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Evaluation of Root Canal Obturation Using Gas Permeability Method

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SUMMARY

Introduction Prognosis of root canal treatment is highly dependent on the quality of endodontic space obturation. The main task of successful root canal treatment is to achieve adequate reparation processes in the apical periodontium. The aim of this study was to evaluate the quality of root canal obturation using the method of gas (argon) penetration through three different endodontic materials.

Material and Methods Thirty recently extracted human single-rooted teeth after root canal instrumentation were divided into three identical groups and obturated with three different endodontic materials: group I – GuttaFlow (RSA, Germany), group II – AH Plus (DeTray, Germany), group III – Acroseal (Septodont, France). The quality of root canal obturation was evaluated using the method of gas permeability.

Results The best results were obtained with GuttaFlow. The average penetration rate of argon was 186.7 seconds. Slightly higher gas porosity had AH Plus, 179.9 seconds, while the highest gas permeability was observed after the application of Acroseal, 178.5 seconds. However, there was no statistically significant difference in gas penetration among these endodontic materials ($p>0.05$).

Conclusion All three endodontic materials showed gas permeability in a given time interval. The best quality of obturation was achieved with GuttaFlow, while the lowest quality was obtained with Acroseal.

Keywords: Acroseal; AH Plus; endodontic materials; gas permeability; GuttaFlow; obturation

INTRODUCTION

Root canal obturation is the final stage of endodontic therapy which main task is to provide good coronal, lateral and apical seal. Complex anatomy, irregularities of root canals and inability to achieve dry working field in the region of apical ramifications make obturation phase very complex. Numerous studies have confirmed that successful outcome of endodontic treatment depends on hermetic obturation of root canals especially in the apical area [1, 2, 3]. Scientific and technological advances in the recent decades have offered numerous endodontic materials of different composition and characteristics. Modern endodontics requires application of biocompatible, adhesive and physically and chemically stable endodontic materials [4]. These materials should also be practical and easy to handle with sufficiently long time of plasticity. The main task of successful root canal treatment is to achieve adequate reparation processes in the apical periodontium [5, 6].

The aim of this study was to evaluate the quality of root canal obturation using the method of gas (argon) penetration through three different endodontic materials.

MATERIAL AND METHODS

Thirty human single-rooted teeth, recently extracted for periodontal reasons were used in this study. Age and gender of patients were not registered. Coronal part of the teeth was removed from the root at the enamel-cementum junction using high speed handpiece and fissure diamond bur to provide clear and direct access cavity preparation. Preoperative radiographs of the teeth included in the experiment were performed. Pulp tissue was removed using barbed broach. The patency and working length was determined using hand instruments (Kerr files #10 and #15). Working length was determined by the length of the instrument, where its tip was located on the outer side of apical foramen and subtracted by 1 mm. Root canals were instrumented using crown-down technique with Ni-Ti rotary instruments and irrigated using 1% sodium hypochlorite and Canal + (Septodont, France). Canal obturation was performed using lentulo spirals and monopercha cones with three different types of endodontic materials (Table 1).

After obturation teeth were divided into three different groups. Group I was obturated with GuttaFlow (Roeco, Germany), an endodontic material that contains polydimethylsiloxane and small spherical particles. Group II was obturated using AH Plus (DeTray, Gremany) endodontic paste based on artificial resins. Group III was filled with Acroseal (Septodont, France), a material based on calcium hydroxide and epoxy resins.

Access cavities were temporary filled with Cavit (Premier, Dental Products). The teeth were kept 7 days at 37°C in conditions of absolute humidity to allow definite

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Table 1. Composition of endodontic materials
Tabela 1. Sastav endodontskih materijala

Material (Manufacturer) Materijal (proizvođač)	Composition Sastav	
Acroseal (Septodont, France)	Paste A Pasta A	Calcium hydroxide Kalcijum-hidroksid
		DGEBA DGEBA
		Radiopaque excipient Radioopacitetni punilac
	Paste B Pasta B	Glycyrrhetic acid (enoxolone) Gliciretična kiselina (enoksolon)
		Methenamine Metenamin
		Radiopaque excipient Radioopacitetni punilac
GuttaFlow (Colthane/Whaledent kangenau/Germany)	Paste A Pasta A	Gutta-percha powder Prah gutaperke
		Polydimethylsiloxane Polidimetilsiloksan
		Silicone oil, Parffin oil Silikonsko ulje, parafinsko ulje
	Paste B Pasta B	Hexachloroplatinic acid Heksahlorplatinska kiselina
		Zirconium oxide Cirkonijum-oksid
		Nano-silver (preservative) Nano-srebro (prezervativ)
AH Plus (DeTrey, Germany)	Paste A Pasta A	Epoxy resin Epoksi smola
		Calcium tungstate Kalcijum-tungstat
		Zirconium oxide Cirkonijum-oksid
		Aerosil Aerosil
		Iron oxide Oksid gvožđa
	Paste B Pasta B	Adamantane amine Adamantanamin
		N,N-Dibenzoyl-5-oxanonane N, N, dibenzoil-5-oksanonan
		TCD-diamine TCD diamin
		Calcium tungstate Kalcijum-tungstat
		Zirconium oxide Cirkonijum-oksid
		Aerosil Aerosil
		Silicone oil Silikonsko ulje

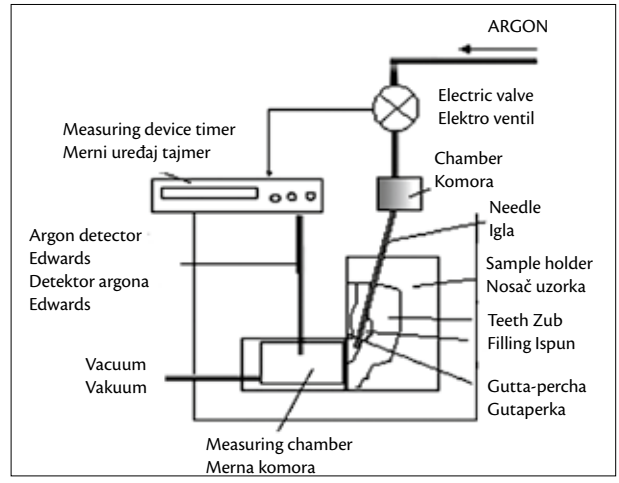

Figure 1. Schematic view of gas porosity measurements
Slika 1. Shematski prikaz merenja gasne poroznosti

hardening of sealers. To check the quality of root canal obturation the method of gas permeability was used. Argon concentration was measured using argon-leak detector Edwards LD 416. The teeth were fixed in prospecting detectors for stability. Argon gas was introduced by a special micro-cannula placed in the teeth samples, after which the measurement chamber was vacuumed. The time needed for gas penetration was measured in seconds on timer detector. The quality of the material was expressed as the time needed for argon to penetrate through all its layers. If the time needed for gas penetration was longer, the quality of obturation was better (Figure 1).

The results were statistically analyzed using the analysis of variance – Newman-Keuls test.

RESULTS

Based on results shown in Table 2, it can be seen that argon gas penetrated through all tested endodontic materials in a given time interval. The shortest time for gas permeability was observed in the samples filled with Acroseal (178.5 sec), then AH Plus (179.9 sec) and the longest time was with GuttaFlow (186.7 sec).

The analysis of variance (Table 3) showed no statistically significant difference in gas permeability through tested endodontic materials ($F=4.75$; $p>0.05$).

Table 2. Statistical parameters of gas porosity of endodontic materials
Tabela 2. Statistički parametri gasne poroznosti endodontskih materijala

Material Materijal		n	X (s)	SD	SE	CV%	Min-Max	Volume Opseg
A_1	*GuttaFlow*	10	186.7	2.94	0.98	1.57	180.2–190.1	9.9
B_1	*AH Plus*	10	179.9	1.69	0.56	0.90	173.3–182.5	5.2
C_1	*Acroseal*	10	178.5	2.08	0.69	1.16	175.8–181	5.2

n – number of samples; X – mean; SD – standard deviation; SE – standard error; CV% – conversion percentage; Min-Max – minimum and maximum
n – broj uzoraka; X – srednja vrednost; SD – standardna devijacija; SE – standardna greška; CV% – procenat konverzije; Min-Max – najmanja i najveća vrednost

Table 3. Analysis of dependence between groups I, II and III
Tabela 3. Analiza zavisnosti grupa I, II i III

Source of variation Izvor varijacije	Sum of squares Suma kvadrata	DF	Mean sum of squares Srednje vrednosti sume kvadrata	F	p
Between groups Između grupa	14.09	1	14.09	4.75	>0.05
Within groups Unutar grupa	20.81	7	2.96		
Total Ukupno	34.81	8	-		

DF – degree of freedom; F – ratio; p – statistical significance
DF – stepen slobode; F – odnos; p – statistička značajnost

DISCUSSION

To evaluate the quality of root canal obturation different methodologies such as color penetration test, the application of radioisotopes, electrochemical test, SEM analysis, bacterial penetration test as well as gas permeability method were used [7, 8, 9]. Each research work imposes the need for critical review of methodology applied so obtained results could be more realistically considered. The main disadvantage of using gas permeability method is that it shows porosity between endodontic materials and dentin but not the region or the type of destruction of dentin-material bonding [10, 11].

The results of the current study showed that GuttaFlow provided a high-quality endodontic space obturation. GuttaFlow is a new generation sealer, which consists of two components based on polydimethylsiloxane and gutta-percha in the particle size of less than 30 μm. Innovative composition of this sealer based on artificial resins, its consistency and application enable good seal [12, 13]. Both components (paste-paste system) are precisely dosed in a capsule which prevents contamination with controlled mixing in trituration device. Excellent bond with gutta-percha is enhanced by small gutta-percha particles that sealer contains in the second component of the paste-paste system. This material shows low solubility in oral fluids and therefore provides stability inside the walls of the canal space [14]. Low solubility and good adhesion of GuttaFlow were confirmed in the study of Vasiliaidis et al. [15] who found less leakage with GuttaFlow than AH Plus. Results of our study are consistent with the findings of Bouillaguet et al. [16] who examined the permeability of various endodontic materials for a period of 12 months and detected lower permeability of GuttaFlow compared to AH Plus. Contrary to these results, Brackett et al. [17] in their study found no substantial difference in the degree of apical permeability between GuttaFlow and AH Plus.

Good adhesion of AH Plus confirmed in the current study is attributed to the expansion of material in the first hours of binding as well as its low contraction rate. In addition, this material has exceptional fluidity and lubricity that provide "stickiness" to dentinal walls in the clean canal [18].

Acroseal showed the highest gas permeability in the current study which is in agreement with the results of Eldeniz et al. [19] and Siqueira et al. [20]. In contrast to these findings, McMichen et al. [21] found that Acroseal had significantly lower color penetration than other endodontic materials. Acroseal is contemporary endodontic material based on calcium hydroxide and epoxy resin, which possesses sufficient fluidity and good diffusion. However, a certain degree of solubility of this material causes some defects and cracks in the contact area between Acroseal and dentin walls which can affect the quality of obturation.

CONCLUSION

All tested endodontic materials showed gas permeability in a given time interval. The best quality of obturation was obtained with GuttaFlow, while the lowest quality was found with Acroseal.

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Ispitivanje kvaliteta opturacije kanala korena zuba metodom gasne propustljivosti

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KRATAK SADRŽAJ

Uvod Prognoza lečenja kanala korena zuba umnogome zavisi od kvaliteta opturacije endodontskog prostora. Uspešno izvedeno endodontsko lečenje omogućava i stimuliše odgovarajuće reparacijske procese u apikalnom periodoncijumu, što je osnovni zadatak svakog lečenja kanala korena zuba. Cilj ovog rada je bio da se metodom merenja prodora gasa (argon) kroz tri različita endodontska materijala utvrdi i uporedi dobijeni kvalitet opturacije kanala korena zuba.

Materijal i metode rada Trideset sveže ekstrahovanih jednokanalnih humanih zuba je nakon endodontske instrumentacije svrstano u tri identične grupe, nakon čega su opturisani primenom tri različita endodontska materijala: I grupa – *GuttaFlow* (*Roeko*, Nemačka), II grupa – *AH Plus* (*DeTray*, Nemačka), III grupa – *Acroseal* (*Septodont*, Francuska). Kvalitet dobijene opturacije kanala korena zuba ispitivan je metodom merenja gasne propustljivosti.

Rezultati Najbolje rezultate pokazao je endodontski materijal GuttaFlow, sa prosečnom brzinom prodora gasa argona od 186,7 sekundi. Nešto veću gasnu poroznost imala je pasta AH Plus, 179,9 sekundi, dok je najveća gasna propustljivost uočena nakon primene paste Acroseal – 178,5 sekundi. Međutim, između samih endodontskih materijala nije utvrđena statistički značajna razlika u brzini propuštanja gasa ($p>0,05$).

Zaključak Dobijeni rezultati su pokazali da je kod sva tri endodontska materijala došlo do propuštanja gasa argona u određenom vremenskom intervalu. Najbolji kvalitet opturacije ostvaren je primenom GuttaFlow, dok je najslabiji rezultat dobijen nakon primene paste Acroseal.

Ključne reči: Acroseal; AH Plus; endodontski materijali; gasna propustljivost; GuttaFlow; opturacija

UVOD

Punjenje kanala korena zuba je završna faza endodontskog lečenja čiji je osnovni zadatak da omogući kvalitetnu apikalnu i bočnu opturaciju endodontskog prostora, kao i da izvrši odgovarajuće zatvaranje ulaza u korenski kanal zuba. Složena anatomsko-morfološka građa kanala korena zuba, njihova nepravilnost i nemogućnost uspostavljanja potpuno suvog radnog polja u predelu apikalnih ramifikacija čine fazu opturacije veoma složenim endodontskim postupkom. Mnoga istraživanja su potvrdila da uspešan ishod endodontskog lečenja zavisi upravo od hermetičnosti opturacije korenskih kanala, a posebno njihove apikalne trećine [1, 2, 3]. Naučna i tehnološka dostignuća poslednjih decenija ponudila su stomatološkoj praksi razne endodontske materijale, različitih sastava i svojstava. Zahtevi savremene endodoncije idu isključivo u pravcu primene biokompatibilnih, adhezivnih i fizičko-hemijski stabilnih endodontskih materijala [4]. Ovi materijali takođe moraju biti praktični i laki za manipulaciju, sa dovoljno dugim vremenom plastičnosti, kako bi se omogućio lakši i ležerniji rad terapeuta. Uspešno izveden endodontski tretman omogućava i stimuliše reparacijske procese u apikalnom periodoncijumu, što je i osnovni cilj svakog lečenja kanala korena zuba [5, 6].

Cilj rada je bio da se metodom merenja vremena prodora gasa argona kroz tri različita endodontska materijala utvrdi i uporedi kvalitet opturacije kanala korena zuba.

MATERIJAL I METODE RADA

Kao materijal u ispitivanju korišćeno je 30 humanih jednokorenih zuba sveže izvađenih iz parodontalnih razloga. Starost i pol pacijenta nisu registrovani. Krunice zuba su odstranjene od korenova na nivou gleđno-cementne granice korišćenjem visokoturažne bušilice i fisurnog dijamantskog svrdla, da bi se obezbedila jasna i direktna preparacija pristupnog kaviteta. Pre početka endodontskog postupka načinjeni su radiografski snimci svih zuba uključenih u ispitivanje. Pulpno tkivo je eliminisano upotrebom nerv-ekstirpatora, a ispitivanje prohodnosti i upoznavanje sa anatomsko-morfološkim detaljima kanalnog prostora, kao i same dužine kanala, izvedeno je ručnim instrumentima tipa K br. 10 i 15. Određivanje radne dužine urađeno je tako što je dužina instrumenta, kada se vrh turpije nalazi na spoljašnjem foramenu apikale, skraćivana za 1 mm. Kanali su preparisani tzv. *crown-down* tehnikom korišćenjem nikl-titanijumskih (Ni-Ti) rotirajućih instrumenata, uz irigaciju jednoprocentnim rastvorom natrijum-hipohlorita i lubrikaciju sa *Canal+* (*Septodont*, Francuska). Konačna opturacija obavljena je metodom lentulo spirale i monogutaperka-kočića primenom tri različite vrste endodontskih materijala (Tabela 1).

Korenovi zuba su svrstani u tri različite grupe. Grupa I je definitivno opturisana pomoću materijala *GuttaFlow* (*Roeko*, Nemačka), koji se sastoji od polidimetilsiloksana i malih sferoidnih čestica. Grupa II je trajno opturisana upotrebom endodontske paste na bazi veštačke smole *AH Plus* (*DeTray*, Nemačka). Grupa III je napunjena pomoću materijala *Acroseal* (*Septodont*, Francuska) na bazi kalcijum-hidroksida i epoksi smole.

Pristupni kaviteti su po završenom punjenju kanala zatvoreni sa *Cavit*-om (*Premier, Dental Products*). Korenovi zuba su držani sedam dana na 37°C u uslovima apsolutne vlažnosti, kako bi se omogućilo konačno vezivanje materijala za trajnu opturaciju. Za proveru kvaliteta opturacije kanala korena zuba primenjena je metoda merenja gasne propustljivosti. Koncentracija argona je merena pomoću *Leak*-detektora (*Edwards LD 416*). Uzorci napunjenih korenova zuba fiksirani su u ležište detektora radi stabilnosti. Gas argon je unošen pomoću specijalne mikrokanile koja je prethodno postavljena u ispitivane uzorke, nakon čega je merna komora bila vakuumirana. Vreme prodora gasa, izraženo u sekundama, mereno je na tajmeru detektora za svaki pojedinačni uzorak. Kao mera kvaliteta veze korišćeno

je vreme koje je bilo potrebno da gas argon prođe kroz nanete slojeve endodontskih materijala. Ukoliko je vreme proboja gasa bilo duže, utoliko je kvalitet opturacije bio bolji (Slika 1).

Dobijeni rezultati su statistički obrađeni, a razlike između grupa utvrđene su analizom varijanse Njuman–Kolsovim (*Newman–Keuls*) testom.

REZULTATI

Na osnovu dobijenih rezultata prikazanih u tabeli 2 može se uočiti da je kod svih ispitivanih endodontskih materijala došlo do propuštanja gasa argona u određenom vremenskom intervalu. Najbrža gasna propustljivost zabeležena je u uzorcima punjenim pastom Acroseal (178,5 s), potom kod uzoraka punjenih pastom AH Plus (179,9 s), dok je najsporija bila kod primene GuttaFlow (186,7 s).

Analizom varijanse (Tabela 3) nije utvrđena statistički značajna razlika u stepenu gasne propustljivosti između ispitivanih endodontskih materijala ($F=4,75$; $p>0,05$).

DISKUSIJA

Za određivanje kvaliteta opturacije kanala korena zuba upotrebljavaju se različite metode ispitivanja: test prodora boje, studije primene radioaktivnih izotopa, elektrohemijski test, SEM analiza, test prodiranja bakterija i merenje gasne propustljivosti [7, 8, 9]. Svaki istraživački rad nameće potrebu za kritičkim osvrtom na primenjenu metodologiju, kako bi se dobijeni rezultati mogli što realnije primeniti. Glavni nedostatak metode gasne propustljivosti je to što ona pokazuje ukupnu, integralnu poroznost veze između endodontskog materijala i tvrdog zubnog tkiva, a ne i samog mesta i načina destrukcije veze između materijala i tvrdog zubnog tkiva [10, 11].

Rezultati ovih istraživanja su pokazali da je GuttaFlow omogućio veoma kvalitetnu opturaciju endodontskog prostora. GuttaFlow je siler nove generacije koji se sastoji od dve komponente, i na bazi je polidimetilsiloksana i gutaperke u vidu čestica veličine manje od 30 μm. Inovativni sastav ovog silera na bazi veštačke smole, njegova konzistencija i način primene omogućavaju izuzetnu moć zaptivanja [12, 13]. Obe komponente (pasta-pasta sistem) su u kapsuli tačno dozirane i mešanje je kontrolisano uz primenu aparata za trituraciju, te je onemogućena kontaminacija materijala. Odlična veza sa gutaperkom je pojačana i svojstvima samog silera koji sadrži gutaperka prah, sitne čestice koje predstavljaju drugu komponentu pasta-pasta sistema. Materijal je praktično teško rastvorljiv u oralnim tečnostima, što odlikuje stabilnost u okviru tvrdih zidova kanalnog prostora [14].

Malu rastvorljivost i dobro prianjanje GuttaFlow potvrđuju rezultati istraživanja Vasilijadisa (*Vasiliadis*) i saradnika [15] u kojem je ovaj materijal pokazao manju propustljivost u odnosu na AH Plus. Rezultati naših istraživanja saglasni su nalazima studije Bujažiea (*Bouillaguet*) i saradnika [16] u kojoj su, ispitujući propustljivost različitih endodontskih materijala tokom 12 meseci, zaključili da je GuttaFlow znatno manje propustljiv nego AH Plus. Za razliku od ovih nalaza, Braket (*Brackett*) i saradnici [17] tokom svojih ispitivanja nisu utvrdili bitniju razliku u stepenu apikalne propustljivosti između GuttaFlow i AH Plus.

Dobra adhezivnost paste AH Plus koja je potvrđena u ovom radu pripisuje se ekspanziji materijala u prvim satima vezivanja, kao i malom stepenu njegove kontrakcije. Osim toga, reč je o materijalu koji ima izrazitu fluidnost i lubrificijentnost, kojom se postiže „lepljivost" za čiste dentinske zidove kanala [18].

Acroseal je u ovom radu pokazao najveću propustljivost gasa, što se podudara s rezultatima istraživanja Eldeniza (*Eldeniz*) i saradnika [19] i Sikeire (*Siqueira*) i saradnika [20]. Nasuprot ovim nalazima, Mekmičen (*McMichen*) i saradnici [21] ističu dobra svojstva paste Acroseal, koje je u njihovom istraživanju pokazala značajno manju propustljivost bojenog rastvora u odnosu na ostale endodontske materijale. Acroseal je savremeni endodontski materijal na bazi kalcijum-hidroksida i epoksi smole, a ima dovoljnu fluidnost i dobru difuziju. Međutim, određen stepen rastvorljivosti ovih materijala verovatno uzrokuje i pojavu malog broja oštećenja i pukotina na granici dodira Acroseal sa dentinom zidova kanala, što može uticati na kvalitet opturacije.

ZAKLJUČAK

Rezultati istraživanja su pokazali da je pri primeni sva tri endodontska materijala došlo do propuštanja gasa u određenom vremenskom intervalu. Najbolji kvalitet opturacije ostvaren je korišćenjem GuttaFlow, dok je najveća gasna poroznost uočena nakon primene paste Acroseal.