

In vitro ispitivanja krunične ikropropustljivosti kod dve tehnike opturacije

DOI: 10.2298/SGS0703184Z

In vitro evaluation of coronal microleakage associated with two root obturation techniques

Slavoljub Živković, Borislava David-Burlica, Jelena Stanišić, Sonja Stojčić,
Milica Medojević-Jovanović, Dragoslav Dačić

Klinika za bolesti zuba, Stomatološki fakultet Beograd
Dept. of Conservative Dentistry and Endodontics, School of Dentistry, Belgrade

ORIGINALNI RAD (OR)
ORIGINAL ARTICLE

KRATAK SADRŽAJ

Cilj: Cilj ovog rada je bio da se proveri uticaj razmaznog sloja na krunično mikopropuštanje kanala opturiranih primenom Termafil i tehnike hemijski razmekšane gutaperke.

Materijal i metod: Korišćeno je 60 ekstrahovanih jednokorenih zuba sa pravim kanalima koji su podeljeni u dve eksperimentalne grupe. Kanali su obrađeni primenom STEP-BACK tehnike i primenom proširivača i turpija tipa K uz obilnu irigaciju 2,5% rastvorom NaOCl. U prvoj grupi kanal je tretiran 17% rastvorom EDTA i 2,5% rastvorom NaOCl radi uklanjanja razmaznog sloja, a uzroci druge grupe su bili sa očuvanim razmaznim slojem. Zubi prve i druge grupe su potom opturirani tehnikom hemijski razmekšane gutaperke (28 zuba) odnosno primenom Termafil tehnike opturacije (28 zuba) primenom pasti RSA RDEKO SEAL i AH-PLUS. Zubi su pripremljeni za proveru krunične mikropropustljivosti potapanjem u rastvor srebrno-nitrata. Linearni prodor boje procenjivan je uz pomoć binokularne lupe sa mikrometarskim razmernikom i uvećanjem 25 puta.

Rezultati: Dobijeni rezultati su ukazali na manju kruničnu mikropropustljivost u grupi gde je razmazni sloj bio uklonjen i kod tehnike hemijski razmekšane gutaperke (RSA-1,71mm, AH-PLUS-1,61mm) i primenom Termafil tehnike opturacije (RSA-1,65mm, AH-PLUS-1,66mm). U grupi gde razmazni sloj nije uklonjen uočena je veća mikropropustljivost i primenom tehnike hemijski razmekšane gutaperke (RSA-3,06mm, AH-PLUS - 2,83mm) i primenom Termafil tehnike (RSA - 2,99, AH-PLUS - 2,83). Razlika je bila statistički značajna između grupa gde je razmazni sloj uklonjen i grupe gde nije uklonjen kod oba testirana materijala na nivou $p < 0,001$.

Zaključak: Dobijeni rezultati su pokazali da uklanjanje razmaznog sloja značajno poboljšava kvalitet zaptivanja u kruničnom delu i time značajno smanjuje krunično mikropropuštanje.

Cljučne reči: krunično-poropuštanje, razmazni sloj, hemijski razmekšana gutaperka, Termafil

SUMMARY

Aim: The purpose of this study was to determine the influence of the smear layer on the coronal microleakage in root canals obturated with laterally condensed cold gutta-percha or Termafil and two root canal sealers.

Materials and methods: Sixty extracted single-rooted human teeth with straight root canals were allocated to two experimental groups. The root canals were instrumented using the STEP-BACK technique, K reamers and K files and irrigated with 2.5 % NaOCl. The teeth in the first group were treated with 17% EDTA and 2.5 % NaOCl to remove the smear layer. The teeth in both groups were obturated either with laterally condensed cold gutta-percha (28 teeth) or Termafil gutta-percha with plastic cores (28 teeth) and RSA or AH-PLUS sealers. The specimens were evaluated for coronal microleakage using silver nitrate solution. The linear penetration of the dye was assessed using a binocular magnifying glass (x25), with an inserted micrometer scale.

Results: The results showed low coronal microleakage in the group where the smear layer was removed in both the lateral compaction technique (RSA - 1.71mm and AH-PLUS - 1.61mm) and the Termafil groups – RSA (1.65mm) and AH-PLUS (1.66mm). In the group with the intact smear layer, greater microleakage was noticed in both groups, lateral compaction technique –RSA (3.06 mm) and AH-PLUS (2.83mm) and Termafil technique –RSA (2.99mm) and AH-PLUS (2.83mm). The difference was statistically significant between the groups with and without the smear layer for both RSA ($p < 0.001$) and AH-PLUS sealers ($p < 0.001$).

Conclusion: The present results suggest that the removal of the smear layer significantly improves the tightness of the coronal seal and reduces the coronal microleakage.

Key words: coronal leakage, smear layer, lateral compaction, Termafil

Osnovni zadatak endodontske terapije je potpuna i kompletna opturacija kanalnog sistema zuba. Jedan od osnovnih uslova za uspešan tretman kanala korena zuba je i sprečavanje mikroorganizama i njihovih toksina iz oralne flore da kroz neadekvatno ispunjen kanal prodru u periapikalne strukture. Iako se do skora smatralo da je apikalno propuštanje osnovni faktor kliničkog neuspeha endodontske terapije¹, danas je potvrđeno da i krunično mikropropuštanje ima značajnog udela na konačan ishod endodontskog lečenja. Neadekvatni privremeni ili stalni ispuni posle opturacije često dovode do kontaminacije kanala.²⁻⁶ Mnogi autori potvrđuju da je bakterijski prodor moguć između zida kanala korena i paste za opturaciju i da je to izraženije u prisustvu razmaznog sloja.^{7,8} Razmazni sloj se formira na zidovima kanala tokom instrumentacije i sečenja dentina, a najčešće se sastoji iz neorganskih komponenti kalcifikovanog tkiva, organskih sastojaka, ostataka pulpe, mikroorganizama i ćelije krvi.^{9,10} Uklanjanje razmaznog sloja pre opturacije može značajno uticati na vezu materijala za opturaciju i dentina zidova kanala.¹¹

Najčešće korišćena metodologija za proveru krunične mikropropustljivosti je linearni prodor bojenih rastvora (metilen plavo,¹² indijan tuš,^{3,7} i srebro nitrat⁴) primena radioizotopa, skening elektronska mikroskopija,⁶ ili trodimenzionalna kompjuterska metodologija.¹⁴

Cilj ovog rada je bio da se proveriti uticaj razmaznog sloja na krunično mikropropuštanje kanala opturiranih primenom Termafil i tehnike hemijski razmekšane gutaperke.

Materijal i metod

Kao materijal u ovim istraživanjima korišćeno je 60 jednokorenih zuba, koji su do eksperimenta čuvani u alko-holu. Radi lakše instrumentacije krunice zuba su diskom presećane u nivou gleđno-cementne granice. Radna dužina svakog kanala je određivana 1 mm kraće od dužine endodontskog instrumenta br. 15 kada se pojavi na vrhu korena. Kanali su obrađivani Step Back tehnikom i primenom proširivača i turpija tipa K (Dentsply, Maillefer Instruments, Switzerland). Za svaki kanal korišćeno je po 5 ml 2,5% rastvora NaOCl. Zubi su podeljeni u dve grupe po 28 zuba. Po dva zuba je korišćeno za pozitivnu i negativnu kontrolu. U prvoj grupi je korišćen 17% rastvor EDTA i 2,5% rastvor NaOCl za uklanjanje razmaznog sloja, a u drugoj razmazni sloj nije uklonjen. Za svaki kanal je upotrebljeno 5ml EDTA i 10ml NaOCl. Finalno ispiranje je urađeno sa 3ml destilovane vode a potom je kanal osušen i opturisan. Kao pasta za opturaciju korišćen je AH-PLUS (Dentsply De Trey, GmbH, Konstanz, Germany) i RSA-Roeko Seal Automix (Roeko, Langenau, Germany) a korišćena je tehnika hemijski razmekšane gutaperke i Termafil tehnika opturacije.

The ultimate objective of conventional endodontic therapy is the complete obturation of the root canal space. One of the main principles for a successful root canal treatment is to prevent microorganisms and toxins from oral flora to penetrate through the root canal into the periapical tissues. Until recently, apical leakage was considered the crucial factor for the clinical failure of endodontic therapy.¹ However, nowadays coronal microleakage appears to be of equal or greater clinical relevance as a factor of endodontic failure than apical leakage. Inadequate temporary or permanent fillings after root canal obturation may result in root canal contamination.²⁻⁶ Many authors showed that bacterial penetration is possible between the canal wall and the sealer and this phenomenon may be increased by the presence of a smear layer.^{7,8} The smear layer is created during the instrumentation and the cutting of dentine and is primarily composed of inorganic particles of calcified tissue and organic elements such as pulp tissue debris, microorganisms and blood cells.^{9,10} Smear layer removal prior to the root canal obturation may enhance the bond between sealers and dentinal walls.¹¹

The most commonly used method for coronal microleakage evaluation is the linear measurement of dye penetration (methylene blue solution¹², Indian ink^{3,7} and silver nitrate⁴), the use of radioisotopes, scanning electron microscopic analysis⁶ and three-dimensional computerized method.¹⁴

The purpose of this study was to evaluate the influence of the smear layer on the coronal microleakage in root canals obturated using lateral compaction or Thermafil techniques with plastic cores and two root canal sealers.

Materials and methods

Sixty extracted single-rooted teeth were used in the present study. The teeth were stored in distilled water prior to use. The crowns were removed at the cement-enamel junction with diamond discs. The working length in all teeth was determined by placing a # 10 file to the apical foramen and reducing the length by 1mm. The root canals were then instrumented conventionally using the STEP-BACK technique with K files and reamers (Dentsply Maillefer Instruments Switzerland). Irrigation of each root canal during instrumentation was done with 5 ml of 2.5% NaOCl. The prepared teeth were randomly allocated to two groups of 28 teeth each, 28 positive and 28 negative controls. In the first group, root canals were treated with 17% EDTA and 2.5% sodium hypochlorite to remove the smear layer while in the second group, the smear layer was not removed. Five ml of EDTA and 10 ml of NaOCl were used for each root canal. The final irrigation was done with 3 ml of distilled water and then the canals were dried with paper points and obturated. The following sealers were used: AH-PLUS (Dentsply De Trey, GmbH, Konstanz, Germany) and RSA – Roeko Seal Automix Roeko, Langenau, Germany) with either cold lateral compaction or the Thermafil technique for root canal obturation.

Tehnika hemijski razmekšane gutaperke

Glavni gutaperka poen treba da bude veći za 2-3 veličine od završnog instrumenta korišćenog za apikalnu preparaciju i treba da bude kraći 2-3 mm od radne dužine preparacije. Nakon unošenja paste u preparisani kanal, glavni gutaperka poen je razmekšan u hloroformu (5 sec), aplikovan u kanale i nabijačima potisnug apikalno. Krunični deo kanala je potpuno opturisan zagrejanim nabijačem.

Thermafil tehnika opturacije

Odgovarajuća gutaperka sa plastičnim nosačem je prethodno zagrejana u aparatu. Nakon što je u kanale unošena pasta AH-PLUS ili RSA zagrejana gutaperka na nosaču je aplikovana do odgovarajuće radne dužine kanala. Gutaperka na nosaču je skraćena a krunični deo kanala je potpuno opturisan primenom odgovarajućih nabijača.

Krunični deo kanala je potom privremeno zatvoren tankim slojem Cavia (Espe, GmbH, Seefeld, Germany). Uzorci su čuvani u uslovima 100% vlažnosti na temperaturi 37°C tokom sedam dana. Posle ovog perioda korenovi su premazani sa dva sloja laka za nokte izuzev 1mm oko privremenog ispuna i potopljeni u 50% rastvor srebrno nitrata tokom šest sati. Posle toga su isprani vodom u trajanju od jednog minuta i potopljeni u 10% rastvor univerzalnog foto razvijaa tokom dva sata.

Po dva zuba su ispunjena tehnikom lateralne kompakcije i Thermafil tehnikom bez paste. Zubi koji su korišćeni za negativnu kontrolu su potpuno pokriveni sa dva sloja laka, a dva zuba koja su pokrivena sa dva sloja laka izuzev 2mm oko kruničnog otvora kanala, poslužili su kao pozitivna kontrola. Svi uzorci zuba su potom presečeni uzdužno dijamantskim diskom i pažljivo odvojeni. Linearni prodor boje meren je uz pomoć binokularne lupe i uvećanja od 25 puta.

Dobijeni rezultati su statistički obrađeni a razlike između grupa testirane su primenom i Studentovog T-testa.

Rezultati

Dobijeni rezultati prikazani su na tab. 1 i grafikonu 1.

Kod zuba korišćenih kao negativna kontrola nije bilo prodora boje, dok je kod zuba sa pozitivnom kontrolom uočen potpuni prodor bojenog rastvora duž celog kanala.

Dobijeni rezultati su pokazali da nije bilo statistički značajne razlike između korišćenih tehnika opturacije. Međutim statistička analiza prosečnog prodora boje između grupa gde je razmazni sloj uklonjen i grupe gde je ostao intaktan je pokazala visoko statistički značajnu razliku i u uzorka opturisanih pastom AH-PLUS ($p < 0,001$) i u uzorka opturisanih pastom RSA ($p < 0,001$).

Prosečan prodor boje u grupi bez razmaznog sloja u uzorka opturisanih tehnikom hemijski razmekšane gutaperke

Lateral condensation

The master gutta-percha cone should be 2-3 sizes larger than the instrument used for apical preparation and it should be 2-3 mm shorter than the working length in each canal. After inserting the sealer into the root canal, the main gutta-percha cone was softened in choloform (5 sec), applied into root canals and pressed apically using pluggers. The coronal part of the root canal was completely obturated using pre-heated pluggers.

Thermafil obturation technique

A thermafil gutta-percha with the plastic core and suitable size was melted in the Therma prep oven. A small amount of AH-PLUS and RSA was placed in the root canal and the heated thermafil obturator positioned to the working length. Gutta-percha was shortened and the coronal part of the root filling was then vertically condensed with pluggers.

The coronal part of all canals was sealed with Cavit (Espe, GmbH, Seefeld, Germany). All roots were stored at 100% humidity and 37°C for one week. After this period, the roots were covered with two layers of nail varnish excluding 1 mm from the cemento-enamel junction and immersed in 50% solution of silver nitrate for six hours. Following rinsing with distilled water for 1 min, the samples were immersed in a 10% solution of universal film developer for two hours.

Four roots were obturated with laterally condensed gutta-percha or Thermafil without any sealer. The negative controls were covered completely with two coats of nail varnish and the two roots were covered with nail varnish except for the coronal 2 mm and served as positive controls.

Each root was then longitudinally sectioned with a diamond disc and roots were carefully separated. The linear penetration of the dye was estimated using a binocular magnifying glass (x25).

The data were statistically analyzed and the differences between the groups were tested using Student's *t* test.

Results

The obtained results are given in Table 1 and Graph 1.

The negative controls did not show any dye penetration, whereas the positive controls demonstrated complete dye penetration.

The obtained results showed no significant differences in the coronal microleakage between the obturation techniques. However, statistical evaluation of the results for mean microleakage values in the teeth obturated with lateral condensation showed significant differences between the group with removed smear layer and in the group with intact smear layer in RSA ($p < 0.001$) and AH-PLUS sealer group ($p < 0.001$).

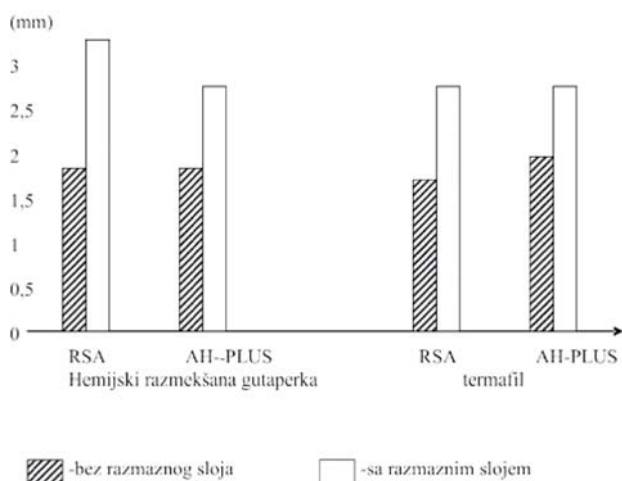
perke bio je veći primenom paste RSA (1,71mm) nego posle primene AH-PLUS (1,61mm). Primenom Termafil-tehnike prosečan prodor boje je bio prilično ujednačen (RSA-1,65mm i AH-PLUS 1,66mm).

There was significantly less microleakage in the teeth obturated with Thermafil without the smear layer than those where obturation was performed with the intact smear layer in both RSA ($p<0.001$) and AH-PLUS groups ($p<0.001$).

Tabela 1. Srednja vrednost kruničnog mikropropuštanja (mm) korišćenih pasti za obturaciju

Table 1. The mean coronal leakage (mm) of endodontic sealers

	Hemijski razmekšana gutaperke gutaperka				Termafil			
	Bez razmaznog sloja		Sa razmaznim slojem		Bez razmaznog sloja		Sa razmaznim slojem	
	RSA	AH-PLUS	RSA	AH-PLUS	RSA	AH-PLUS	RSA	AH-PLUS
N	10	10	10	10	10	10	10	10
Srednja vrednost	1,71	1,61	3,06	2,83	1,65	1,66	2,99	2,83
SD	0,12	0,18	0,15	0,30	0,17	0,21	0,23	0,26
Minimum	1,54	1,38	2,88	2,29	1,41	1,39	2,63	2,38
Maximum	1,89	1,92	3,33	3,21	1,92	1,98	3,47	3,21



Grafikon 1. Prosečne vrednosti kruničnog mikroprodora (mm)
Graph 1. The mean coronal leakage (mm)

Značajno manji linearni prodor boje u grupi bez razmaznog sloja u odnosu na grupu sa očuvanim razmaznim slojem uočen je posle primene Termafil tehnike opturacije i sa pastom AH-PLUS ($p<0,001$) i sa pastom RSA ($p<0,001$).

Veći prosečan prodor boje bio je u grupi sa očuvanim razmaznim slojem i gde je opturacija urađena tehnikom hemijski razmekšane gutaperke primenom paste AH-PLUS (2,88mm) i RSA (3,06mm) ($p<0,05$). U grupi sa očuvanim razmaznim slojem kod Termafil tehnike razlike između uzoraka opturiranih pastom AH-PLUS (2,83mm) i RSA (2,99mm) nije bilo.

U grupi bez razmaznog sloja i kod uzorka ispunjenih pastom AH-PLUS i uzorka ispunjenih pastom RSA kod obe opturacione tehnike značajnih razlika nije bilo.

The mean dye penetration in the group without the smear layer obturated using lateral condensation was greater in RSA (1.71 mm) than AH-PLUS group (1.61 mm). In the Thermafil technique, the mean penetration was similar (RSA 1.65 mm and AH-PLUS 1.66 mm).

Significantly less linear penetration in the group without the smear layer than the group with the intact smear layer was noticed after using the Thermafil technique with both sealers, AH-PLUS ($p<0.001$) and RSA ($p<0.001$).

The mean values of linear penetration in the teeth obturated with lateral condensation between AH-PLUS (2.88 mm) and RSA (3.06 mm) showed significantly less coronal microleakage in the group with the smear layer ($p<0.05$). No significant difference was found in the teeth

Diskusija

Adekvatna opturacija je jedan od osnovnih uslova za uspešan tretman kanala korena zuba. Za proveru kvaliteta kanalne opturacije korišćene su brojne metode: provera propustljivosti korišćenjem radioizotopa, SEM analize, metode bojenih rastvora i trodimenzionalne kompjuterske tehnike.^{3,4,5,7,14} Metoda bojenih rastvora je ipak najčešće korišćena metoda zbog preciznosti, jednostavnog izvođenja i brze realizacije.^{3,4,7} Međutim, ono što im se zamera, to je da su vrlo kritične i da su čestice „markera” mnogo manje od molekula endotoksina i bakterija i ne mogu ih klinički imitirati.¹⁵

Na krubičnu mikropropustljivost utiču brojni faktori.^{3,5,6} U ovoj studiji je analiziran uticaj razmaznog sloja na krubično mikropropuštanje u uslovima koji su vrlo bliski kliničkim. Uprkos anatomskim razlikama između apeksne i koronarne trećine, problem krubičnog mikropropuštanja nije dovoljno razmatran. Uklanjanjem razmaznog sloja broj i veličina otvara dentin tubula u krubičnoj trećini je mnogo veći nego u apeksu što može uticati na bolju adheziju paste za opturaciju za zidove kanala.¹⁶ Uprikos različitim izveštajima o razmaznom sloju, ipak je potvrđeno da on blokira i sprečava dobru adheziju materijala za zidove kanala korena, a samim tim utiče i na dobro koronarno zaptivanje.^{7,8}

Rezultati ovog istraživanja su pokazali da ni jedan materijal ne omogućava dobro krubično zaptivanje, ali da razmazni sloj značajno povećava krubično mikropropuštanje. Ovo potvrđuje da razmazni sloj utiče na mikropenetraciju boje, a samim tim i na neuspeh opturacije, odnosno konačan ishod endodontske terapije.^{7,8}

Uklanjanje razmaznog sloja limunskom kiselinom predložio je Tidmarsh¹⁷ ali su istraživanja potvrdila da je ipak efikasnije uklanjanje razmaznog sloja rastvorom EDTA i NaOCl.

RSA je noviji materijal za opturaciju kanala i bazira na polidimetilsiloksanu kiselinu. Rezultati ovih istraživanja su potvrdili dobro krubično zaptivanje i vrlo slične rezultate sa pastom AH-PLUS primenom obe tehnike opturacije. Ovi nalazi su saglasni sa nalazima Eberta i sar.¹⁸ odnosno Sevimay-a i Dalat-a¹⁹ koji su dobili nešto slabije rezultate primenom ove paste u poređenju sa pastom AH-26. Wu i sar. su u svojim in vitro istraživanjima takođe potvrdili da je RSA u kombinaciji sa lateralnom i vertikalnom kompakcijom gutaperke pokazao zadovoljavajuće rubno zaptivanje posle 18 meseci.²⁰

AH-PLUS je pasta za opturaciju na bazi epoksi smola i u ovim ispitivanjima je potvrđeno dobro krubično zaptivanje. AH-PLUS je pasta sa dobrim adhezivnim osobinama i uglavnom zadovoljava u raznim tehnikama opturacije, bilo u apikalnom, bilo u krubičnom segmentu.^{6,9,21,22,23}

Tehnika hemijski razmekšane gutaperke i Termafil tehnika su tehnike koje se često koriste u opturaciji kanala. I kod jedne i kod druge tehnike gutaperka ispunjava

obturatoru sa Thermafil tehnikama između RSA (2.99 mm) i AH-PLUS (2.83 mm) u grupi sa slojem boje. Srednja mikroizliva između RSA i AH-PLUS grupa bez sloja boje i obe obturativne tehnike nisu pokazale značajnu razliku.

Discussion

Adequate obturation is considered to be one of the main requirements for a successful root canal treatment. The following methods were used for assessing root canal obturation: permeability of radioisotopes, SEM analysis, dye methods and three-dimensional computerized methods.^{3,4,5,7,14} Dye penetration tests are most frequently used because of their precision, simplicity and speed.^{3,4,7} However, one of the disadvantages is that “marker” particles are much smaller than endotoxin molecules and bacteria and cannot mirror clinical conditions.¹⁵

A variety of different factors affect the coronal microleakage.^{3,5,6} The present study focused on the smear layer effect on the coronal microleakage in conditions resembling clinical. Despite anatomical differences of the apical and coronal parts, the coronal microleakage has not been sufficiently studied. As the number of dentinal tubules and the size of their lumens are far greater in the coronal than the apical area after smear layer removal, this can enhance adhesion between the sealer and root canal walls. Despite different reports on the smear layer, it has been shown that the smear layer disables good adhesion of the material to canal walls and thus also affects good coronal seal.^{7,8}

The present study showed that no material allows complete coronal seal and the smear layer increases the coronal microleakage. This confirms that the smear layer affects dye penetration and, consequently, obturation success.^{7,8}

The removal of the smear layer with citric acid was advocated in endodontic therapy by Tidmarsh¹⁷ but the most effective chemical method for removing the smear layer has been shown to be irrigation of the root canal with EDTA and NaOCl.

RSA is a newly formulated endodontic sealer based on polydimethylsiloxane. The present study showed the good coronal seal using RSA, and very similar coronal dye penetration with AH-PLUS sealer in both groups and obturation techniques. The results in this study are in agreement with the results reported by Ebert et al.¹⁸ and Sevimay & Dalat¹⁹ who reported slightly worse results for this paste compared to AH-26. Wu et al. confirmed in vitro that RSA in combination with lateral and vertical compaction showed a satisfactory seal after 18 months.²⁰

AH-PLUS is an epoxy-resin material and with a good coronal seal, as showed in the present study. AH-PLUS shows good adhesion and is satisfactory in different obturation techniques, in both apical or coronal segments.^{6,9,21,22,23}

najveći deo kanala a pasta je u minimalnim količinama što je jedan od osnovnih zahteva obturacije. Osim toga gutaperka u kruničnom delu može biti dodatno koprimovana kompakterima čime se značajno može poboljšati krunično zaptivanje. Poredeći kvalitet obturacije kod pravih i zakrivljenih kanala primenom Termafil tehnike obturacije, Schafer i Olthoff su potvrdili da ova tehnika obezbeđuje dobro rubno zaptivanje i da se može porediti sa tehnikom lateralne kompaktacije.²⁴ De Moor i De Bruyne su u svojim istraživanjima proveravali tri tehnike obturacije u dužem observacionom periodu i zaključili da je krunično mikropropuštanje bilo najizraženije kod Termafil tehnike bez obzira da li je korišćena pasta AH-26 ili AH-PLUS.²² Sredstvo za privremeno zatvaranje u ovim ispitivanjima nije imalo značaja jer je ovaj materijal postavljen u tankom sloju a kao najvažniji parametar kruničnog zaptivanja analizirana je upravo tehnika obturacije u kruničnom delu.

Ovi rezultati su saglasni sa rezultatima Saunders-a i Saunders-a koji su takođe dobili značajan prodor boje u kruničnom delu uzoraka punjenih lateralnom kompaktacijom gutaperke i Termafil tehnikom, kada je u kanalu bio prisutan razmazni sloj.⁷ U *in vitro* studiji Kytridou i saradnici su dobili dobre rezultate opturacije i u kruničnoj i apeksnoj trećini primenom Termafil i tehnike opturacije sistemom B.²⁵

Naravno, rezultati *in vitro* ispitivanja kruničnog mikropropuštanja ne mogu se direktno porediti sa kliničkim ali mogu poslužiti za određena poređenja upravo zbog činjenice da je sam razmazni sloj mnogo jednostavnije i lakše ukloniti u *in vitro* nego u *in vivo* uslovima.⁵

Zaključak

Dobijeni rezultati ukazuju da nijedna pasta ni tehnika opturacije ne obezbeđuje potpuno krunično zaptivanje. Uklanjanje razmaznog sloja sa zidova kanala značajno smanjuje kruničnu mikropropustljivost. Primena pasti RSA i AH-PLUS pokazuje značajne razlike u kruničnom mikropropuštanju između grupa sa razmaznim slojem i grupa gde je razmazni sloj uklonjen u obe korišćene tehnike opturacije.

The technique of chemically softened gutta-percha and the Thermafil technique are both frequently used in root canal obturation. In both techniques, gutta-percha fills the major part of the root canal while the sealer is minimized, which is one of the main requirements of obturation. Moreover, gutta-percha in its coronal part can be additionally compressed with compactors to significantly enhance the coronal seal. Comparing the quality of Thermafil obturation in straight and curved root canals, Schafer & Olthoff confirmed that this technique provides a good marginal seal, comparable to lateral compaction.²⁴ De Moor & De Bruyne investigated three techniques of obturation after a long period of time and concluded that the coronal microleakage was most prominent in the Thermafil technique with either AH-26 or AH-PLUS.²² Temporary fillings had no influence because this material was set in a thin layer, and the most crucial parameter of the coronal seal was obturation technique in the coronal segment.

The present results correlate with the results of Saunders & Saunders who reported greater coronal penetration of dye in the group with the intact smear layer in both Thermafil and lateral condensation techniques.⁷ In an *in vitro* study, Kytridou et al. showed favourable obturation in the coronal and apical third using Thermafil and system B obturation techniques.²⁵

The results from *in vitro* studies cannot be directly extrapolated clinically, but they do allow certain comparisons, especially due to the fact that the smear layer is more easily removed *in vitro* than *in vivo* conditions.⁵

Conclusion

The present results confirm that no sealer or obturation technique provide a complete coronal seal. The removal of the smear layer from the root canal walls significantly reduces the coronal microleakage. The use of RSA and AH-PLUS sealers results in significant differences in coronal microleakage between the groups with and without the smear layer in both obturation techniques.

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Autor odgovoran za korespondenciju

Slavoljub Živković
 Klinika za bolesti zuba
 Stomatološki fakultet Beograd
 Rankeova 4
 11000 Beograd
 Tel. 011/2435 722/222

Address for correspondence

Slavoljub Živković
 Dept. of Conservative Dentistry and Endodontics
 School of Dentistry, Belgrade
 Rankeova 4
 11000 Belgrade, Serbia
 Tel. +381 11 2435 722 ext. 222