dimensional computerized methods<sup>8</sup>). One of the most convenient and widely employed method is the dye penetration (indian ink, methylene blue solution) due to its sensitivity, simplicity and convenience.<sup>9</sup>

The aim of this study was to evaluate the coronal sealing ability using the root cross sections method in teeth obturated with lateral condensation of gutta-percha.

## Materials and methods

Ninety-eight human, single-rooted premolars were used. The crowns of the teeth were sectioned at the cement-enamel junction using a high-speed bur and water spray. Working length for each root was then established at 1mm short of the apical foramen using a #10 file, and the step back flaring technique was used to instrument each canal three sizes larger than the first file that bound at the established working length. The root canals were instrumented to a #50 K file, and 5 ml of 2.5% NaOCl was used for irrigating each root canal.

The prepared teeth were randomly allocated to two groups (of 45 roots each), a eight teeth were used as positive and negative controls. In the first group, root canals were treated with EDTA and 2.5% NaOCl to remove the smear layer. Final irrigation was carried out with 3 ml of distilled water and root canals were dried with paper points.

Each group was further randomly divided into three subgroups (15 roots each), and obturated using laterally condensed gutta-percha and one of the following sealers: AH-26, Sealapex and Ketac-Endo (Table 1). The main gutta-percha cone was inserted into the root canal and laterally condensed with a spreader followed by the fitting of accessory cones coated with the sealer. Obturation was complete when no additional accessory cones could be placed into the canal.

Tabela 1. Testirani materijal i distribucija zuba  
Table 1. Tested materials and distribution of teeth

MATERIJAL MATERIAL	PROIZVOĐAČ MANUFACTURER	BROJ KORENOVA NUMBER OF ROOT CANALS	
		BEZ RAZMAZNOG SLOJA WITHOUT SMEAR LAYER	SA RAZMAZNIM SLOJEM WITH SMEAR LAYER
AH 26	Detrey, Dentsplay, Konstanz, Germany	15	15
SEALAPEX	Kerr, Manufacturing, Co	15	15
KETAC-ENDO	ESPE, GmbH, Oberbay, Germany	15	15

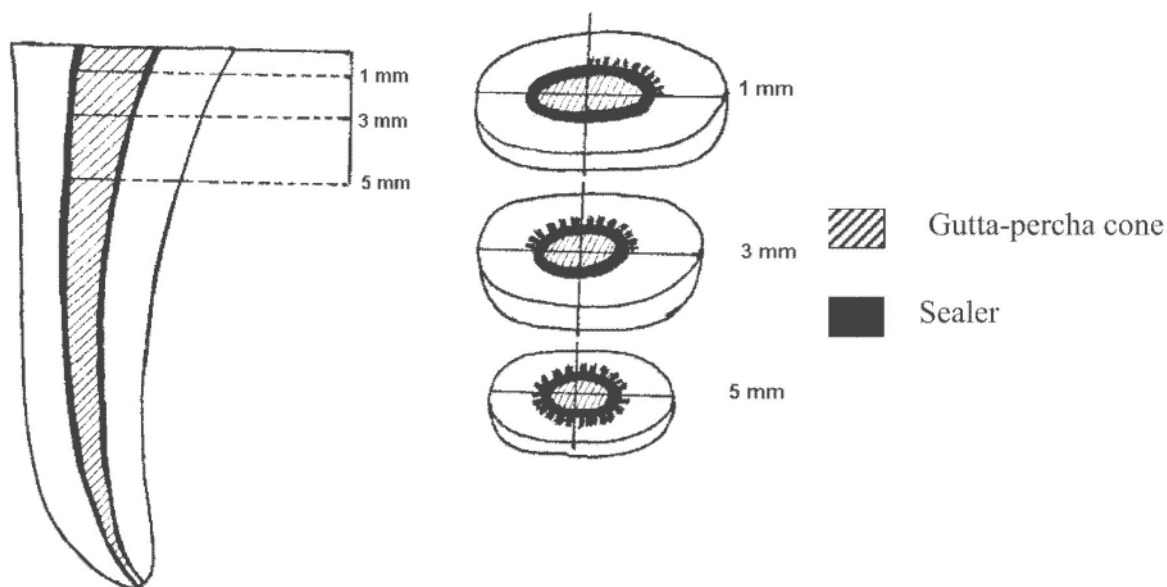
Krunični deo kanala je privremeno zatvoren tankim slojem KAVITA (ESPE GmbH, Seefeld Germany). Posle opturacije zubi su čuvani u fiziološkom rastvoru na 37° C u uslovima apsolutne vlažnosti tokom 8 dana. Posle ovog perioda svaki koren je premazan sa dva sloja laka za nokte izuzev 1mm oko kruničnog dela i zatim potopljen u 1% rastvor metilen-plavila.

Osam zuba je opturirano metodom lateralne kompaktacije ali bez paste. Četiri korena su premazana sa 2 sloja laka celom površinom i služili su kao negativna kontrola, a ostala 4 zuba su premazana sa 2 sloja laka izuzev 1 mm oko kruničnog dela i poslužili su kao pozitivna kontrola.

Posle šest dana uzorci su uklonjeni iz rastvora metilen-plavila, isprani osušeni i potom na svakom korenu dijamantskim diskom napravljeni poprečni preseki na udaljenosti 1mm, 3mm i 5mm od kruničnog dela korena (Sl. 1). Svaki poprečni presek je posmatran pod mikroskopom na uvećanju od 50 puta.

The coronal part of each root canal was sealed with Cavit (ESPE, GmbH, Seefeld Germany). After obturation, all roots were stored at 100% humidity and incubated at 37° C for eight days. After this period, each root was coated with two layers of nail varnish, except for 1 mm in the coronal area, and immersed in aqueous 1% methylene blue dye. Eight roots were obturated with laterally condensed gutta-percha without any sealer. Four of these roots were covered totally with two coats of nail varnish and served as the negative control. The other four roots were covered with nail varnish, except for the coronal 2 mm, and served as the positive control.

After six days, the roots were removed from the dye, rinsed and sectioned perpendicular to the long axis with a diamond disc. Three sections of each root were made at 1 mm, 3 mm and 5 mm from the coronal area (Figure 1). Each section was evaluated under a light microscope using a 360-degree protractor and a goniometric eyepiece at x50 magnification.

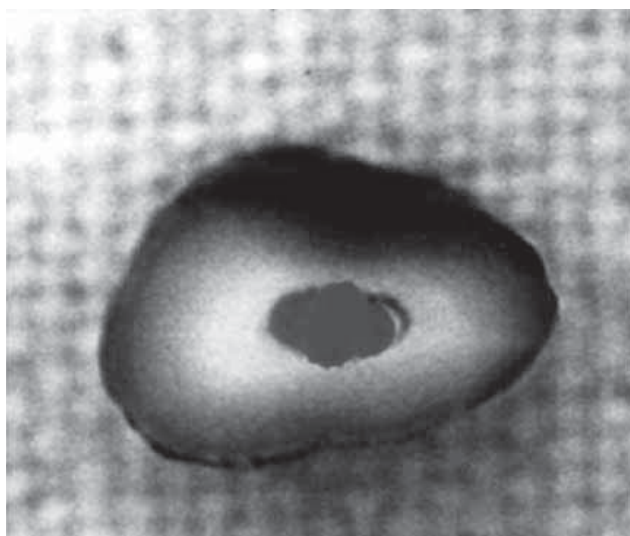


Slika 1. Serijski poprečni preseki u kruničnom delu korena i kriterijumi procene prodora boje.  
Figure 1. Serial cross-sections at the coronal part of the root and criteria of dye penetration

Za procenu krunicnog mikropropuštanja između materijala za opturaciju i zida kanala korena zuba korišćena je sledeća skala (12).

- 0 – nema prodora boje
- 1 – slab prodor boje (90° ili ¼ obima kanala, Sl. 2)
- 2 – srednji prodor boje (180° ili ½ obima kanala)
- 3 – potpuni prodor boje celim obimom kanala (Sl. 3)

Stepen prodora je procenjivan posebno na svaki kanal, a statistička analiza dobijenih rezultata i komparativna analiza urađena je primenom neparametrijskog KRUSKAL-WALLIS i MANN-WHITNEY U testa na nivou značajnosti  $p \leq 0,05$ .

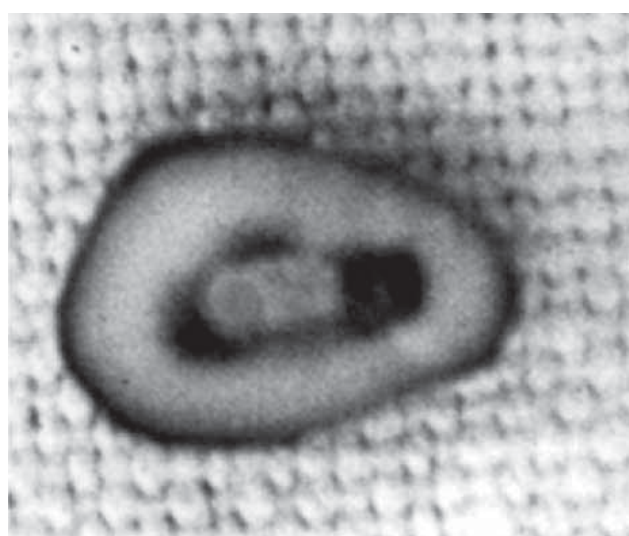


Slika 2. Prodor boje u zub opturisan gutaperkom i pastom Ketac-Endo. Presek na 5 mm udaljenosti od krunicnog dela (ocena 1).  
Figure 2. Dye leakage pattern of tooth obturated with gutta-percha and Ketac - Endo as sealer. Section of root at 5 mm from coronal area (Score 1)

Criteria of the dye penetration between the canal sealer and the root canal wall were defined: (10)

- 0 - no penetration (absence of the dye)
- 1 – slight dye penetration within the root canal (up to 90° or ¼ canal volume) (Figure 2)
- 2 – moderate dye penetration within the root canal (up to 180° or ½ canal volume)
- 3 – complete dye penetration within the root canal (full volume) (Figure 3)

The dye penetration score was determined for each tooth. Values were pooled for each group and statistical analyzed using non-parametric Kruskal-Wallis test and Mann-Whitney U test and the level of significance set at  $p \leq 0.05$ .



Slika 3. Prodor boje u zub opturisan gutaperkom i pastom Ketac-Endo. Presek na 1 mm udaljenosti od krunicnog dela (ocena 3).  
Figure 3. Dye leakage pattern of tooth obturated with gutta-percha and Ketac - Endo as sealer. Section of root at 1 mm from coronal area (Score 3)

## Rezultati

Dubina prodora boje u krunicnom delu korena za svaku grupu zuba prikazana je u tabeli 2. Kod uzoraka sa pozitivnom kontrolom uočen je kompletan prodor boje na svim presecima, a kod uzoraka negativne kontrole prodor boje nije registrovan ni u jednom uzorku.

Analiza krunicnog mikropropuštanja u uzoraka opturiranih pastom KETAC-ENDO je ukazala na značajan prodor boje kod svih preseka zuba (ocena u skali 2). Uzorci zuba opturirani pastom SEALAPEX i AH-26 su pokazali slabiji prodor boje (ocene 0 i 1). Razlika je bila statistički značajna između uzoraka opturiranih SEALAPEX pastom i pastom KETAC-ENDO ( $p < 0.001$ ) u grupi gde razmazni sloj nije uklonjen. U grupi gde je razmazni sloj uklonjen razlika nije bila statistički značajna između testiranih pasti za opturaciju.

## Results

The depth of dye penetration in the coronal area for each group is presented in Table 2. All positive controls showed complete dye penetration. Negative controls showed no dye penetration in all specimens.

Considerable coronal microleakage in obturated canals was observed with the Ketac-Endo in both groups (score 2). Specimens obturated with Sealapex and AH-26 exhibited less coronal penetration of the dye (score 0 and 1). There was a significant difference between Sealapex and Ketac-Endo groups with the smear layer ( $p < .001$ ). However, no significant difference in dye penetration was found in groups without the smear layer.

A statistically significant difference was found in Sealapex group between specimens with and without the smear layer ( $p < .001$ ).

Tabela 2. Dubina prodora boje kod testiranih materijala

Table 2. The depth of dye penetration of tested materials

OCENA SCORE	AH - 26						SEALAPEX						KETAC-ENDO					
	BEZ RAZMAZNOG SLOJA			SA RAZMAZNIM SLOJEM			BEZ RAZMAZNOG SLOJA			SA RAZMAZNIM SLOJEM			BEZ RAZMAZNOG SLOJA			SA RAZMAZNIM SLOJEM		
	WITHOUT SMEAR LAYER			WITH SMEAR LAYER			WITHOUT SMEAR LAYER			WITH SMEAR LAYER			WITHOUT SMEAR LAYER			WITH SMEAR LAYER		
	1mm	3mm	5mm	1mm	3mm	5mm	1mm	3mm	5mm	1mm	3mm	5mm	1mm	3mm	5mm	1mm	3mm	5mm
0	/	12	15	/	9	14	/	12	15	/	10	13	/	10	15	/	/	12
1	/	3	/	/	6	1	/	3	/	/	5	2	/	5	/	/	2	3
2	2	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	13	/
3	13	/	/	15	/	/	15	/	/	15	/	/	15	/	/	15	/	/

Testirajući razlike u dobijenim rezultatima između dve grupe uočena je statistički značajna razlika samo između uzoraka opturiranih SEALAPEX pastom ( $p < 0,001$ ).

Generalno rečeno, rezultati ovih ispitivanja ukazuju da je bolje koronarno zaptivanje ostvareno primenom pasti AH-26 i SEALAPEX, a neadekvatno zaptivanje primenom paste KETAC-ENDO.

## Diskusija

Brojne metode i tehnike se koriste u proveru kvaliteta veze između tvrdih zubnih tkiva i materijala za opturaciju kao što je SEM, radioaktivni izotopi, semikvantitativne metode prodora boje i kompjuterizovane tehnike.<sup>6,8-10</sup>

U ovim istraživanjima metod bojenih rastvora je korišćen zbog preciznosti i mogućnosti jednostavnog i jasnog očitavanja prodora boje na poprečnim presecima. Mnogi autori u kvantifikovanju linearnog prodora boje radije koriste uzdužne<sup>8,13</sup> nego poprečne preseke zuba.<sup>14</sup> Ove studije prilikom procene boje daju sigurne podatke o prodoru boje na vidljivom preseku, ali ne i na pokrivenim površinama. Limkangwalmongkol i sar.<sup>14</sup> na serijskim poprečnim presecima debljine 0,5 mm od apeksa korena zuba prodor boje procenjuju ocenom „uočava se“ ili „ne uočava se“. Sa serijskim presecima se prekida kada se boja na preostaloj površini sečenog korena više ne uočava, već se registruje kvalitetna trodimenzionalna hermetična opturacija.

U ovim istraživanjima na poprečnim presecima je jasno uočavana cirkumferencija kanala i prodor boje na različitim nivoima korena (1 mm, 3 mm i 5 mm) i time olakšana kvantifikacija prodora boje. Serijskim poprečnim presecima od kruničnog dela prema apeksu moguće je registrovati dubinu penetracije duž opturacije celom cirkumferencijom kanala korena zuba. Međutim, problem u ovoj metodi penetracije boje sa serijskim poprečnim presecima je u tome što se analizira mala površina pa to može dati neadekvatne i neprecizne rezultate<sup>12</sup>. Međutim radi

Generally speaking, this study indicated that better coronal seal was achieved by AH-26 and Sealapex, while an inadequate seal was noted with Ketac-Endo.

## Discussion

Several methods are available for analyzing the coronal seal between sealers and dental tissues, such as SEM, radioactive isotopes, semi quantitative methods with dye solutions and three-dimensional computerized methods.<sup>6-10</sup>

In this study, the dye penetration method was used because of its precision, simplicity and the possibility for direct scoring under a microscope. Many authors use longitudinal<sup>8,13</sup> rather than cross sectioning.<sup>14</sup> These studies offer good results on dye penetration on visible but not on covered surfaces. Limkangwalmongkol et al. made 0.5 mm cross sections from the apex and evaluated every slice with a yes/no score.<sup>12</sup> The sectioning was continued until no more dye was seen and a good 3D hermetical obturation was achieved.

In this study, the circumference of the sealer was evaluated after making cross sections at 1 mm, 3 mm and 5 mm from the coronal area, to achieve optimal quantification of dye penetration. The amount of dye penetration was assessed by considering its depth and the penetration along the circumference of the sealer. However, the problem in this dye penetration method is that a small area is analyzed and therefore, the data may be inadequate or imprecise.<sup>12</sup> However, in the present study, a microscope with x 50 magnification was used to obtain precise results.

In this study, methylene blue dye was used because of its smaller molecular size which results in superior penetration ability and its better performance during the meas-

preciznosti u ovom istraživanju je korišćeno uvećanje na mikroskopu od 50 puta sa umetnutim razmernikom.

Izbor metilen plavila sa malim molekulima za procenu koronarnog zaptivanja u ovom istraživanju je potvrdio njegovu dobru kontrastnost i penetraciju i mogućnost lakog očitavanja volumetrijske mikropropustljivosti.<sup>9</sup> Ovaj pasivan mikroprodor boje je takođe blizak kliničkim uslovima i prodoru oralnih fluida.

Takođe, ni uklanjanje razmaznog sloja ne može potpuno eliminisati krunični mikroprodor, jer na to utiču i brojni drugi faktori u opturisanom kanalu. Rezultati ove studije ipak pokazuju da razmazni sloj utiče na linearni i volumetrijski mikroprodor i time nesumnjivo i na uspeh opturacije.<sup>5</sup> Zato je neophodno pre opturacije ukloniti ovaj sloj i na zidovima kanala obezbediti čistu površinu za vezu sa materijalima za opturaciju i time obezbediti preduslove za uspešan tretman kanala korena zuba.<sup>15-17</sup>

Dobijeni rezultati ovih istraživanja pokazuju da nije dan materijal nije ostvario potpuno koronarno zaptivanje. Najveći prodor boje je uočen kod uzoraka opturiranih pastom KETAC-ENDO, a nešto bolje zaptivanje je registrovano primenom paste AH-26 i SEALAPEX.

Pasta AH-26 je pokazala dobro apeksno zaptivanje i dobru adheziju za zidove kanala u mnogim tehnikama opturacije.<sup>14,15</sup> U ovim istraživanjima je takođe ostvareno dobro krunično zaptivanje i dobra veza za zidove kanala primenom tehnike lateralne kompakcije. Veza je naravno bolja ako se ukloni razmazni sloj sa zidova kanala.<sup>15</sup> Iz tih razloga se veći prodor boje na poprečnom preseku 1mm od kruničnog dela posle opturacije i primene paste AH-26 može objasniti činjenicom da se hladna gutaperka ne adaptira dobro uz samu pastu i zidove proširenog u ovom delu kanala, čime se stvaraju uslovi za mikroprodor.<sup>12</sup>

Paste na Bazi kalcijum hidroksida su uvedene u endodontsku terapiju zbog svojih antibakterijskih i bioloških osobina. SEALAPEX kao pasta sa dobrim fizičkim i biološkim karakteristikama je ovde pokazala i dobre kvalitete u kruničnom zaptivanju. Slične rezultate primenom ove paste dobili su Danin i sar.<sup>18</sup> odnosno Holland i sar.<sup>19</sup> u svojim istraživanjima.

Rezultati ove studije su takođe saglasni sa nalazima drugih istraživanja i kada je pasta na bazi glas jonomer cementa KETAC-ENDO u pitanju.<sup>4,20</sup> Na sva tri nivoa poprečnih preseka i u obe grupe registrovan je izrazit prodor boje kod uzoraka, gde je tokom opturacije korišćena pasta KETAC-ENDO. Rezultati ovog istraživanja su saglasni sa nalazima Rhode i sar.<sup>21</sup> i De Almeida i sar.<sup>22</sup> De Almeida i sar. su dobili veći prodor boje primenom paste KETAC-ENDO nego kod uzoraka gde je korišćena pasta FILL KANAL i AH PLUS. U in vitro istraživanjima Rhode i saradnici<sup>21</sup> su uočili veći prodor posle primene paste KETAC-ENDO, dok su Ray i Seltzer<sup>23</sup> demonstrirali dobro zaptivanje i dobru adheziju za zid kanala korena primenom paste KETAC-ENDO.

urement of depth and volumetric microleakage.<sup>9</sup> Similarly, passive microleakage approach was preferred because it is closer to the actual *in vivo* conditions and the penetration of oral fluids.

Undoubtedly, the removal of smear layer alone cannot eliminate coronal microleakage because a number of other factors may affect leakage into the filled root canals. Nevertheless, as indicated by the results of this study, the smear layer affects the linear and volumetric coronal micro penetration and consequently the success of the obturation.<sup>5</sup> Therefore, it may be prudent to create as clean as possible dentinal surface, and the removal of the smear layer may be considered an essential step in the process of successful root canal treatment.<sup>15-17</sup>

According to the results of this study, no material showed a complete coronal seal. Greater leakage was observed in samples sealed with Ketac-Endo, while satisfactory coronal sealing ability was observed with Sealapex and AH - 26.

AH - 26 showed a good apical seal and satisfactory adhesion to the dentinal walls in many obturation techniques.<sup>14,15</sup> In this study, we also verified a good coronal seal and adhesion to the canal walls using lateral condensation of gutta-percha. This might also be due to the removal of the smear layer.<sup>15</sup> The reason for the weaker coronal seal in sections 1 mm from the coronal area in combination with lateral condensation could be that thin gutta-percha points do not adapt well with the sealer paste and canal walls, which are widened in this region, and this may lead to microleakage.<sup>12</sup>

Calcium hydroxide sealers have been widely used in endodontics because of their antimicrobial and biological properties. Sealapex possesses good physical and biological properties and has shown in this study satisfactory coronal sealing ability. Similar results were reported by Danin et al.<sup>18</sup> and Holland et al.<sup>19</sup>

The results of this study are in agreement with literature data with regards to Ketac-Endo.<sup>4,20</sup> In all three levels of sectioning, complete dye penetration occurred in both Ketac-Endo groups. The results of this study correlate well with those obtained by Rhode et al.<sup>21</sup> and de Almeida et al.<sup>22</sup> De Almeida et al. observed greater dye penetration with Ketac-Endo then Fill canal and AH-plus sealer. In an in vitro study, Rhode et al.<sup>21</sup> observed greater leakage with Ketac-Endo, while Ray & Seltzer<sup>23</sup> demonstrated a better seal and good adhesion to the dentinal wall with Ketac-Endo.

## Zaključak

Metod bojenih rastvora i tehnika sa poprečnim prescima opturiranih zuba je vrlo koristan metod za proveru kvaliteta krunicnog zaptivanja. Rezultati ovih istraživanja su pokazali da nijedna pasta ne obezbeđuje potpuno krunicno zaptivanje. Manji prodor boje pokazale su paste AH-26 i SEALAPEX a značajno krunicno mikropropuštanje pasta KETAC-ENDO.

## Conclusions

The dye penetration method and root cross sections method are simple and useful tools for the quality analysis of the coronal seal. This study demonstrated that no sealer showed a complete coronal seal. Less dye penetration was seen with AH-26 and Sealapex whereas Ketac-Endo was associated with substantial coronal microleakage.

## Literatura / References

- Holland R, Sakashita MS, Murata SS, Junior E. Effect of dentine surface treatment on leakage of root fillings with a glass ionomer sealer. *Int Endod J* 1995; 28: 190-193.
- Madison S, Swanson K, Chiles S. An evaluation of coronal microleakage in endodontically treated teeth, part II. *J Endod* 1987; 13: 109-112.
- Madison S, Wilcox LR. An evaluation of coronal microleakage in endodontically treated teeth, part II. *J Endod* 1988; 14: 455-458.
- Beltes P, Kolokouris I, Economides N, Koulouriou E. A comparative study of apical sealing ability of a new glass-ionomer cement (Ketac-Endo) and three conventional root canal sealers. *Hellenic Dent J* 1993; 3: 45-48.
- Saunders WP, Saunders EM. The effect of the smear layer upon the coronal leakage of gutta-percha root fillings and glass ionomer cement. *Int Endod J* 1992; 25: 245-249.
- Roghanized N, Jones JJ. Evaluation of coronal microleakage after endodontic treatment. *J Endod* 1996; 22: 471-473.
- Zaia AA, Nakaguna R, De Quadros I, Gomes BPF, Ferpaz CCR, Teixeira FB, Souza-Filho FJ. An in vitro evaluation of four materials as barriers to coronal microleakage in root filled teeth. *Int Endod J*, 2002, 35:7290-734
- Živković S, David-Burlica B, Stanišić J, Medojević-Jovanović M, Dačić D. In vitro evaluation of coronal microleakage in two root obturation techniques. *Serb Dent J*, 2007, 54:184-190
- Vassiliadis L, Liolios E, Kouvas V, Economides N. Effect of smear layer on coronal microleakage. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1996; 82: 315-320.
- Lyrudia K, Pantelidou O, Mikrogeorgis G, Chatzikallinikidis C, Nikopulos N, Pitas I. The use of 3D computerized reconstruction for the study of coronal microleakage. *Int Endod J* 2000; 33: 243-247.
- Matloff IR, Jensen JR, Singer L, Tabibi A. A comparison of methods used in root canal sealability studies. *Oral Surg Oral Med Oral Pathol* 1982; 53: 203-208.
- Barthel CR, Losche GM, Zimmer S, Roulet JF. Dye penetration in root canals filled with AH -26 in different consistencies. *J Endod* 1994; 20: 436-9.
- Simons J, Ibanez B, Friedman S, Trope M. Leakage after lateral condensation with finger spreaders and D-11-T spreaders. *J Endod* 1991; 17: 101-4.
- Limkangwalmongkol S, Burtscher P, Abbott PV et al. A comparative study of the apical leakage of four root canal sealers and laterally condensed gutta-percha. *J Endod* 1991; 17: 495-9.
- Gettleman GH, Messer HH, El Deeb ME. Adhesion of sealer cements to dentin with and without the smear layer. *J Endod* 1990; 17: 15-20.
- Wu MK, Tigas E, Weselink PR. An 18 month longitudinal study on a new silikon-based sealer RSA, A leakage study in vitro. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2002, 94: 499-502
- Snafer E, Olthoff G. Effect of three different sealers on the sealing ability of root thermofil obturators and cold laterally compacted gutta-percha. *J Endod* 2002, 28: 638-642
- Danin J, Linder L, Sund ML, Stromberg T, Torstenson B, Zetterquist L. Quantitative radioactive analysis of microleakage of four different retrograde fillings. *Int Endod J* 1992; 25: 183-8.
- Holland R, Crivelini MM, Zampieri JrM, Souza V, Saliba O. Qualidade de selamento marginal obtido com diferentes cimentos a base de hidróxido de calcio. *Revista Paulista de Odontologia* 1991a; 13: 27-35.
- Smith MA, Steiman HR. An in vitro evaluation of microleakage of two new and two old root canal sealers. *J Endod* 1996; 22: 365-7.
- Rhode TR, Bramwell JD, Hutter JW, Roahen JO. An in vitro evaluation of microleakage of a new root canal sealer. *J Endod* 1996; 22: 365-7.
- De Almeida WA, Leonardo MR, Tanomaru Filho M, Silva LAB. Evaluation of apical sealing of three endodontic sealers. *Int Endod J* 2000; 33: 25-27.
- Ray H, Seltzer S. A new glass ionomer root canal sealer. *J Endod* 1991; 17: 598-603.

## Autor odgovoran za korespondenciju

Dejan Marković  
Klinika za dečiju i preventivnu stomatologiju  
Stomatološkog fakulteta u Beogradu  
Rankeova 4  
11000 Beograd

## Address for correspondence

Dejan Marković  
Dept. of Pediatric Dentistry  
School of Dentistry, Belgrade  
Rankeova 4  
11000 Belgrade, Serbia