ACTA
STOMATOLOGICA
CROATICA
www.ascro.net

Acta Stomatol Croat. 2007;41(2):115-21.

IZVORNI ZNANSTVENI RAD
ORIGINAL SCIENTIFIC PAPER

Denis Katić[1], Sonja Pezelj-Ribarić[2], Ivana Miletić Karlović[3], Ivica Anić[3]

Propusnost ispuna korijenskog kanala postignutog konstrukcijom za prijenos tekućine kod tri različite tehnike punjenja

Fluid Movement Along the Root Fillings Placed by Three Different Gutta-Percha Techniques

[1] Dom Zdravlja Sinj, Ambulanta Dicmo, Sinj
Health Centre Sinj, Dental Office Dicmo, 21 230 Dicmo, Croatia
[2] Zavod za oralne bolesti, Studij stomatologije Medicinskog fakulteta
Department of Oral Pathology, School of Medicine, University of Rijeka
[3] Zavod za endodonciju i restaurativnu stomatologiju Stomatološkog fakulteta Sveučilišta u Zagrebu
Department of Endodontics and Restorative Dentistry, School of Dental Medicine, University of Zagreb

Sažetak
Svrha rada bila je ispitati propusnost ispuna korijenskih kanala punjenih tehnikom hladne lateralne kondenzacije, "Touch'n Heatom" i "Thermafil" tehnikom te konstrukcijom za prijenos tekućine.
Materijali i postupci: Za rad je rabljen uzorak od 70 jednokorijenskih trajnih zuba obrađenih tehnikom "step-back". Slučajnim odabirom zubi su podijeljeni u tri skupine po 20 uzoraka i ispunjeni navedenim tehnikama, a koristilo se punilo Diaket. Propusnost ispuna mjereila se konstrukcijom za prijenos tekućine (pomakom mjehurića zraka u mikropipeti povezanoj s uzorkom).
Rezultati: Statistički znatano manje propuštanje ustanovljeno je kod uzoraka ispunjenih Thermafilom (0,46 µL ±0,13) u odnosu prema uzorcima ispunjenima Touch'n Heatom (0,77 µL ±0,50) i tehnikom hladne lateralne kondenzacije (0,71 µL ±0,19).
Zaključak: U ovom su radu uzorci punjeni tehnikom "Thermafil" pokazali najmanju propusnost.

Zaprimljen: 9. veljače 2007.
Prihvaćen: 10. svibnja 2007.

Adresa za dopisivanje
Ivana Miletić Karlović
Sveučilište u Zagrebu
Stomatološki fakultet
Zavod za endodonciju i restorativnu stomatologiju
Gundulićeva 5
10 000 Zagreb
miletic@sfzg.hr

Ključne riječi
dentalno propuštanje; zubna pulpa; bolesti korijenskih kanala; materijali za punjenje

Uvod

Svrha punjenja korijenskog kanala je trodimenzionalna obturacija endodontskog prostora. Tehnika hladne lateralne kondenzacije najčešće je rabljena tehnika (1-3), a koristi se kao standard za usporedbu u odnosu prema drugim tehnikama punjenja. No, u slučaju interne resorpcije ili engl.: ribbon shape kanala, hladnom lateralnom kondenzacijom nije moguće postići dobru adaptaciju punjenja u kori-

Introduction

One of the goals of the root canal treatment is well-compacted and tightly adapted root filling. Cold lateral condensation technique is the most commonly used root canal filling technique (1-3) and is regarded as the benchmark against which others must be evaluated. A key limitation of cold lateral condensation technique is when the root canal system has an abrupt change of diameter, as seen in

jenskom kanalu (4). Takvi slučajevi zahtijevaju primjenu tehnika zagrijane gutaperke, kao što su vruća vertikalna kondenzacija ili Thermafil. (5). Do danas su razvijene različite tehnike kod kojih se koristi zagrijana gutaperka. Tijekom vertikalne kompakcije može se rabiti uređaj Touch'n Heat (Analytic Technology, Redmond, WA, SAD). Temperatura na nosaču topline može biti viša od 250°C (6). Thermafil (Dentsply Tulsa Dental, Tulsa, Oklahoma, SAD) je tehnika kojom se u u korijenski kanal unosi zagrijana gutaperka na plastičnom nosaču. Za to se rabi α-faza gutaperke. To je niskotemperaturna tehnika, pa je mala mogućnost zagrijavanja okolnog tkiva (7).

Najčešći načini za ispitivanje propusnosti su: tehnika prodora boje, konstrukcija za prijenos tekućine i tehnika bakterijske propusnosti (8). Tehnika prodora boje često se koristi za usporedbu brtvljenja materijala za punjenje korijenskih kanala i usporedbu tehnika punjenja korijenskog kanala (9). Smatra se da je konstrukcija za prijenos tekućine osjetljivija tehnika za ispitivanje propusnosti ispuna od najčešće upotrebljavane tehnike prodora boje i da je moguće ponoviti mjerenja u određenom vremenskom razdoblju, jer se uzorci tijekom ispitivanja ne oštećuju. (9).

Svrha ovog rada bila je konstrukcijom za prijenos ispitati tekućine za brtvljenje ispuna postignutog tehnikom hladne lateralne kondenzacije, Touch'n Heata i Thermafila.

Materijali i postupci

Za pokus je uzet uzorak od 70 trajnih jednokorijenskih zuba. Odabrani su srednji sjekutići gornje čeljusti i očnjaci obiju čeljusti. Zubi su dobiveni u Zavodu za oralnu kirurgiju Stomatološkog fakulteta Sveučilišta u Zagrebu i u Domu zdravlja Sinj.

Kruna zuba odrezana je na caklinsko-cementnom spojištu fisurnim dijamantnim brusilom, uz stalno hlađenje vodom. Svi kanali obrađeni su u apikalnom dijelu do Kerr proširivača #40 (ISO #40) i tehnikom "step-back" do Kerr proširivača #80 (ISO #80), uz ispiranje 2,5%-tnom vodenom otopinom natrijeva hipoklorita (NaOCl) u količini od 5 ml po kanalu. Zaostatni sloj stvoren na stijenkama korijenskog kanala (engl. smear layer) uklonjen je etilendiamin tetraoctenom kiselinom (EDTA) – djelovala je dvije minute. Završno su svi uzorci isprani 2,5% NaOCl-om te osušeni papirnatim štapićima (Johnson & Johnson, Slough, Velika Britanija). Slučajnim odabirom zubi su podijeljeni u tri skupine po

internal resorption. Adaptation may be equally limited in ribbon-shaped canals (4). In such cases the application of thermoplastic technique is required. Various root canal filling techniques based on heated or preheated gutta-percha have been introduced in order to enhance complete filling of the root canal (5). During warm vertical compaction of gutta-percha, heat can be applied using heated instrument such as Touch'n Heat (Analytic Technology, Redmond, WA, USA). The temperature of the heat carrier of that device may exceed 250°C (6). Thermafil system (Dentsply Tulsa Dental, Tulsa, Oklahoma, USA) represents another way of delivering thermally softened gutta-percha into the endodontic space which involves the obturation of the root canal with heated α-phase gutta-percha on a plastic carrier. This is a low temperature technique with little risk of overheating tissues (7).

Dye leakage, fluid transport and bacterial penetration are currently the methods which are used most often (8). Dye penetration has been frequently measured in order to compare the sealing ability of root-filling materials and techniques (9). However, it has been suggested that the fluid transport model is more sensitive than dye penetration for the detection of full-length voids along root canal, and at the same time it is highly reproducible (9).

The objective of this study was to evaluate the sealing ability of three different filling techniques: cold lateral condensation technique, Touch'n Heat and Thermafil using fluid transport model.

Materials and methods

Seventy single-rooted permanent teeth (middle incisives of upper jaw and canines from both jaws) were used for this study. The teeth were obtained from Department of Oral Surgery, School of Dental Medicine, University of Zagreb and from Health Centre Sinj. After mechanical cleaning and sterilization the crowns were removed on the cemento-enamel junction, using fissure diamond drill with permanent water-cooling, leaving the roots 11 mm in length. Apical part of all samples was prepared to Kerr file (Maillefer, Ballaigues, Switzerland) #40 (ISO #40), and step-back technique was prepared to Kerr #80 (Maillefer). For irrigation, after the use of each file, 5 mL of a freshly prepared solution of 2.5% NaOCL was used. After instrumentation, the smear layer was removed with 17% EDTA for 2 min. Final irrigation of all samples was carried out with 3 mL 2.5% NaOCl and the canals were dried with sterile paper points (Johnson & Johnson, Slough,

dvadeset uzoraka. Deset uzoraka bilo je u kontrolnoj skupini.

Skupina A punjena je tehnikom hladne lateralne kondenzacije sa standardiziranim štapićima gutaperke (Kerr, Romulus, MI, SAD) te punilom Diaket (ESPE, Seefeld, Njemačka). Štapić gutaperke umetnut je do prije određene dubine. Nakon toga u kanal je uveden ručni potiskivač #25 (Anataeos, Minhen, Njemačka). Glavna gutaperka potisnuta je apikalno i u stranu, a u nastalo mjesto, nakon što je izvučen potiskivač, umetnut je dodatni štapić #25. Tehnika se ponavljala sve dok potiskivač nije mogao ući u koronarni dio kanala dublje od dva milimetra.

Skupina B punjena je uređajem Touch'n Heat, model 5004 (Kerr, Analytic Tehnology, Redmond, USA) uz uporabu standardiziranih štapića gutaperke i punila Diaketa. Proširivačem #40 (Maillefer) unesena je mala količina Diaketa. Štapić gutaperke #40 bio je postavljen u korijenski kanala milimetar kraće od pune radne dužine s nekoliko dodatnih štapića zagrijanih uređajem Touch'n Heat. Postupak kondenziranja gutaperke ponavljao se dok nije bila ispunjena koronarna trećina korijenskog kanala.

Skupina C punjena je obturatorom Thermafil izabranom prema potvrđivaču (engl. verifier). Veličina obturatora bila je #40. Potvrđivačem je unesena mala količina punila pokretom obrnutim od smjera kazaljke na satu. Obturator Thermafil stavljen je u specijalni grijač ThermaPrep (Dentsply Tulsa Dental, Tulsa, Oklahoma, USA) i nakon 10 sekundi postavljen u korijenski kanal do pune radne dužine. Višak je uklonjen ručnim instrumentom zagrijanim na plamenu.

Lateralne površine zuba premazane su dvama slojevima izolacijskog laka (obojeni lak za nokte), osim dva milimetra oko apeksa zuba. Kontrolna skupina sadržavala je 10 zuba - 5 je služilo kao pozitivna kontrola, a 5 kao negativna. Uzorci pozitivne kontrole punili su se štapićima gutaperke bez uporabe punila, a uzorci negativne kontrole bili su napunjeni kao skupina A kod koje je cijela površina zuba, uključujući i apeks, bila premazana izolacijskim lakom.

Kvaliteta punjenja ispuna korijenskog kanala mjerila se konstrukcijom za prijenos tekućine koju su opisali Wu i suradnici (9), pomakom zračnog mjehurića tijekom 5 minuta pod tlakom od 120 kPa (1,2 atm). Za svaki uzorak mjerenje je ponovljeno tri puta i izračunana je aritmetička sredina. Rezultati su izraženi u μL.

Rezultati su statistički obrađeni jednosmjernom analizom varijance s "*post hoc" testovima* LSD.

UK). After the instrumentation the teeth were divided in three experimental groups, each consisting of 20 specimens, and two control groups consisted of five specimens.

Group A was obturated using cold lateral condensation technique with gutta-percha points (Kerr, Romulus, MI, USA) and Diaket sealer (ESPE, Seefeld, Germany). A standardized gutta-percha cone #40 was placed into each root canal to working length with tugback. The master cone was coated with the sealer and seated in root canal. Spreader #25 (Anataeos, Munich, Germany) and standardized gutta-percha points #25 were used for lateral condensation. Cones were added until the spreader would penetrate beyond the coronal third of the canal.

Group B was obturated using Touch'n Heat device, model 5004 (Kerr, Analytic Technology) with standardized gutta-percha points and Diaket sealer. Canals were coated with Diaket sealer using a #40 reamer (Maillefer). Gutta-percha cone #40 was positioned 1 mm short of the canal length with few additional gutta-percha points which were heated by Touch'n Heat device (Kerr). The procedure was repeated until the coronal third of the root canal was filled.

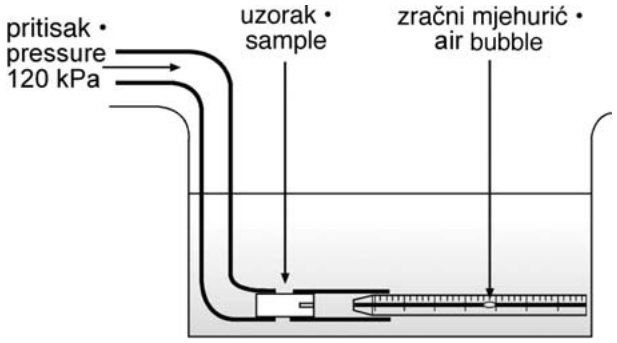
In group C, Thermafil obturators with Diaket sealer were used and they were chosen by the verifier. A #40 Thermafil verifier was used to check the size of the canal. Before obturation, the walls of the canal were coated with a small amount of sealer using file. Thermafil obturator was placed in special heater (Dentsply Tulsa Dental) and 10 seconds afterwards the obturator was inserted to working length. The excess was removed with hot plugger.

The teeth of all the groups were coated with nail polish, leaving 2 mm at the end of the apex. After 24h each sample was mounted in fluid transport model.

Five roots were obturated with gutta-percha without sealer and were used as the positive control. Five root canals, obturated with cold lateral condensation technique using gutta-percha cones and Diaket sealer, were completely coated with two layers of nail varnish and served as the negative controls.

The sealing ability was measured by the movement of an air bubble in capillary tube for five min. intervals under the pressure of 120 kPa (1.2 atm), using the fluid transport model described by Wu et al. (9) (Figure 1). Each specimen was tested four times and the mean value was calculated. The results were expressed in μL.

Results were statistically analyzed using one-way analysis of variance with *post hoc* LSD tests.



Slika 1. Konstrukcija za prijenos tekućina
Figure 1 Fluid transport model

Uzorci koji su pokazali odstupanja veća od krajnje očekivanih vrijednosti, nisu uvršteni u statističku obradu.

Rezultati

U Tablici 1. prikazani su rezultati propusnosti ispuna kod tehnike hladne lateralne kondenzacije, Thermafila i Touch'n Heata, uz pomoć konstrukcije za prijenos tekućine. Propusnost svih uzoraka bila je između 0,46 μm do 0,77 μm. Kod uzoraka u pozitivnoj kontrolnoj skupini pomak zračnog mjehurića bio je prebrz, a u negativnoj nije zabilježen pomak mjehurića zraka.

Na Slici 2. može se uočiti da su kod tehnike hladne lateralne kondenzacije rezultati grupirani između 0,6 μm i 0,9 μm (u višim vrijednostima), kod Thermafila između 0,3 μm i 0,6 μm (oko sredine distribucije), a kod Touch'n Heata nema izrazitih grupiranja rezultata.

Jednosmjernom ANOV-om ustanovljena je statistički znatna razlika u propusnosti ispuna korijenskog kanala postignutog ispitivanim tehnikama punjenja (p = 0,016). Post hoc test je pokazao da uzorci punjeni Thermafilom statistički znatno manje propuštaju u usporedbi s uzorcima punjenim Touch'n Heatom i tehnikom hladne lateralne kondenzacije (p = 0,02 i p = 0,007). Između uzoraka punjenih Touch'n Heatom i tehnikom hladne lateralne kondenzacije nije utvrđena statistički znatna razlika (p>0,05).

Samples with high deviation from expected values haven't been considered in the statistical evaluation.

Results

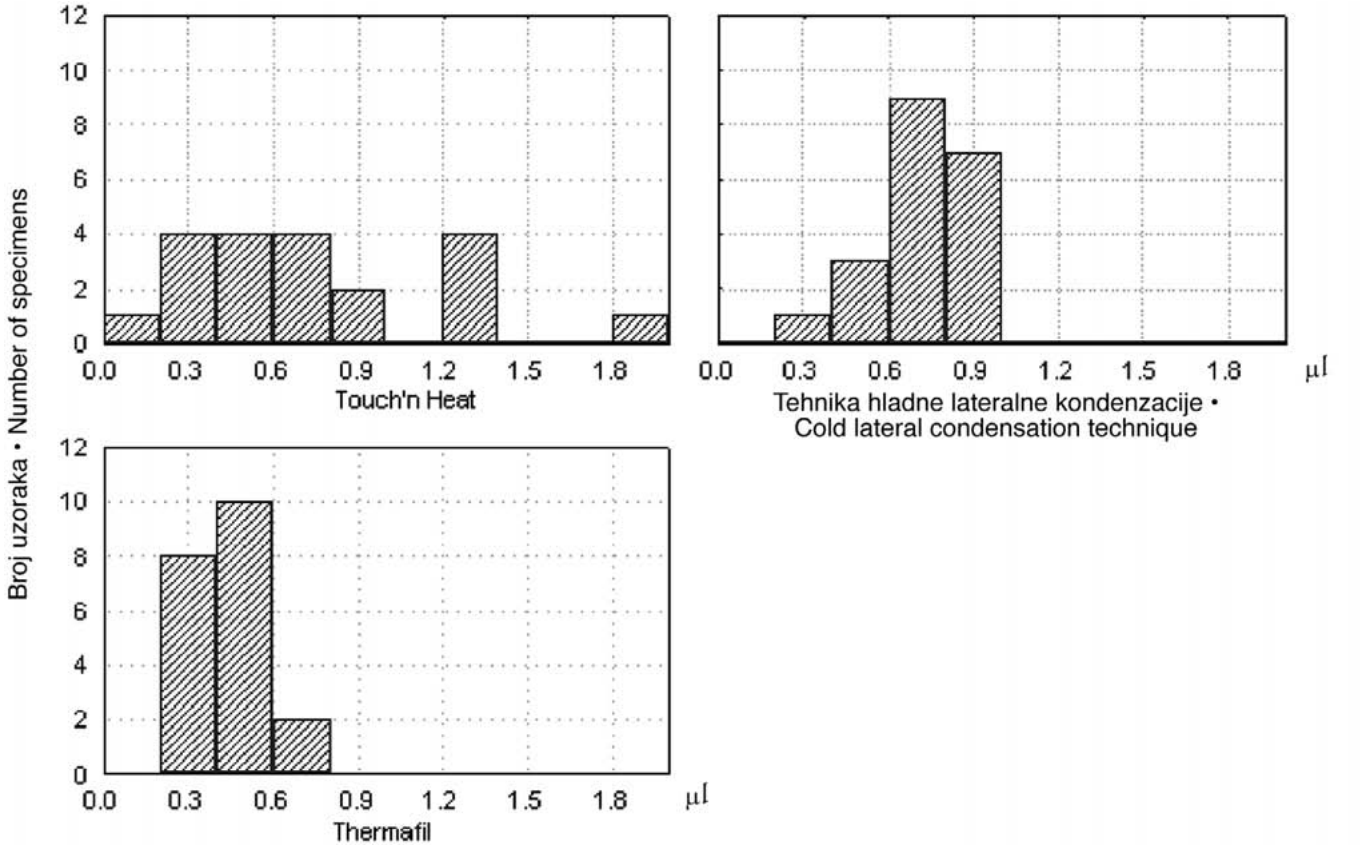
Table 1 shows the results of leakage measurement by fluid transport model. Leakage in all samples range between 0.46 μm to 0.77 μm. In the negative controls, no fluid transport was recorded, whereas in positive controls the air bubble moved too fast to be measured.

In figure 2 it could be noted that the results were grouped between 0.6 μm and 0.9 μm (higher values) with the cold lateral condensation technique. For Thermafil techniques the results were groups between 0.3 μm and 0.6 μm (around the middle of distribution) while in the Touch'n Heat technique the significant grouping of the results was not recorded.

The one-way ANOVA showed that differences between leakage in groups filled using different techniques were statistically significant (p = 0.016). *Post hoc* test showed that specimens obturated with Thermafil had significantly less leakage than either specimens obturated by Touch'n Heat or lateral condensation technique (p = 0.02 and p = 0.007, respectively). No significant differences were found between Touch'n Heat and cold lateral condensation technique (p>0.05).

Tablica 1. Rezultati propusnosti triju ispitivanih tehnika punjenja konstrukcijom za prijenos tekućine
Table 1 Results of leakage for three obturation techniques by fluid transport model

Tehnika punjenja • Filling technique	Broj uzoraka • Number of specimens	Srednja vrijednost • Mean value (μl) •	Standardna devijacija • Standard deviation
Tehnika hladne lateralne kondenzacije • Cold lateral condensation technique	16	0.71	0.19
Thermafil	17	0.46	0.13
Touch'n Heat	16	0.77	0.50



Slika 2. Raspodjela uzoraka s propusnosti ispuna u ispitivanim skupinama.
Figure 2 Leakage distribution: number of specimens in each group

Rasprava

Rezultati rada pokazali su da uzorci punjeni tehnikom hladne lateralne kondenzacije i Touch'n Heatom imaju veću propusnost od uzoraka punjenih Thermafilom. Karagenc i suradnici (10) su, rabeći konstrukciju za prijenos tekućine, ustanovili statistički znatno manju propusnost uzoraka ispunjenih tehnikom hladne lateralne kondenzacije nego Thermafilom, što nije u skladu s rezultatima ovog rada. Suprotno tome, utvrdili su testom bakterijske propusnosti da Thermafil bolje brtvi nego tehnika hladne lateralne kondenzacije (10). To potvrđuje da tehnika ispitivanja propusnosti ima velik utjecaj na rezultate propusnosti. U našem prijašnjem radu (11) kada smo se koristili tehnikom prodora boje, uzorci punjeni Touch'n Heatom manje su propuštali u usporedbi s tehnikom hladne lateralne kondenzacije, za razliku od rezultata u ovom radu u kojemu nije ustanovljena znatna razlika u propusnosti između Touch'n Heata i tehnike hladne lateralne kondenzacije.

Osim tehnike, na kvalitetu punjenja utječe i materijal za obturaciju. Bez punila, ispun korijenskog kanala ne brtvi (12). Rezultati propusnosti za uzorke punjene Touch'n Heatom mogu se objasniti utje-

Discussion

The results of this study showed that root canals obturated with lateral condensation and Touch'n Heat leaked more than those obturated with Thermafil. Karagenc et al. (10) found, by using fluid filtration test, that lateral condensation showed statistically less leakage than Thermafil technique which is not in accordance with our results. However, in the bacterial leakage test, they found that Thermafil showed less leakage than lateral condensation (10). This confirms that the method of testing the sealing ability has major influence on the results. Also, in our previous study (11) it was found by dye penetration method, that samples obturated with Touch'n Heat provide less leakage than samples obturated with lateral condensation technique, while in this study there was no statistical difference between those two techniques.

The sealer has major influence for the leakage. Without sealer, root fillings leak (12). The results for samples obturated with Touch'n Heat could be explained by the fact that the gutta-percha was heated for 4 s using Touch'n Heat at a power setting of 8. Under these conditions, the setting of Diaket was

cajem temperature na punilo. U ovom radu gutaperka je zagrijavana četiri sekunde uređajem Touch'n Heat snagom postavljenom na 8. U tim uvjetima rada stvrdnjavanje Diaketa je upitno. Tijekom zagrijavanja gutaperke u kanalu, zagrijava se i punilo. Himel i Cain (13) ustanovili su da toplina povećava viskoznost nekih punila. U skladu s tim originalna svojstva materijala za punjenje korijenskog kanala mogu se promijeniti na višim temperaturama i negativno utjecati na brtvljenje ispuna.

U ovom radu uzorci punjeni Thermafilom pokazali su najmanju propusnost. Thermafil rabi gutaperku u zagrijanoj alfa fazi. Ta vrsta gutaperke ima specifična svojstva: visoki radioopacitet, izvrsnu viskoznost i adherenciju. Rezultati De Deusa i suradnika (14) pokazali su da Thermafil osigurava znatno veći postotak površine prekrivene gutaperkom u usporedbi s tehnikom hladne lateralne kondenzacije i tehnikom System B. Ti rezultati dokazuju da se Thermafilom smanjuje količina punila koje se koristi tijekom punjenja korijenskog kanala. Time se može objasniti najmanja propusnost dobivena u ovom radu kod uzoraka punjenih Thermafilom. Propusnost nastaje kroz punilo ili zbog njegove topljivosti između punila i stijenke dentina ili između punila i gutaperke (15). Gutaperka je također dimenzijski stabilna za razliku od punila koje je topljivo u tkivnoj tekućini (16).

Zaključak

U ovom su radu svi uzorci punjeni ispitivanim tehnikama punjenja korijenskog kanala u kombinaciji s punilom Diaketom, pokazali određenu propusnost. Najmanja je bila kod uzoraka punjenih Thermafilom.

Zahvala

Ovaj je rad pripremljen u sklopu projekata "Eksperimentalna i klinička endodontologija" br. 065-0650444-0418 i "Biološki učinci stomatoloških materijala" br. 062-0650444-0442, oba je odobrilo Ministarstvo znanosti, obrazovanja i športa Republike Hrvatske.

a concern. During the heating procedure, not only the gutta-percha in the canal is heated but also the sealer. Himel & Cain (13) found that the use of heat increases the viscosity of some sealers. Due to that, the original properties of sealer could be changed at high temperature, and this could negatively influence the sealing ability of root fillings.

In this study Thermafil technique showed the least leakage. The Thermafil system used gutta-percha in the heated alpha-phase during obturation. This type of gutta-percha has specific characteristic: high radiopacity, excellent viscosity and fluidity, and enhanced adherence. The results of De Deus et al. (14) showed that coated carrier gutta-percha system Thermafil produced significantly higher percentage of gutta-percha filled area than lateral condensation and System B techniques which indicated that the Thermafil system can reduce the sealer component. This could be the reason for the superior results of Thermafil technique in this study because the leakage may occur within the sealer or by its dissolution, either in the interface between sealer and dentin, or between sealer and the gutta-percha (15). Also, the areas filled by sealer are more vulnerable because gutta-percha is dimensionally stable whilst the sealer can dissolve over time (16).

Conclusion

In this study none of the obturation techniques combined with Diaket sealer prevented leakage. However, Thermafil technique showed the least leakage.

Acknowledgments:

This study was performed and financed within the research projects "Experimental and Clinical Endodontology" No. 065-0650444-0418 and "Biological effect of dental materials" No. 062-0650444-0442 approved by the Ministry of Science, Education and Sports of the Republic of Croatia.

Abstract
Objective of work: To asses the leakage of three different root canal filling techniques: cold lateral condensation, Touch'n Heat and Thermafil technique by fluid transport model. The root canals of 70 single rooted teeth were prepared using step-back technique and obturated with tested techniques and Diaket sealer. The leakage was measured by the movement of an air bubble in a capillary glass tube connected to the experimental root. Thermafil technique showed statistically significantly less leakage (0,46 µL ±0,13) than Touch'n Heat (0,77 µL ±0,50) and cold lateral condensation technique (0,71 µL ±0,19). Under the conditions of this study, specimens obturated with Thermafil techniques showed the least leakage.

Received: February 9, 2007
Accepted: May 10, 2007

Address for correspondence
Ivana Miletić Karlović
University of Zagreb
School of Dental Medicine
Department of Endodontics and
Restorative Dentistry
Gundulićeva 5, HR-10 000 Zagreb
miletic@sfzg.hr

Key words
Dental Leakage; Dental Pulp Diseases;
Root Canal Filling Materials

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